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Diogo Miguel Mendes Correia

O Cidadão como Agente-Chave das Cidades Inteligentes: Referenciais para um Planeamento Urbano Inclusivo e Sustentável

The Citizen as a Key Actor of Smart Cities: Frameworks for Inclusive and Sustainable Urban Planning

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Tese apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Engenharia e Gestão Industrial, realizada sob a orientação científica da Professora Doutora Leonor da Conceição Teixeira, Professora Associada do Departamento de Economia, Gestão, Engenharia Industrial e Turismo da Universidade de Aveiro e do Professor Doutor João José Lourenço Marques, Professor Auxiliar do Departamento de Ciências Sociais, Políticas e do Território da Universidade de Aveiro.

Thesis submitted to the University of Aveiro for fulfillment of the necessary requirements leading to the Doctoral degree in Industrial Engineering and Management, carried out under the scientific supervision of Professor Doctor Leonor da Conceição Teixeira, Associate Professor of the Department of Economics, Management, Industrial Engineering and Tourism at the University of Aveiro, and Professor Doctor João José Lourenço Marques, Assistant Professor of the Department of Social, Political and Territorial Sciences at the University of Aveiro.

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palavras-chave

Cidades Inteligentes, Planeamento Urbano, Logística Urbana, Cadeia de Abastecimento, Última Milha, Indústria 4.0, Quarta Revolução Industrial, Cidadão, Inclusão, Participação.

Resumo

As tecnologias de comunicação e informação associadas à quarta revolução industrial promoveram um novo paradigma de suporte ao planeamento urbano através da recolha e análise de dados de forma integrada, estabelecendo-se assim as raízes das Cidades Inteligentes. No entanto, a introdução de soluções tecnológicas no mobiliário urbano, sem planeamento estratégico e consideração das reais necessidades dos cidadãos, trouxeram desafios à sua interoperabilidade e eficácia, levantando questões acerca do verdadeiro propósito das Cidades Inteligentes. A necessidade de se combater a pressão urbana, e de responder às alterações climáticas alicerçada nos objetivos da Comissão Europeia e das Nações Unidas, motivou o desenvolvimento do presente trabalho de investigação, que tem como propósito promover referenciais para um planeamento urbano inclusivo e sustentável, no sentido de suportar a compreensão e decisão para o desenvolvimento de iniciativas e implementação de Cidades Inteligentes. Com base nestas premissas definiram-se como objetivos específicos, clarificar as bases do conceito, identificar e classificar as barreiras existentes, enunciar indicadores de avaliação e monitorização de desempenho e estudar metodologias que promovam a participação do cidadão. O papel do cidadão enquanto ator-chave na co-criação de políticas públicas é igualmente alvo de análise. Adicionalmente, a pandemia da Covid-19 veio realçar a fragilidade das cadeias de abastecimento tradicionais e a necessidade de haver lógicas de proximidade para a entrega de bens essenciais. Assim, esta tese tem também como objetivo munir os decisores políticos de capacidade de resposta a acontecimentos extremos, de modo a satisfazer as necessidades dos cidadãos em tempo-real. No processo de investigação, e através de uma abordagem metodológica mista, a presente tese foi suportada por uma combinação de técnicas de recolha (e de análise) de dados qualitativos e quantitativos, garantindo o rigor dos resultados apresentados por via da triangulação de métodos e de dados. Os resultados do estudo empírico revelaram existir discrepância nas fases de desenvolvimento existentes entre territórios, a necessidade de educar os cidadãos para a temática, e de formular metodologias dedicadas de participação ativa considerando as suas características individuais, assim como a vontade de incrementar a sustentabilidade das cidades através de ferramentas que apoiem a organização da logística urbana em tempo real. Deste modo, tendo em consideração os referenciais propostos, identificam-se, nesta tese, contributos teóricos para uma área de conhecimento emergente e pouco explorada na literatura. Numa perspetiva prática, espera-se que as linhas orientadoras resultantes do presente projeto de investigação contribuam para suportar estratégias e decisões de implementação de Cidades Inteligentes, ao mesmo tempo que potenciam a reflexão sobre a atual conjuntura da temática nos diversos territórios.

keywords

Smart Cities, Urban Planning, Urban Logistics, Supply Chain, Last-mile, Industry 4.0, Fourth Industrial Revolution, Citizen, Inclusion, Participation.

abstract

The communication and information technologies associated with the fourth industrial revolution created a new paradigm of supporting urban planning through the collection and analysis of data in an integrated way, thus establishing the roots of Smart Cities. However, the introduction of technological solutions in urban furniture, without strategic planning and consideration for citizens' needs, has challenged its interoperability and effectiveness, raising questions about the true purpose of Smart Cities. The need to combat urban pressure and respond to climate change, based on the objectives of the European Commission and the United Nations, has motivated the development of this research. Moreover, it aims to propose frameworks for inclusive and sustainable urban planning, to support decision-making on the development of initiatives and implementation of Smart Cities. Based on these premises, specific objectives were defined, such as clarifying the concept's basis, identifying, and classifying existing barriers, enunciating performance evaluation and monitoring indicators, and study methodologies that promote citizen participation. The role of the citizen as a key actor in the co-creation of public policies is also analyzed. In addition, the Covid-19 pandemic has highlighted the fragility of traditional supply chains and the need for proximity models for the delivery of essential goods. Therefore, this thesis also aims to provide policymakers with the capacity to answer extreme events by meeting citizens' needs in real-time. In the research process, and through a mixed methodological approach, this thesis was supported by a combination of qualitative and quantitative data collection (and analysis) techniques, ensuring the accuracy of the results through the triangulation of methods and data. The empirical study results revealed a discrepancy in the concept development stages between territories, the need to educate citizens on the subject, and to formulate dedicated participatory methodologies based on their characteristics. In addition, it demonstrated the policymakers' desire to increase the sustainability of cities through tools that support the organization of urban logistics in real-time. Furthermore, considering the proposed frameworks, this thesis identifies theoretical contributions to an emerging knowledge area, little explored in the literature. From a practical perspective, the guidelines resulting from this research are expected to support decision-making strategies for the implementation of Smart Cities while enhancing the reflection on the current conjuncture of the theme in the various territories.

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1SLP – One-stop logistics
AI – Artificial Intelligence
AIOTI - Alliance for the Internet of Things Innovation
AM - Additive Manufacturing
ANMP - National Association of Portuguese Municipalities
API - Application Programming Interface
B2C - Business-to-Consumer
BVC – BeeVeryCreative
CAVs - Connected and Autonomous Vehicles
CPS - Cyber-Physical Systems
DEA - Data Envelopment Analysis
DER - distributed energy resources
DSR - Design Science Research
E - EMBERS
EC – European Commission
EIP - European Innovation Platform
EIP-SCC – European Innovation Partnership on Smart Cities and Communities
ETP - European Technology Platform
EU – European Union
EV - Electric Vehicles
FVH - Forum Virium Helsinki
GDP – Gross Domestic Product
GDPR - General Data Protection Regulation
HLG - High-Level Group
I4.0 – Industry 4.0
ICIEA - International Conference on Industrial Engineering and Applications
ICT - Information and Communication Technologies
IEEE - Institute of Electrical and Electronics Engineers
IEOM - Industrial Engineering and Operations Management
InSMART - Integrative Smart City Planning project
IoT – Internet of Things
IoT-EPI - Internet of Things-European Platforms Initiative
IS - Information System
ISO - International Organization for Standardization
IT – Information Technology
ITS - Intelligent Transport Systems
ITU - International Telecommunication Union
KPIs - Key Performance Indicators
L – LUGGit
LMaaS – Last-mile-as-a-Service
LvPD - Living Laboratories for Decarbonization
M2M - Machine-to-machine
MaaS - Mobility as a Service
MAS - Multi-Agent System
MCDS - Multi-Criteria Decision Analysis
MDA - Median Absolute Deviation
MDPI - Multidisciplinary Digital Publishing Institute
MDVRP - Multi-Depot Vehicle Routing Problem

NDC - Nationally Determined Contribution
NGOs - Non-governmental Organizations
OIP - Operational Implementation Plan
PAVs - Personal Aerial Vehicles
PCA - Principal Component Analysis
PDCA - Plan-Do-Check-Act
PM – Policymaker
PPP - Public-Private Partnerships
RES - Renewable Energy Sources
RFID - Radio Frequency Identification
SC – Smart Cities
SCSP - Smart Cities Stakeholder Platform
SDVRP - Single Depot Vehicle Routing Problem
SEAPs - Sustainable Energy Action Plans
SEO – Search Engine Optimization
SGD - Sustainable Development Goals
SIP - Strategic Implementation Plan
SM - Subtractive Manufacturing
UAVs - Unmanned Aerial Vehicles
UN – United Nations
US – United States
WWII - World War II

Part I

Introduction

Chapter 1 – Relevance and context of the theme, objectives, methodology and structure

The present doctoral thesis aims to detail frameworks to support policymakers' decisions towards implementing Smart Cities with concerns to sustainability and the inclusion of citizens.

Concerning its structure, this introductory chapter starts by explaining the relevance and contextualization of the thesis pinpointing the objectives of United Nations and the European Commission to combat climate change.

Globalization and urbanization, the complexity and inefficiency of current supply chains and the Industry's impact on cities sustainability represent significant challenges to cities. These facts motivated the development of this doctoral thesis. The next section presents the motivation and gaps. The literature review performed follows by highlighting the roots and foundations of Smart Cities and the most relevant topics for this research. The objectives and the methodology are granted in the fourth section. Finally, the structure of this doctoral thesis is presented.

1.1. Relevance and context of the theme

When thinking about Smart Cities, there is an association with new technologies and the connection of networked devices for the automation of processes and communications. The implementation of Smart Cities is intrinsically linked to the will of urban planning to improve inhabitants' quality of life. However, according to the community wishes, the city personalization requires a paradigm shift in which city planning' decisions acknowledge citizens' view. Moreover, there is the need to have mechanisms that allow the collection and analysis of data and the creation of methodologies that engage citizens to co-create initiatives for the cities.

In addition, events such as the Ever Given blockage of the Suez Canal - that stopped the world shipping industry for several days, and the Covid-19 pandemic - that obligated people to stay at their homes without any physical contact recall the need to think about collaborative last-mile models to meet the needs of the population. Moreover, it has been given importance to citizens' transportation, however, it lacks discussion about urban logistics. Cities' sustainability is often associated with the transport and manufacturing sector. Thus, it is expected the evolution to a paradigm where goods and services are available (and manufactured) within the last-mile to meet citizens needs without having to move.

Horizon Europe defines five missions to improve people's lives, by a set of actions, such as research and innovation projects, policy measures and legislative initiatives, to achieve concrete goals with significant societal impact and within a specified timeline (European Commission, 2021). Among the missions are "Adaptation to Climate Change" and to have "100 Climate-Neutral and Smart Cities by 2030". On the one hand, the adapting to climate change call will fund large-scale demonstrations to address major climate hazards and extreme events. On the other hand, the Climate-Neutral and Smart Cities mission, will involve citizens in drawing up 'Climate City Contracts' to reach climate neutrality by 2030.

To combat climate change, world leaders at the UN Climate Change Conference (COP21) in Paris reached a breakthrough deal on 12 December 2015 - the Paris Agreement (United Nations, 2015a). This set long-term goals to limit the global temperature increase to 2 degrees Celsius and limit the increase to 1.5 degrees, in this century. In addition, the Paris Agreement established a five-year cycle of increasingly ambitious climate action carried out by countries. At the same time, provide financing to developing countries to mitigate climate change. Each country is expected to submit an updated national climate action plan (Nationally Determined Contribution, or NDC) every five years.

The European Green Deal reflects the Commission priority for the following years. Moreover, all 27 EU Member States committed to turning the EU into the first climate-neutral continent by 2050. To get there, they pledged to reduce at least 55% of their emissions by 2030 (compared to 1990 levels) (European Commission, 2019a). Sustainable Industry and Sustainable Mobility are within the Green Deal's scope. Moreover, two Green Deal goals strive towards sustainable and smart mobility, thus pushing the Industry to a clean and circular economy (European Commission, 2019b). Furthermore, the aim is to promote green transportation, reduce the number of vehicles and their traveled distances. In line with this, the United Nations proposed "The 2030 Agenda for Sustainable Development" adopted by all United Nations Member States in 2015, to provide a shared blueprint for peace and prosperity for people and the planet and promote global partnership between developed and developing countries (United Nations, 2015b). Moreover, within the 17 Sustainable Development Goals (SDGs), in the present research emphasis will be placed on "Goal 9 – Industry, Innovation and Infrastructure" to build resilient infrastructure, sustainable industrialization and foster innovation, "Goal 10 – Reduced Inequalities" to reduce inequality within and among countries, "Goal 11 - Sustainable Cities and Society" to make cities inclusive, safe, resilient and sustainable, "Goal 13 – Climate Action" to take urgent actions to combat climate change, and "Goal 17 – Partnership for the Goals" to strengthen the global partnership for sustainable development.

Another priority of the European Commission has been to promote a Single Digital Market throughout Europe by breaking telco companies' silos and breaking the barriers of communication within the continent (European Commission, 2015). This allows the boost of digital skills across society and the development of innovative business models for all industries to be created on top of this horizontal policy without further costs.

Thus, the present thesis is fully aligned with Horizon Europe, the priorities of the European Green Deal, and the Sustainable Development Goals proposed by the United Nations. The purpose is to develop frameworks to support policymakers to implement sustainable and inclusive Smart Cities. First, this research aims to clarify to policymakers the Smart City concept, assisting cities with a reference framework to support the implementation of Smart Cities strategies and solutions, while considering the combination of bottom-up and top-down approaches and participatory methodologies to promote inclusion. Additionally, this thesis highlights the need of the territories to raise the discussion about how inequalities can be reduced, and the need to create innovative proximity models in the supply chain, more specifically in the last-mile, to reduce emissions. In line with these concerns, some of the solutions can benefit from practices, technologies, and principles of Industry 4.0, thus motivating the need to study the relationship and impact between Smart Cities and Industry 4.0 throughout this research. Thus, this research aims to create mechanisms to improve citizens' quality of life and prevent cities with the occurrence of extreme natural events while promoting the inclusion of citizens and the sustainability of territories.

Moreover, this thesis starts from the lack of empirical evidence of the current theme to support the creation of mechanisms to address the lack of tools and methodologies to implement and monitor Smart Cities. In addition, guidelines are developed to promote participation in public policy-making processes, while new logistics models are defined, and tools are created to promote a better organization of urban logistics to allow cities to consider industry developments and adapt the necessary means to community's real-time necessities.

1.1.1 Urbanization and Globalization

More than half of the World's population lives in urban areas (Chourabi et al., 2012). Ten percent of the world population lives in the top 30 metropolises, and just 600 cities accommodate a quarter (Dobbs et al., 2011). United Nations expected that around seventy percent of the world's population in 2050 will live in cities and neighbouring regions (United Nations, 2011). Moreover, the world's population will increase to 9.3 billion, and the urban population is estimated to grow to 6.3 billion (Mattoni, Gugliermetti, & Bisegna, 2015; United Nations, 2015c).

This mass migration to the cities will increase the number of densely populated areas, further complicating urban mobility and putting even more significant strain on public services (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017). Such rapid urbanization also has an environmental impact. While cities occupy 2 percent of the planet, they already account for 60 percent to 80 percent of energy consumption, and 75 percent of carbon dioxide emissions. Increased traffic, pollution, waste, and energy costs will continue to present a growing threat to human health and sustainability (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014).

The above problems require newfangled ways of urban thinking grounded in a holistic approach and long–term perspective concerning to the conception, planning, and development of the built, infrastructural, operational, and functional forms of cities (Bibri & Krogstie, 2017).

In the 18th century, less than 5% of the global population lived in a city. By the end of this century more than 80% of the population will live in cities (Harrison & Donnelly, 2017).

Urban areas consume about three-quarters of the energy produced and are responsible for about four-fifths of the emissions of greenhouse gases (Mattoni et al., 2015).

Every day, thousands of commuters use their car as the preferred means of transport, increasing city's traffic congestion and, consequently, environmental pollution. One of the reasons for this problem lies in the current transport public systems and traffic planning forcing commuters and drivers to choose their cars over the transport public. Besides having direct consequences on time spent and fuel consumed, it increases emissions of greenhouse gases. It ultimately reduces the citizens' quality of life. In addition, globalization and urbanization increased goods transportation in the city center. Urban logistics is one of the most resource consumer and greenhouse gas emission existing activities, challenging cities' sustainability (Bibri & Krogstie, 2017). It is a primary cause of pollution and congestion in cities representing between 8% and 18% of urban traffic, decreasing road capacity by 30% because of pick-up and delivery services (Nocerino, Colorni, Lia, & Luè, 2016).

1.1.2 Supply Chain Fulfillment

E-commerce represents a significant challenge in urban logistics (Eiichi & Yasushi, 2004; Gatta, Marcucci, Nigro, Patella, & Serafini, 2018; Van Duin, De Goffau, Wiegmans, Tavasszy, & Saes, 2016; Visser, Nemoto, & Browne, 2014).

Online sales are expected to be 5 US $ trillion by the end of 2021 (eMarketer, 2019). With increasing client service level expectations, efficient delivery to fulfill their wishes is demanded (Janjevic, Winkenbach, & Merchán, 2019). This phenomenon, especially in the case of business-to-consumer (B2C), represents a significant challenge in urban logistics, increasing the difficulties of product distribution with a direct impact on traffic congestion and environmental pollution (Ducret, 2014; Eiichi & Yasushi, 2004; Gatta et al., 2018; Morganti, Dablanc, & Fortin, 2014; Van Duin et al., 2016; Visser et al., 2014).

Successful deliveries are desirable to avoid costs with new attempts, additional storage needs, and package handling (Florio, Feillet, & Hartl, 2018). These costs can easily eradicate a personalized service (Agatz, Fleischmann, & van Nunen, 2008).

From fixed reception boxes in consumers' garages to controlled access systems, several solutions and modes of delivery were put in place to fulfill the needs of consumers (Iwan, Kijewska, & Lemke, 2016). These alternatives present missing delivery ratios much lower than home delivery, help to reduce congestion and environmental pollution, and the aggregation, efficiency, and capillary capacity those options bring, have momentarily, for the past years, solved the problem of delivery. However, they do not present a reliable and comfortable operations model for the home delivery service (Punakivi, Yrjölä, & Holmström, 2001).

The fulfillment of the most demanding logistics requests has always been a challenge where clients had to opt either for quick or personalized service. However, the revenue share economy has brought a new dynamic, and nowadays both goals can be achieved.

1.1.3 The emergence of the Fourth Industrial Revolution

Although there is still no agreement on what constitutes an industrial revolution (Maynard, 2015) there are specific pillars that can base one (Liao, Deschamps, Loures, & Ramos, 2017). In the 18th century, the first industrial revolution was characterized by the invention of the steam engine by James Watt. In the 19th century, energy sources emerged (Oztemel & Gursev, 2020) and the mass production through electricity-powered machines. The most well-known representative was Henry Ford, founder of the Ford Company, and the Ford Model T. Assembly labor lines were created. Industry 3.0 born from the introduction of programmable microprocessors in manufacturing and the discovery of computers and advanced technological developments, which generated the automatization of processes using electronics, and Information and Communication Technologies (ICTs) (Mehmet Karaköse & Yetiş, 2017). Later, industrial robots were introduced (Maksimchuk & Pershina, 2017; Zhou, Liu, & Zhou, 2016). Nowadays, manufacturing is moving from machine dominant to digital. Incorporating the Internet of Things, Cloud Technology, and Big Data into the production created Industry 4.0. The nomenclature was for the first time introduced in 2011 at the Hannover Fair on behalf of an initiative to increase the competitiveness of Germany in the manufacturing industry (Kagermann, Wahlster, & Helbig, 2013). Despite its complexity, Industry 4.0 can be defined by the integration of technologies to adapt value chain processes based on real-time data acquisition and transmission to flexibly provide personalized services and products (Dinardo, Fabbiano, & Vacca, 2018; Hermann, Pentek, & Otto, 2016; Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray, 2018; Pisching, Junqueira, Filho, & Miyagi, 2016; Schumacher, Erol, & Sihn, 2016; Trappey, Trappey, Hareesh Govindarajan, Chuang, & Sun, 2017).

The bibliometric analysis performed by Storolli, Makiya, and César (2019) revealed the importance of fourth industrial revolution technological tools to foster Smart Cities development. In addition, Smart Cities can bridge the gaps between technology and sociology (Doshi, Roy, Iyer, & Mishra, 2020).

The interoperability between systems and the prediction of events based on data processing and analysis are hot topics of Smart Cities and Industry 4.0. The development of one may affect the development of the other. Smart Cities are evolving towards a co-creation paradigm with the citizen and the interoperability of information systems to improve their quality of life. Industry 4.0 tends to allow end-to-end personalization, starting in the product's specifications to be purchased until home delivery (M. Karaköse & Yetiş, 2017; Lom, Pribyl, & Svitek, 2016). Decisions and development in each of the topics may impact the other, to the extent that they include connection point through the mobility of people and logistics of goods, with a shared concern about promoting cities sustainability.

5G represents a significant opportunity for all Industry. Artificial Intelligence (AI) applications for a range of industries are still emerging. 3G and 4G solved the problem of connecting people. 5G reduces the distance between the devices and the cloud, putting the computing power of the cloud in the device. 5G enables people separated by a long distance to communicate in real-time over a 5G network - a band of musicians can play without delays. AI is grounding Smart City initiatives and solutions, which also demands regulation crossing the borders of technologies and domain to ensure social and ethical matters (Diran, Veenstra, Timan, Testa, & Kirova, 2021).

In a world increasingly dominated by technologies, robotics, and AI, where ethical discussions arise, Smart Cities have associated a decisive and interconnected role between engineering and the social sciences, towards taking the most out of technologies while looking to the characteristics and individuality of each community.

New forms of working and new business models are emerging, impacting the Industry's development and how communities relate.

The fact that innovative business models are grounded on the dematerialization of subcontractors' processes and work has raised ethical and social questions that are leading the debate of employment. Although they lack entrance barriers for workers, they also lack social security background. Thus, it is essential to find the right balance between allowing unqualified people to access these jobs while not letting global disruptive business models take advantage of workers. In addition, it is a priority to ensure the interests of communities and local businesses.

Mass production has so far justified resorting to manufacturing in third-world countries, often extremely far away, derived from the cheap cost of production and labor. However, personalization and small-scale production are increasingly disabling the rationale for mass production and standard supply chains. The traditional advantage of reduced manufacturing costs, also related to the close relationship with suppliers, is being replaced by innovative models of information partnerships - Business-to-Business alliances formed by two or more companies - to share information and gain competitive advantages. Companies are joining forces to access new customers, create new opportunities for cross-selling and share investment costs in hardware and software (Laudon & Laudon, 2012).

Several authors point Industry 4.0 as the motor of Smart Cities' ambition (Nick, Pongrácz, & Radács, 2018; Safiullin, Krasnyuk, & Kapelyuk, 2019; Yoon et al., 2019). Innovation in Smart Cities can be explained by Industry 4.0 technological advances that end up having similar purposes and applications and Industry 4.0 developments can bring disruptive changes and have a huge impact on social life (Nguyen, 2020; Oztemel & Gursev, 2020).

The implementation of Smart Cities is intrinsically linked to the efficiency of urban mobility and logistics to reduce circulating vehicles.

1.2. Gaps and Motivation

As mentioned above, urban pressure is one of priorities that Smart Cities want to answer. Nevertheless, the lack of strategic planning has delayed the capacity of cities to face this challenge. In addition, participatory methodologies shall be considered to increase participation and promote inclusion. This, allied to the isolation of inhabitants will be ultimately fulfilled when the incapacity to organize urban logistics in real-time would be overcome. Furthermore, the gaps that motivated the present doctoral thesis are detailed further in this section.

1.2.1. Lack of Strategic Planning

Strategic planning is still an explored theme in the design thinking of Smart Cities. Most of the Smart City studies reported that, in this subject, are mostly explored technological aspects, leaving aside considerations on the management of the city and its policies (Accenture, 2011; Asea Brown, 2012; Huber & Mayer, 2012; Komninos, 2014). In addition to this *gap*, the literature identifies the need to create tools capable of supporting and clarifying the strategic planning of cities (Zygiaris, 2013). Some authors even point to this type of tools as extremely important in supporting decision-making regarding urban development, as they may be helpful to assess the progress of cities towards the goals set at prior (Mohanty, Choppali, & Kougianos, 2016), and to support the correct alignment and development of strategies (Marsal-Llacuna, Colomer-Llinàs, & Meléndez-Frigola, 2015).

An information system (IS) has three associated dimensions: organization, management, and information technology. Regardless of IS, which differs according to its organizational level (operational, knowledge, management and strategic) and type of decision (structured, semi-structured and unstructured), the planning of any information system is dependent on a strategic analysis, definition, and implementation. In this way it is necessary to have an identification and characterization of the organization and the surrounding environment to determine the needs. Moreover, it is intended to achieve and what the role of the system is pretended to be and how to include it in the organization's activity through the motivation of people and allocation of resources (Laudon & Laudon, 2012).

Better planning is a synonym of a better collection of data. Data can be acquired through different sources. The data collected by third parties can also be integrated through external Application Programming Interfaces (APIs). The broker layer is responsible for the aggregation and standardization of the multiple-source data to permit the IoT platform to integrate and process it (Silva, Khan, & Han, 2018). Services and Smart City applications are built on top of that. Moreover, Smart Cities applications originate live events to city officers perform real-time decision making. The analysis of these events provides useful historical data for urban planning (Rathore, Ahmad, Paul, & Rho, 2016).

The public sector has a legacy of a risk-averse environment, and it is usually focused on the short-term goals lacking a long-term strategy and service innovation (Cromer, 2010). Medium- and long-term planning is needed (Sharifi, 2019). It is paradoxical to invest in innovation without considering strategic planning. The result can be a risky disorder (Seravalli, Alessandro; Zubizarreta, Iker; Arrizabalaga, 2016). Most projects fail due to non-technological challenges (T. Nam & Pardo, 2011). Therefore, there is the need for public administrations to accelerate digitization, improve resources and information sharing, and interoperability (Gil-Garcia, Chun, & Janssen, 2009; Janssen, Chun, & Gil-Garcia, 2009; Pardo, Nam, & Burke, 2012).

The enthusiasm and expectations created without the correct knowledge of the technology and its impact, the misalignment verified between the objectives of the project and the strategic objectives of the municipality, and the vulnerability and lack of planning by the executive, are among the main reasons the projects tend to fail. In addition, these projects are isolated, without any strategic framework on its basis, a dedicated team, or formal monitoring by cities (Van Den Bergh & Viaene, 2015).

In this context, although some researchers begin to orient their efforts to facilitate the implementation of solutions, public bodies still need assistance (Neirotti et al., 2014).

The lack of proper strategic planning and progress follow-up can lead in many cases to the abandonment of the solution due to the costs of maintenance and lack of results. While it is difficult to find a clear and widely accepted definition of Smart City, understanding the inherent process is even more challenging (Van Den Bergh & Viaene, 2015).

This is corroborated by empirical evidence when communicating with city executives about the strategies behind their decisions on the allocation of their financial resources. However, the analysis of solutions and acquisition of technologies is still done mainly through executive elements with political backgrounds in a personal way, sometimes without expert support, neglecting technical knowledge. This scenario brings barriers to globalization and the acquisition of the most appropriate technologies rather than locally developed solutions.

The lack of knowledge about existing solutions and guidelines to support the choice of the most appropriate solutions to the context of each city represent some of the current challenges in the implementation of a Smart City strategy. Moreover, there is a need to create mechanisms to assess their development stage and support the planning and construction of a grounded action plan to achieve the desired objectives.

In addition, concerning aggregated, inter cities' and national-wide approaches, when searching for holistic strategies, the results in the literature are scarce. In specific the case of Portugal, there is little research and empirical evidence about Smart Cities.

1.2.2. Lack of Participatory methodologies (People-centered)

Giffinger et al. (2007), when reflecting about Smart City dimensions and factors, have identified the dimension "Smart People" and referred that "Participation in Public Life" is one of the main factors. However, the empirical evidence does not follow up this reflection since there is a lack of participatory mechanisms to evolve citizens in decision-making. Moreover, design thinking - which considers the user at the center - shall inspire Smart Cities planning and implementation (Brown, 2008).

Participation is not just about citizens, but remaining stakeholders, recurring to the so-called Smart Partnerships (Public-Private Partnerships (PPP) in the Smart City ecosystem) where local governments do not act in isolation but in collaboration with the stakeholders in the ecosystem (Coe, Paquet, & Roy, 2001), challenging third parties to develop themselves the needed solutions (Fishenden & Thompson, 2013). Smart Cities have considerable opportunities for businesses to partner with public authorities (Barrionuevo, Berrone, & Ricart Costa, 2012). Cities increasingly providing open data and open access to information, so third parties can develop applications on top of it, emerging new inter-organizational partnerships built around developing and implementing data-driven governance projects

(Shelton, Zook, & Wiig, 2015). New business models are emerging and can be seen as financial enablers (García-Fuentes & de Torre, 2017).

Due to the high costs of technological solutions and operational costs, PPP are joint. Smart City initiatives require the search for new business models and a creative approach to available financing sources. Thus, PPP are an inevitable and a significant Smart City enabler, mostly if is taken advantage of the private sector's competences (Cathelat, 2019; Chan, Yeung, Yu, Wang, & Ke, 2011; Jayasena, Mallawaarachchi, & Waidyasekara, 2019; Milenkovic, Rasic, & Vojkovic, 2017).

Rather than technology-pushed there is a need for frameworks whose approach is application-pulled, flexible, and that combine formal planning, market analysis, and citizen involvement, integrating tools and technologies for data e-participatory management (Valdez, Cook, & Potter, 2018). Therefore, emerging frameworks must be based on problems identified by decision-makers and the citizens. This will engage cities with citizen-led initiatives, focusing on the policy process, driving forces, power, and sociological context (Hollands, 2015).

Therefore, Smart Cities can act as social policy actors because they make available technology to bridge isolation and social exclusion. Nevertheless, there is the need to design methodologies that acknowledges bottom-up approaches and that promote participation.

During this research was noticed that pilot projects have been carried out without proper monitoring and maintenance. In addition, pilots are usually performed in controlled environments. Due to the lack of budget funds and dedicated resources, many projects have been wholly misused and paused for years. This can also be explained by the community's misrepresentation and inclusion in the design and implementation of initiatives.

The differences among the community are also translated between cities. For example, some cities do not yet have LED luminaires; others have already switched to LED with Smart Lighting solutions for their optimized regulation when it comes to energy efficiency. The cities that are already looking at the luminaire as a vital part of urban furniture are implementing solutions with the possibility of charging electric vehicles, including 5G and integrating sensors and cameras to collect data. Moreover, there is a need to study and find why there is a discrepancy between cities and communities and how Smart Cities and designed guidelines help to combat the heterogeneity between territories. This reveals some of the reasons behind the need to conceive and implement Smart Cities.

1.2.3. Lack of Urban Logistics Organization

Cities' sustainability and citizens quality of life are directly connected to the reduction of greenhouse gases emissions and the daily time spent in transports to get from point A to point B. These are linked to the development of the Industry and the public services available to citizens. Moreover, the sustainability of cities is negatively impacted by the Industry and commercial activities that use the urban space and citizens' need to use private cars. Furthermore, there is the need to reduce unadded value transportation activities and decrease the number of circulating vehicles. Thus, to achieve that paradigm, it is necessary to fulfill citizens' needs within the last-mile, to enable the sole usage of smooth mobility and logistics means of transportation (Boysen, Fedtke, & Schwerdfeger, 2020; Le Pira, Tavasszy, de Almeida Correia, Ignaccolo, & Inturri, 2021).

The traditional procurement process, which is often complex, has been replaced by marketplaces in which the validation and verification of each supplier are continuously evaluated. These are usually ground on revenue share models and subcontractors' services (Daugherty, Bolumole, & Grawe, 2019; Qi, Li, Liu, & Shen, 2018).

Moreover, over time there was a concern about the accumulation of deliveries to optimize the supply chain. However, this proved not to be enough for consumers personalized requirements. The last-mile delivery aggregation logic highlighted in recent years may move to an individual-to-individual perspective because of the need to respond quickly to consumers in a similar model similar to nowadays grocery delivery platforms. When several purchases are made online (from different suppliers), it is customary to have multiple deliveries on the same day or on different days, even if we have made purchases in the same store at different times. The aggregation of deliveries is essential for a decrease in vehicles and kilometers travelled. That can be achieved by more significant forecasting and stock management to aggregate services and the optimization of routes itself. The close relationship between cities and the Industry can also be noted here. This, there is the need to understand the city's role on the organization of urban logistics, motivated by events such as the Covid-19 pandemic and the need to meet real-time citizens' needs.

Examples of the similarities of industry models implemented on cities scope can be noted in several applications. Moreover, the Smart Waste management solution, usually use the data collected by sensors placed in containers about their real-time filling level for routes optimization. The system will only contemplate only those that need to be collected by crossing the data with the associated historical information. According to the data analysis, the location of the containers can be changed, or new containers can be added to a particular location. This can inspire other logistics models to fulfill the community needs (Shyam, Manvi, & Bharti, 2017; Tamakloe & Rosca, 2020).

However, this represents a significant challenge when considering immediate real-time deliveries. Carriers and transporters have resorted to pick-up points to optimize the logistics network and combat the rigid home delivery schedules. By empirical evidence, there is no current capacity to perform the services in a personalized way, at the exact time chosen by each customer. Given the current concern for citizens' quality of life and customer experience, the customer's pick-up logic will necessarily tend homogeneously across all sectors to the drop-off from a nearby store location. Moreover, new models and urban furniture equipment will emerge to fulfill the existing gap.

1.3. State of the Art and Related Work

This section aims to expose the state-of-the-art and related work about the topics that supported this research. Moreover, it starts with comprehending how data enhances the emergence of new concepts on the city and industry's scope. After the emergence of Smart cities is detailed regarding the roots of the concept and the evolution noticed. Finally, attention is oriented to the Fourth Industrial Revolution's impact on urban dynamics and landscape. The findings of this section of Smart City concept foundations and the relationship with Industry 4.0 ground this research.

1.3.1. Data as the backbone of Urban development

Data has a critical role in urban governance. Nowadays, urban planning is characterized by a data-driven mindset (Shelton et al., 2015). The capabilities generated by data collection and analysis are endless. The amount of today's data turn challenging the task to analyze with traditional tools. Big data, data sets whose size is beyond the capacity of common software tools processing data within a tolerable time frame, is characterized by volume (in terms of size), variety (in terms of the different formats and types) and velocity (in terms of how fast it changes, and it is generated) - also known as the three Vs. Moreover, storage, processing, and analytics are the three methodological pillars to support decision making (Elgendy & Elragal, 2014).

There is an increased need to model scenario-making techniques to deal with future uncertainties on urban systems' dynamics (Sharifi, 2019). Big data analytics allow a better understanding of complex urban dynamics and the correlation of existing interlinkages (Woods, Labastida, Citron, Chow, & Leuschner, 2017). Furthermore, it will advocate real-time analysis of city life, new modes of urban governance, and provision of raw material (Kitchin, 2014).

The Covid-19 pandemic raised awareness to cities' capacity of respond to citizens' needs in real-time. Moreover, big data also plays a vital role in providing updated on-site disaster data to create real-time feedback loops to assist decision-makers (Yang, Su, & Chen, 2017).

The fact that cities are evolving to support real-time decisions on data analysis gives Big Data a decisive role. In addition, the search for traditional data collection methods or device placement will lead to primary data to analyze and subsequently be considered in urban planning. As an example, in London, there are 8 million trips a day on tubes, heavy rail and buses, where 85% of the passengers use the smart card. So, it represents about 45 million travel journeys a week. Thus, the data set is of infinite importance to help policymakers' actions planning (Michael Batty, 2013).

In addition, new tendencies are emerging. Open data is the ground for new ideas and solutions. This paradigm allows greater transparency and accountability. An open data policy fuels entrepreneurship and innovation, enhancing the creation of new services and products. This can be noted in cities on the sharing of best practices and development of new solutions and, in Industry, through 3D printing and the sharing of designs and models to others pint (Oztemel & Gursev, 2020).

The living labs are associated with open data whose objective is to promote the joint creation and experimentation of solutions within the urban scope. As an example, the city of Amsterdam created an urban living lab to allow the test and demonstration of innovative products and services (focusing on sustainable energy, innovative health solutions, better transport, and citizen participation), creating an infrastructure for knowledge exchange and learning between businesses, authorities, research institutions and citizens (Meijer & Bolívar, 2016).

Thus, some initiatives promote this paradigm as Fiware. It is an open-source community that operates on a global scale, whose mission is to create an open ecosystem, free and implementation-driven software platform standards that will ease the development of new applications in multiple sectors (De Fatima Pereira Marquesone, De Brito Carvalho, Guimaraes, & Dias, 2018; Fiware Foundation, 2021; Munoz-Arcentales et al., 2020).

Digital platforms based on real-time events and data analysis have introduced disruptive business models, such as the sharing economy, bringing innovative income opportunities to citizens and the community. For example, the implementation of Mobility as a Service (MaaS) systems by cities can replace privately owned vehicles using an all-in-one platform to provide integrated journey planning, booking, smart ticketing and real-time information services (Alexandros Nikitas, Michalakopoulou, Njoya, & Karampatzakis, 2020). This can reduce the number of cars, energy consumption dramatically, and transport-related social exclusion, increasing traffic safety and accident prevention, health and wellbeing, social cohesiveness, accessibility and household expenditure (Alexandros Nikitas et al., 2020). In addition, the incorporation of autonomous vehicles on car-sharing and ride-sharing schemes can maximize the MaaS potential (Alexandros Nikitas, Kougias, Alyavina, & Njoya Tchouamou, 2017).

Internet of Things (IoT) can integrate different technologies with the existing communication infrastructures, providing intelligence, interconnection, and instrumentation to cities. IoT interconnects components as electronics, sensors, networks, firmware, software and objects including computers, smartphones, sensors, actuators, wearable devices, homes, buildings, structures, vehicles, and energy systems, providing a platform where things can communicate seamlessly enabling an increasingly convenient information sharing across platforms (Gubbi, Buyya, Marusic, & Palaniswami, 2013; Hernández-Muñoz et al., 2011; Mohanty et al., 2016; Zanella, Bui, Castellani, Vangelista, & Zorzi, 2014).

IoT consists of three layers: 1) perception layer (sensors, RFID, and cameras), 2) the network layer (gateways, WiFi, 2G, 3G, 4G, 5G, etc.), and 3) the application layer (solutions) (Talari et al., 2017). Moreover, the Internet of Things considers the pervasive presence of objects (things) that can interact and cooperate to create new applications and services (Vermesan & Friess, 2013).

There has been an increase in embedded devices, such as sensors, actuators, and smartphones (Rathore et al., 2016). The everyday objects will be equipped with microcontrollers, transceivers for digital communication with one another and with the users, becoming an integral part of the Internet (Atzori, Iera, & Morabito, 2010). The information generated can be shared across diverse platforms and applications to develop a common operating picture (COP) of the city (Jin, Gubbi, Marusic, & Palaniswami, 2014). IoT is also the base for urban planning having integrated historical information gathered from the different devices allow cities to also take future actions accordingly.

This new paradigm gives city decision-makers the capacity to support their decisions better. It increases the velocity of data analysis and information exchange.

With the combination of IoT and the introduction of big data technology, a large amount of data can be processed quickly. Moreover, cloud computing can provide the virtual infrastructure to enable end-to-end service provisioning for businesses and users to access applications on-demand from anywhere (Armbrust et al., 2010; Clohessy, Acton, & Morgan, 2014). Cloud computing refers to a variety of different types of computing models and computers connected through real-time communication networks to perform complex, large-scale computational tasks (V. I. Chang, Bacigalupo, Wills, & Roure, 2010; V. Chang, Walters, & Wills, 2013; Hashem et al., 2016; Mell & Grance, 2011). In addition, Fog Computing aims at moving the Cloud Computing facilities and services to the access network to reduce delays in data transmission and analysis (Baccarelli, Naranjo, Scarpiniti, Shojafar, & Abawajy, 2017; Bonomi, Milito, Zhu, & Addepalli, 2012).

1.3.2. The Historical Perspective of Smart Cities

Several authors refer to the roots of the Smart City concept in the late 1990s related to the smart growth movement (M. Batty et al., 2012; Bollier, 1998; Dameri & Cocchia, 2013; Neirotti et al., 2014; Osella, Ferro, & Pautasso, 2016; Stanković, Džunić, Džunić, &

Marinković, 2017). Then, urban planners were calling for a new vision and new policies to overcome traffic congestion, disconnected neighborhoods, and urban decay, with lack of coordination of housing, transportation, and other infrastructure investments, accompanied by the lack of involvement of local residents in the development of decision-making (Danielsen, Lang, & Fulton, 1999; Ewing, Pendall, & Chen, 2002).

However, evidence is found in the scientific literature about the concept's roots on previous concepts that emerged after the Second World War. Thus, geographers and planners have introduced quantitative and computational methods since the 1950s, the post-war period in urban planning (Shelton et al., 2015). Furthermore, throughout the 1960s, 1970s and 1980s, there was a significant work engaging the emerging information society on the urban scope. Moreover, the instrumentation of the city led to appear different concepts as ' wired cities ', 'cybercities', 'information cities', 'intelligent cities ', 'digital cities' and 'virtual cities' (Angelidou, 2015; Michael Batty, 2012).

In the late 80s and early 90s, a revolution was about to come (Smilor, Gibson, & Kozmetsky, 1989). Gibson, Kozmetsky and Smilor (1992) foresee that an urban-tech phenomenon to come would contribute to the enhancement of the quality of life as well as widening the range of global marketplaces.

The literature mentions minor improvements in systems and services, namely ways to optimize traffic management (Ben-Akiva, Bernstein, Hotz, Koutsopoulos, & Sussman, 1992; Briquet, 1992; Recker, 1992), road pricing and charging (Blythe & Hills, 1993; Thompson, 1990) and payments (Ijaha & Clark, 1993), water supply (D'Antoni, Bowen, & Fredieu, 1988; Smaill, 1994), and others (Samuelsson, 1991). In a holistic perspective, a direction of improving the several city services was undertaken.

Before the expression of Smart City emerge, San Francisco named a project Smart Valley, whose aim was to stimulate the early deployment of advanced communications technologies in the region and encourage the establishment of over 60 applications projects (Mineta, 1991). The importance of having government policy to create the infrastructure and give incentives for the development of Smart City initiatives was also there since the beginning.

In the late 90s (the virtual decade) was introduced the reflection of what could be the benefits and challenges of having cameras displayed throughout the city "to produce electronic simulations of the real world in near real-time" (Crang & Graham, 2007; Graham, 1998; Manovich, 2006).

As a way of fighting against economic crisis and avoiding having to use more resources and recur to cheaper labor costs to compete with larger economies, Singapore shifted the major development thrust into high technology with increased value-added, investing in ICTs with the clear objective of turning itself into a "intelligent island" functioning as an IT hub, not putting aside the locals and the "Asian values" with the aim of being in the forefront of IT, because in the end, the final goal was considered not to be just economic growth but an enhancement of the quality of life for all people (Mahizhnan, 1999; Neville, 1999). At the same time, in Edinburgh, the government invested in technological infrastructure to turn the city into an experimental IT center, where the first e-Government initiatives were introduced (Marsal-Llacuna et al., 2015). Donovan, Kilfeather and Buggy (2008) highlighted a large-scale municipal e-government project in Ireland - Innovative Cities for the Next Generation (ICING) - where the goal was to increase the response capacity of public services to residents.

The term “Digital City” was used before of Smart City. Shanghai used it in a sense of creating an online living platform, providing digital services (library, hospital, etc.) and most of the information of the everyday living with a virtual community, improving the efficiency of the services and reducing their bureaucracy, leveraging businesses and opportunities, and connecting stakeholders (Lin et al., 2020). Bristol was a similar case (de Bruine, 1999). Despite the economic aspect, it was already present in the minds of researchers the importance of connecting and facilitating an active citizens participation in the city planning (Krzanik & Mäkäräinen, 1999). America digital cities’ aimed was to grow businesses on vertical markets. On the other hand, Digital City Amsterdam was focused in providing a public communication space to its citizens. In Helsinki, the goal was to plan the next generation metropolitan network virtually. Similarly to the case of Kyoto, in Japan, the objective was to create a social information infrastructure for urban life (including malls, enterprises, transportation, education, welfare, etc.) (Ishida, 1999, 2002; Tanabe, Besselaar, & Ishida, 2002). In Antwerp, the Intelligent City project, aimed to invent, create and implement telematics solutions for citizens and civil servants, considering a constant dialogue between the local government, the business community and the population (Peeters, 1999).

Thus, “Digital City” was seen by researchers as a phenomenon of transition from offline to online using the best tools available to improve public services and the contact among citizens and between the citizens and the city. Testing, planning, and designing cities virtually by the gather data without constantly changing the physical infrastructure.

The evolution of cities is aligned with the access to information by decision-makers (as noted in section 1.3.1). The Information or Digital Era is rooted in the 90s, matching the emergence of the fourth industrial revolution. At the center of this revolution was not a steam/water machine, the massification of production, or the automation of processes, but data.

Cities are places where different interrelated ecosystems live and have different communication systems (Alber, Adams, & Gould, 1971; Mattoni et al., 2015). Hall et al. (2000) acknowledged the development of the internet and telecommunications networks and the dissemination of their access as the possibility of applying new technologies to urban issues. The authors referred to a Smart City vision, thus conceptualizing one of the first definitions of the term: *"The vision of Smart Cities is the urban center of the future, made safe, secure environmentally green, and efficient because all structures - whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms"* (Hall et al., 2000).

Smart City has been pointed as an ambiguous concept lacking a global perspective (Tranos & Gertner, 2012). Many researchers have discussed its understanding and proposed several definitions (M. Batty et al., 2012; Bibri & Krogstie, 2017; Hollands, 2008; T. Nam & Pardo, 2011; Venkat Reddy, Siva Krishna, & Ravi Kumar, 2017).

Initially, technological companies such as Cisco, IBM or Siemens adopted the term Smart City to refer to technology-based innovations in the planning, development, or management of the urban environment (M. Batty et al., 2012; Harrison & Donnelly, 2017). This contributed to a tendency of considering the Smart City a universal, rational, and depoliticized project biased by the vision of multinational technology companies (Greenfield, 2013). Decision-makers and technology vendors widely used the Smart Cities term in a prolific fashion to market their efforts to implement new technologies (Van Den Bergh & Viaene, 2015).

This led Christiansson (2011) to stress that city administrations needed to look beyond front-end improvements, delivering end-to-end services, including back-office processes. Moreover, the enthusiasm for new technologies had no practical benefit for cities and citizens most of the time. It was just part of the political marketing strategy, disregarding people and the human capital side, blindly believing and promoting that IT itself would automatically transform and improve cities (Hollands, 2008). Reflections started to raise about the fact that local politicians and city managers should not strive to be the best city in the world but for the world (Landry, 2012; Landry & Wood, 2012).

The global economic crisis in 2008 led more companies to look for new market opportunities, particularly in the government sector, increasing their interest in the Smart Cities field. Local government administrations had to cut their budgets and reduce expenses, which turned out to be favorable to the technological companies, who saw there the opportunity to present solutions that promised greater efficiency to city operations (Rodríguez-Bolívar, 2015; Townsend, 2013). Thus, the proactivity that is directly related to existing data analysis may anticipate costs and conflicting situations. Through more effective alerts cities save the agility of recovering the situation. The emergency cycle is extremely challenging. It passes fundamentally through mitigation, prevention, response and then recovery. And for any euro that is invested in mitigation and preparation, more are saved in the recovery.

Thus, political willingness, transparency, and long-term commitment are needed. Additionally, more power and decision should be given to municipalities, promoting decentralization, reducing bureaucracies, and improving transparency. However, this must be followed up with leadership capable of consolidating and inciting the municipality's departments to cooperate and becoming the bridge between them and external stakeholders (Alawadhi et al., 2012; T. Nam & Pardo, 2011).

Smart Cities need to acknowledge a hybrid model, balancing the top-down approach with the ability to engage local stakeholders, enhancing bottom-up community participation (Zygiaris, 2013). Thus, policies definition shall be based on the needs of the city and the citizens, assisted by multi-skilled and motivated teams supported by high-level decision-makers capable of adapting themselves and driving changes with a proactive and forward-thinking attitude (Piercy, Phillips, & Lewis, 2013; Van Den Bergh & Viaene, 2015). Adequate training for those who are not aware of the concept and strategy must be considered. There must be a more significant offer of academic training in the Smart Cities field (Alaverdyan, Kučera, & Horák, 2018). Support and clarification are needed to understand the Smart City's concept and its implications and acquire knowledge regarding existing case studies and their learning (Neirotti et al., 2014). There is a need to create mechanisms capable of creating organizational competencies for the effective use of technological tools addressing institutional and non-institutional problems (Pardo et al., 2012); cultural change, more decisive leadership, a flexible organization (capable of coordinating projects), abroad involvement, and a dual structure (Kotter, 2012). Nevertheless, barriers and best practices shall be further studied.

Monfaredzadeh and Berardi (2015) reviewed the frameworks created until 2013 and compared their indicators with the clusters in which research projects are "often grouped": smart people, smart environment, smart economy, smart living, smart governance, and smart mobility. Borsekova et. al.,(2018), studied the "city size" to a group of 26 Smart City indicators, considering 158 European Smart Cities, divided into two sizes: medium-sized cities and larger cities. After reviewing the evolution of the concept, Stankovic et. al. (2017) criticized current rankings to only consider objective perspectives of citizens and provides the ranking results for 23 Central and Eastern European cities concerning their subjective views. On the other hand, Escolar et al., (2018) concluded that Smart City rankings are generally based on urban development while criteria related to ICT use are not incorporated. Caird (2017) findings suggest there are still needed debates around Smart City indicators to standardize evaluation approaches Other rankings and indexes have also been created and considered. However, lack a common and standard approach to measuring and following Smart City developments.

1.3.2.1. Smart City Areas

Several authors have reflected and identified in the literature the main dimensions of Smart Cities (Lombardi, Giordano, Farouh, & Yousef, 2012).

Mahizhnan (1999) defined four dimensions: IT education, IT infrastructure, IT economy and quality of life. Giffinger (2007) considered six dimensions: smart economy, smart people, smart governance, smart mobility, smart environment and smart living, Albino, Berardi and Dangelico (2015) considered the same dimensions and linked them with aspects of urban such as Industry, education, e-democracy, logistics and infrastructures, efficiency and sustainability, security, and quality. Eger (2009) referred to technology, economic development, job growth, increased quality of life. Thuzar (2011) considered the quality of life, sustainable economic development, management of natural resources through participatory policies, the convergence of economic, social, and environmental goals. Nam and Pardo (2011) mentioned economic, socio-political issues of the city, economic-technical-social issues of the environment, interconnection, instrumentation, integration, applications, innovations. Other studies have proposed: smart health, smart security systems, smart building, smart government, smart tourism, smart grid, smart transportation, smart environment, smart home and smart lifestyle (Caragliu, del Bo, & Nijkamp, 2009; Ismagilova, Hughes, Dwivedi, & Raman, 2019; Pramanik, Lau, Demirkan, & Azad, 2017). Barrionuevo et al. (2012) considered economic (GDP, sector strength, international transactions, foreign investment), human (talent, innovation, creativity, education), social (traditions, habits, religions, families), environmental (energy policies, waste and water management, landscape), and institutional (civic engagement, administrative authority, elections). Kourtit and Nijkamp (2012) stated human capital (e.g. skilled labor force), infrastructural capital (e.g. high-tech communication facilities), social capital (e.g. intense and open network linkages), and entrepreneurial capital (e.g. creative and risk-taking business activities). Chourabi et al. (2012) considered management and organizations, technology, governance, policy context, people and communities, economy, built infrastructure, and natural environment.

Neirotti et al. (2014) presented twelve domains for urban development. Mohanty, Choppali and Kougianos (2016) categorized Smart Cities into ten components: Smart infrastructure, Smart building, Smart transportation, Smart energy, Smart healthcare, Smart technology, Smart governance, Smart education, and Smart citizens.

Ahvenniemi et al., (2017) considered ten sector categories: Natural environment; Built environment; Water and waste management; Transport; Energy; Economy; Education, culture, science and innovation; Well-being, health and safety; Governance and citizen engagement and ICT.

1.3.2.2. Smart City Architecture and Infrastructure

The challenge of developing an urban planning strategy is grounded on the ability to collect and analyze data. Thus, it is vital to integrate different data sources forms. The fact that policymakers started from a top-down approach, where the solutions (application layer) were introduced to the urban ecosystem without the support of a technical framework has delayed and complicated the process of having a generic and broader picture of the city, where data can be manipulated towards meeting the cities' needs. The aim is to create and apply a unified information model to have a complete picture of urban activity (Naphade, Banavar, Harrison, Paraszczak, & Morris, 2011).

As stated before, the topic has its foundations on data gathering from embedded devices (sensors, cameras, etc.), usually through IoT networks (such as Sigfox, LoRa and Narrowband IoT), underlining the importance of having public infrastructure, to transmit to top horizontal platforms. Their purpose is to aggregate, manage, and provide data to help decision-makers in urban planning matters and digitize public services enabling citizens to access information (Talari et al., 2017).

Smart City paradigm provides new tools that enable observation of urban systems at a micro-level focused on the end-user (Harrison & Donnelly, 2017; Yovanof & Hazapis, 2009). Moreover, IoT quickly makes data accessible to increase authorities' responsiveness to city problems and promote citizens' awareness and participation in public matters (Catherine E.A. Mulligan & Olsson, 2013).

One of the leading Smart City objectives is the possibility to have an integrated platform where policymakers can access data (Carli, Albino, Dotoli, Mummolo, & Savino, 2015). Interoperability is fundamental in this context (Taewoo Nam & Pardo, 2011). A Smart City approach requires horizontal thinking looking beyond sectoral silos to create new integrated processes and interactions. This objective is also the most significant challenge cities face, since there are innumerous verticals, companies, technologies, standards, ways of thinking and strategies. Moreover, the difficulty behind the aggregation and correlation of the generated data is vast.

Urban platforms allow the aggregation of solutions in a single dashboard. Nevertheless, a Smart City cannot start by the top without having a solid foundation. A strategic vision is needed to set the architecture of a Smart City, since it is extremely difficult to build it on a later stage because cities would struggle to promote the integration of solutions.

Therefore, the standardization of methods and technologies is a critical aspect. There is the need to have a unifying information management platform across applications domains (Jin et al., 2014). It is also critical that the city reviews the standardization and interoperability issue, ensuring that it can integrate and correlate data from different solutions and city verticals. Cities must adopt an institutional and infrastructural integrated vision (Rodríguez-Bolívar, 2015). Communication, cooperation among relevant stakeholders, and data exchange are desirable and necessary. Thus, cities must have the capacity to combat proprietary solutions and vendor lock-in. Cities shall rely on open and interoperable standards to move towards open innovation ecosystems and breaking down vertical silos (Robert et al., 2017; Zdraveski, 2017). This way, the application layer will have the chance to inter-operate and be integrated (Silva et al., 2018).

The European Commission wanted to promote the collaboration of academia, industry, and public administration. Moreover, the EIP-SCC aimed to join cities, industry, and citizens to improve urban life through more sustainable integrated solutions through the focus areas of energy, transport, and ICT (Francesco Russo, Rindone, & Panuccio, 2016; Shelton et al., 2015).

The AIOTI alliance (AIOTI, 2021) was launched among other initiatives, composed of 13 Work Groups (Robert et al., 2017). Furthermore, a sub-alliance named IoT-EPI (IoT-European Platforms Initiative) was created with the aim to turn existing vertically oriented platforms and services into economically viable IoT ecosystems. Open IoT ecosystems comprise platforms, marketplaces, developer portals, and storefronts, where companies collaborate with exploratory approaches to propose disruptive solutions (Robert et al., 2017).

Usually, the generic layered architecture of a Smart city comprises four layers: 1) Sensing layer (physical devices and infrastructures, sensing components), 2) Transmission layer (transmission and network layer), 3) Data management (data fusion, analysis, processing and storing) and 4) Application layer (solutions and businesses) (Silva et al., 2018). Concerns also shall be oriented to security and institutional security systems (C. Li, Liu, Dai, & Zhao, 2019). The interaction of citizens with technologies in different contexts is the foundation of many proposed business models. Nevertheless, middleware layers should also be accounted to ensure end-users privacy (C E A Mulligan & Olsson, 2013). Moreover, the replacement of proprietary solutions to Open APIs are welcome to uniformized solutions and allow the creation of new applications on top of the combined system (Robert et al., 2017).

Bibri and Krogstie (2017) performed a literature review contemplating existing Smart city frameworks and infrastructures. In addition, Rong et al., (2014) proposed a Smart City architecture composed of several layers. They reviewed the existing literature according to their consideration for the following layers: data acquisition, transmission, visualization and storage, support service and event-driven applications.

Furthermore, efforts are being promoted to give cities a standard technological framework. Moreover, the European Commission recently appointed Deloitte and KU Leuven to develop a proposal for a European Interoperability Framework for Smart Cities and Communities (EIF4SCC) based on case studies and best practices implemented by other cities (Chantillon et al., 2021). However, regardless of the technical framework, it still lacks bridging the knowledge gap of policymakers to help them realize and understand where to start.

1.3.2.3. Overview of Smart City initiatives

Until 2010, the number of Smart City studies reported in the literature was scarce. Only after the emergence of the Smart City projects supported by the European Commission, a proliferation of writings and academic publications on the topic was noted (Jucevičius, Patašienė, & Patašius, 2014). Moreover, European Commission has been supporting and investing in Smart City initiatives. In 2016 there were 34 EU dedicated projects (Akande, Cabral, Gomes, & Casteleyn, 2019).

One of main Smart City references was the City of Barcelona. In 2011, the city was focused on experimentation and technological transformation, through the introduction of new technologies in an innovative way, with a view to improving the operation and management of the city in general, promoting economic growth and strengthening the well-being of citizens (Ferrer, 2017). The top-down approach benefited technology solution providers (Calzada, 2018). Among the initiatives implemented, there were new models of service management and relationship with citizens inspired by e-government principles as well as sustainable growth projects in the areas of smart lighting, mobility and energy, and the installation of the municipal wi-fi network, and the creation of a living lab district “22@” (Ferrer, 2017; Luca Mora & Bolici, 2015).

In 2012, Lee and Hancock (2012) mentioned the existence of 143 ongoing Smart City projects. Of these, 47 were located in Europe and 30 in the US (J. H. Lee, Hancock, & Hu, 2014).

In China, according to the Chinese Smart Cities Forum, six provinces and 51 cities have included Smart Cities in their government plans (Liu & Peng, 2013).

Many projects and applications can be found in the literature about flagship cities as Santander, Manchester, and London (Sanchez et al., 2014; Silva et al., 2018). With critiques to the reasons and foundations of the projects (Cowley, Joss, Dayot, & Cowley, 2018). The references are primarily to sensor and network infrastructure applications for different verticals. Among them are parking solutions, waste management, traffic control, air quality monitoring and WIFI or IoT networks.

The capital of Finland, Helsinki, has a Smart City development area, Smart Kalasatama, facilitated by Forum Virium Helsinki (FVH), that allows the implementation of agile Smart City pilots with a multi-stakeholder collaboration. The Mobility-as-a-Service knows the city

(MaaS) available service. However, it does not have a specific Smart City strategy (Hämäläinen, 2020).

Gohari et al., (2020) literature review stresses that although the Norwegian region has come as far as its European counterparts in terms of Smart City applications and projects, strategies remain in the planning stages and are still very fragmented.

These two examples of developed north-European countries raise the concern of if cities are still committing past errors of neglecting strategic and social aspects, focusing on technological applications.

In the past, a diverse set of projects were being put in place to fulfill the ambition targets for carbon emissions and reducing energy consumption preserving sustainable urban development with the minimal ecological footprint (Kennedy & Sgouridis, 2011). These were called 'Zero Carbon Cities' projects.

Among them are Songdo in Korea, Masdar City in Abu Dhabi, UAE, and Dongtan in Shangai, China. In Songdo, South Korea, a city was built from scratch. This was a highly technologically advanced urban space. Its objective was to have 50% green spaces with smart waste management, among other Smart City technologies (Carvalho, 2015). A similar project was started in Masdar, Abu Dhabi, to make a zero-waste and zero-emission city. The city is still under construction and aims to be a car-free city by favoring public transport and autonomous electric vehicles (Reiche, 2010). In Dongtan, Shanghai, a similar project in an agricultural land located in the third biggest island of China had a half a million-target population and the goal of achieving 100% consumption of renewable energy by 2030 (H. Cheng & Hu, 2010).

These cities' projects, sometimes referred as "Smart Cities in box" (Calzada & Cobo, 2015), have been noticing several constraints and turned cities into Ghost Cities because people did not relate themselves with the built artificial environment and did not want to live there. In a nutshell, Ghost Cities were born from the concept of Zero Carbon Cities, in which cities were created entirely from scratch but whose occupation and habitability fell far short. These cities were thought with the first stage of Smart Cities in mind, having its development been largely pushed from corporations to residents (Carvalho, 2015).

This has drawn attentions to the growing importance of social matters of inclusion and participation, following the evolution of the Smart City concept by including citizens in decision-making to plan the territory accordingly to the preferences and needs of the communities (Albino et al., 2015).

Recently, through text-mining and in-depth content analysis, Hu and Zheng (2021) revealed the differences between China and United States' Smart City initiatives. China focuses on the technology industry and funding innovations to make infrastructure intelligent and sustainable. China’s government top priority is to set standards and guidelines for Smart City practice. The top-down approach and hierarchical governance structure remain the dominant mode. Thus, the political framework may also deserve further studies. In contrast, United States' cities acknowledge a participative governance structure involving multiple actors and cross-sector collaboration.

Thus, more critical than reviewing the individual scope of the projects and applications introduced, it matters to understand the holistic picture and the guidelines to ground the co-creation of strategies.

1.3.2.4. Participation and the Role of the Citizen

The European Parliament synthesized international debate over the Smart City concept by stating that including citizens and relevant stakeholders is a critical success factor (F. Russo, Rindone, & Panuccio, 2014).

The focus changed from technology diffusion to meet corporate and economic interests to break silos and focus on people, governance, and policies (Robert et al., 2017). Simultaneously, citizens passed from a passive role to urban development and planning co-creators (Mainka et al., 2016).

Moreover, the Smart City concept evolved to the Smart City 3.0, developing collaborative cities in a co-creation perspective (Cohen, 2015). Co-creation was first seen as a way for citizens to collaborate with cities to solve specific urban environment issues (Choque, Diez, Medela, & Muñoz, 2019). Then moved to a participatory approach involving citizens and other stakeholders to help plan and design the city (Cossetta & Palumbo, 2016; Cowley et al., 2018; Healey & Gonza, 2005; Sadoway & Univerisity, 2018).

Smart Cities face the challenge of widening inequality and social polarization (Hollands, 2008). Special attention has been noted in the literature to have policies that shall promote the inclusion of citizens by including them in the process of decision making (Oliveira & Margarida Campolargo, 2015). Furthermore, Smart Cities can act as social policy actors and promote inclusion. The decision-making process must promote inclusion and reduce social barriers (Silva et al., 2018). Literature from social policy becomes relevant, such as the notions of welfare regimes and intersectionality (Stephens & Fitzpatrick, 2007; Wincott, 2006).

The bottom-up participatory approaches play an essential role in assessing and developing Smart Cities (Hemment, Woods, Appadoo, & Bui, 2016). Moreover, scholars should be motivated to understand not just whether certain actors are involved in policymaking but in which parts of it and in which ways (Leach, Scoones, & Wynne, 2005).

Therefore, the need for a frame of reference with participatory methodologies is evident. Guidelines that assist municipalities and bring together the various stakeholders to provide greater collaboration can be excellent tools for a better co-definition of policies (Oliveira & Margarida Campolargo, 2015; Shelton et al., 2015).

The research exploring citizens' involvement in Smart Cities is still lacking. Some authors such as Szarek-Iwaniuk and Senetra (2020) and Díaz-Díaz and Pérez-González (2016) focused on case-studies analysis and the pros or cons of a particular way of engaging citizens. Other authors, such as Mueller, Lu, Chirkin, Klein, and Schmitt (2018), Salim and Haque (2015) focus on theoretically understanding this participation, and Boukhris, Ayachi, Elouedi, Mellouli and Amor (2016) on developing tools to help decision making.

Mueller, Lu, Chirkin, Klein and Schmitt (2018) created the concept of Citizen Design Science as the new way to integrate citizens' ideas and wishes in the urban planning process combining crowdsourcing opinions through ICTs with design tools. Salim and Haque (2015) proposed a taxonomy of urban computing, addressing user interaction modes, provocations, and scale of participation, in mobile crowdsensing, urban probes, participatory urbanism, interactive public display, and also interactive urban intervention. Memarovic et al. (2012) defined three levels of engagement in public spaces: passive (people just observe), active (interact with the display) and discovery (learn and appreciate the contents stimulated). Through a workshop with various stakeholders, Forlano and Mathew (2014) set up a collaborative designing process from brainstorming to prototype a 25-30 years future city scenario.

Simonofski, Asensio, De Smedt and Snoeck (2019) proposed the CitiVoice Framework where citizens participate in the three different phases: as democratic participants in decision making, co-creators of ideas and solutions, and users. Boukhris, Ayachi, Elouedi, Mellouli and Amor (2016) proposed a tool based on multicriteria decision making based on citizens' opinions.

Because of the diminished noted existing research of citizen involvement in Smart Cities, Granier and Kudo (2016) studied several Japanese cities and communities through interviews and analysis of official documents. They concluded that public participation is not noted at the city governance level, but instead in the co-production of public services (e.g. energy production and distribution).

Webster and Leleux (2018) defined as mechanisms of Smart city participation and co-production: hackathons, living labs, fab labs and maker spaces, smart urban labs, citizens' dashboards, gamification, open datasets, and crowdsourcing. The survey of Szarek-Iwaniuk and Senetra (2020)'s case study made to Olsztyn's residents revealed that ICTs and mostly online surveys contribute and encourage the public to participate in decision-making. However, other options must not be forgotten to combat exclusion.

Although social media may not be considered as a primary tool for citizen participation, the Díaz-Díaz and Pérez-González (2016)‘s case study of the Santander City Brain shows a collaborative tool designed to promote open innovation by the share of ideas, comment and vote, which proves that a social media adapted method can represent an effective way to set the political agenda and influence political discourse.

Communities differ from each other, not only at the level of their needs but also at their expectations. These are instinctively related to the socio-economic characteristics of the context itself (e.g., level of qualifications and the age structure of the population). Thus, within the same community, aspects must be considered to adjust the responses to these local and socio-economic idiosyncrasies to promote the participation of citizens. It is essential to understand their motivations and provide the necessary tools to encourage them to engage in the process.

1.3.3. The impact of the Fourth Industrial Revolution in the development of Cities

Industry 4.0 was introduced in 2011 and is characterized by the fusion of physical and virtual worlds (Kagermann et al., 2013), where the product will control production (Nick et al., 2018). Its primary goal is not to replace the existing manufacturing assets but to ensure interoperability and interconnectivity among players using ICTs and standards (Trappey, Trappey, Fan, et al., 2017). Furthermore, it aims to promote autonomous processes by its capability of self-optimization, self-adaptation, and self-configuration, considering the changing environment and disturbance minimization (Kovácsházy, 2018). Thanks to the collected data, it is possible to study and predict the behavior of the end-user. The information is used to better plan and allocates resources (Brettel, Friederichsen, Keller, & Rosenberg, 2014).

Transportation has always played a crucial role in Industrial Revolutions (Nguyen, 2020). Industrial Revolution 1.0 created mechanical means of transportation recurring to steam engines, allowing faster transport of people and materials. Industrial Revolution 2.0 offered mass production of private vehicles, which enhanced the creation of new business models and increased the population's comfort. Industrial Revolution 3.0 kept improving the comfort by the automation of systems and applications while working on the security of the community (L. Li, Qu, Zhang, Wang, & Ran, 2019; Sładkowski & Pamuła, 2016).

Nowadays, Smart Mobility aims to develop integrated solutions that allow anyone to move quickly and sustainably. This vision can be achieved by aggregating information about existing mobility services and making them available to citizens. This way, users can move smoothly from point A (start) to point B (end), without the discomfort of having to buy tickets from multiple vendors, wait in queues, or visit various platforms to coordinate transportation (Jittrapirom et al., 2017). On the other hand, Industry is striving to give the end-users the chance of having the right product at the right time in the right place with the proper condition (Wang, Ma, Yang, & Wang, 2017). Thus, the path to a more sustainable Industry involves transitioning to a circular model, where all agents in the supply chain are integrated and can collaborate with each other. Moreover, inspired on the Mobility as a Service (MaaS), freight and passenger trips can be integrated and ground new business models and innovative logistics approaches (Le Pira et al., 2021). Therefore, the impact of the supply chain and the impact of Industry developments in cities are hot topics.

Furthermore, while the first Industrial Revolutions focused on executing tasks considering stocks, Industry 3.0 introduced Lean and Just in Time manufacturing, leveraging attention to the process and organization. Lean manufacturing was focused on optimization by cost-saving through waste elimination (Kang et al., 2016). Nowadays, the supply chain is evolving to considering real-time relationships among stakeholders, thus allowing individual and resilient production. Industry 4.0 is characterized by the consideration of models as a service with the aim to provide an end-to-end service (Kaoutar Douaioui, Mouhsene Fri, Charif Mabroukki, 2018). Moreover, manufacturing has evolved to a prominent trend of be provided as a service for users (Tao & Qi, 2019), and characterized by data-driven decision-making (Helu, Libes, Lubell, Lyons, & Morris, 2016; Kusiak, 2018). Buer, Strandhagen, and Chan (2018) mapped current research and established a research agenda about the linkage of Industry 4.0 and lean manufacturing

Mobility and logistics struggle with the same challenges about real-time events and the capacity to perform personalized services. From taxis to mobility platforms, the one-to-one logic was present until very recently, when flexible concepts began to be explored. However, many inefficient points remain to be optimized. Urban logistics to answer extreme events and quickly meet citizens needs deserve further reflections. How the supply chain shall be organized, and stock aggregation and disaggregation, shall enhance the short-term collaboration among stakeholders and subcontractors to improve urban logistics capillarity while promoting sustainable last-mile delivery fulfilment.

Several entities started trying to predict the needs of consumers by placing sensors and technologies without the client have to formally making a purchase or give any input to deliver their product (Kocsis, Buyer, Submann, Zollner, & Mogan, 2018). The pull ideology became predictive by the analysis of data and systems integration. Barkyn is an example (Barkyn, 2021). The startup created a smart box for the placement of the pet's feed. Through artificial intelligence, they realize the filling level, at what time and the amount of feed ingested by the animal and calculate when the client will need more stock. The feed is customized for each animal depending on its age, weight, size, and breed.

The reasoning is switching from technology to their application based on circular economy. The new paradigm began to be noted in revenue share models and resource sharing to increase optimization and efficiency. This can be found in mobility models such as car-sharing and carpooling. Since the personal vehicle is down for most of the time, these flexible models decrease the number of circulating vehicles.

New models are emerging with the concern to reduce the number of circulating vehicles. Moreover, it is been considered the integration of people and freight transportation using shared vehicles and urban equipment (Beirigo, Schulte, & Negenborn, 2018). Autonomous vehicles are expected to enhance the development of new business models considering the time they will save people from driving unadded value tasks on manufacturing (Mittal, Khan, Romero, & Wuest, 2019). More specifically, the introduction of Connected and Autonomous Vehicles (CAVs) and Unmanned and Personal Aerial Vehicles (UAVs and PAVs), also commonly known as drones, are referred as some of the critical aspects of the Smart City agenda (A. Nikitas, Michalakopoulou, Njoya, & Karampatzakis, 2020). These can disrupt existing mobility and logistics models. Moreover, CAVs with a focus on sustainability and, safety and security standards will allow better road space allocation and traffic congestion management (Alexandros Nikitas, Njoya, & Dani, 2019), UAVs and PAVs will have a massive impact on logistics and travel moving people, expanding the urban landscape and transport networks vertically (Bakogiannis, Kyriakidis, & Zafeiris, 2019; Barmpounakis, Vlahogianni, & Golias, 2016; Hofmann & Rüsch, 2017). Nevertheless, they can conflict with social and environmental sustainability objectives. Therefore there is the need to review legislative, moral, educational, business and social engagement frameworks (A. Nikitas et al., 2020).

The integrated management platform, commonly denominated of control centers (B. Cheng, Longo, Cirillo, Bauer, & Kovacs, 2015), or urban platforms (Gutiérrez, Amaxilatis, Mylonas, & Muñoz, 2018), which cities are intending to adopt with the cross and integration of the data gathered from the different sources and verticals, to help city decision makers having a clear and integrated real-time perspective is something that can be also inspired and related to the digital twin of Industry 4.0. In addition, it should be pointed that Industry 4.0 also applies to new ways of working and the reflection of people's role in industry development (Rutkowska & Sulich, 2020). Furthermore, Pervez et al. (2018) reflected on the changes in society and learning methods to prepare students and workers for future demands, however, the contribution itself seems to focus on the technological component and how it will affect society. Soares et al. (2021) attempted to clarify the alleged dimensions organized by four category planes of Industry 4.0 and found that human dimensions receive little attention, and environmental, societal, and infrastructural concerns are out of the range of the studied models. Most of the time, technology is associated with the impact that it may have on society. Foresti et al. (2020) and Saniuk, Grabowska and Gajdzik (2020) set up a dedicated survey and studied the emerging threats and opportunities for producers, employees and customers. In the last years, a debate has emerged to understand how Industry

4.0 will affect society and the labour market. Matt, Orzes Rauch and Dallasega (2020) shared several assumptions for the sustainable development of the proposed urban production concept as the proximity with the client for integrated product development. The existence of micro labs with 3D printers to allow the production of individual products, the flexible models of the working environment and schedule and a better relationship between work and leisure time to improve the quality of life of inhabitants.

1.4. Objectives and Research Methodology

1.4.1. Objectives

The research question of the present thesis is: "How can Smart cities contribute to increase territories' sustainability and the inclusion and quality of life of local communities?". Based on this general question, sub-questions emerged to bridge the small gaps of this research. Nevertheless, since the present work started from a general picture, the literature reviews performed throughout the research process feed the reflection on several produced documents, which guaranteed the relationship and connection between the pieces.

From the question of research, it was considered relevant to study the dimensions of Urban Development, Strategic Planning, Participation and Inclusion, Industry 4.0 and Technologies, as well as Logistics and Supply Chain. Based on these dimensions, the specific objectives were designed, which were translated into more specific research questions.

Thus, first, this doctoral thesis aimed to reflect on the historical background of the Smart City concept and the current urban development by pinpointing existing case studies and acknowledging the stakeholders' barriers. The goal was to clarify the concept, their associated axes, and frameworks to guide policymakers on Smart Cities design and implementation. Second, as stated before, the role of the citizens has changed. Cities can act as social policy actors by promoting the inclusion of citizens through their participation in decision-making. Therefore, was intended to understand the reasons behind the lack of participation and how could this be promoted by creating dedicated guidelines and engaging methodologies. Third, inclusion may also be considered by creating logistics proximity models to bridge the existing gap to their physical isolation. Furthermore, Industry is evolving to allow the end-to-end personalization of products and services to set up the supply chain in real-time. Innovative models and technologies shall be studied and introduced to cities scope to improve urban logistics organization to answer citizens' real-time needs and reduce the number of circulating vehicles.

In summary, this research aims to design the guidelines that shall support decision-making on the conceptualization, implementation and monitoring of a Smart City. Thus, the created guidelines shall evaluate the maturity level of the city and ground the design of the strategic plan considering the goals that each intended to be achieved. These should be based on the citizens' preferences and contemplate participatory methodologies that guarantee the representativeness of each population group. Therefore, shall be reflected on the personalized methodologies to be undertaken to promote their inclusion and participation. On the other hand, urban logistics shall also be contemplated by giving policymakers the understanding about the current need to consider last-mile organization models to combat extreme events and fulfill community's needs.

Thus, it is intended to provide policymakers and academia with the:

- Clarification of the concept and its axes – by understanding the evolution of the concept and the axes that ground its comprehension.
- Acknowledgment of the existing barriers and challenges – allowing policymakers to understand what the issues are they must consider and how can they be monitored and overcame.
- Monitoring and assessment of the Smart City state – by answering the Key Performance Indicators (KPIs) of each axis together with the realization of the importance allocated by citizens and their preferences, policymakers can combine top-down and bottom-up approaches to monitor the Smart City evolution and compare with other cities.
- Definition of an action and strategic plan – by defining the goals for each of the dimensions and key performance indicators, the priorities and necessary improvements are clarified, which shall base the definition of an action plan to implement the solutions accordingly. Proposal of a standard procedure with the respective steps to implement a Smart City.
- Consideration of participatory methodologies – understanding of the methods and channels to engage each group of population according to specific characterization variables.
- Understanding the impact of Industry 4.0 – study the technologies and realize how innovative models can be applied on the urban dynamics.
- Organization of urban logistics – real-time citizens' needs fulfillment through the organization of resources and set up of last-mile delivery and storage' collaborations.

Fig. 1.1 summarizes the target dimensions of this thesis and their related objectives. The last were translated into detailed sub-research questions related to a substantial gap in the literature.

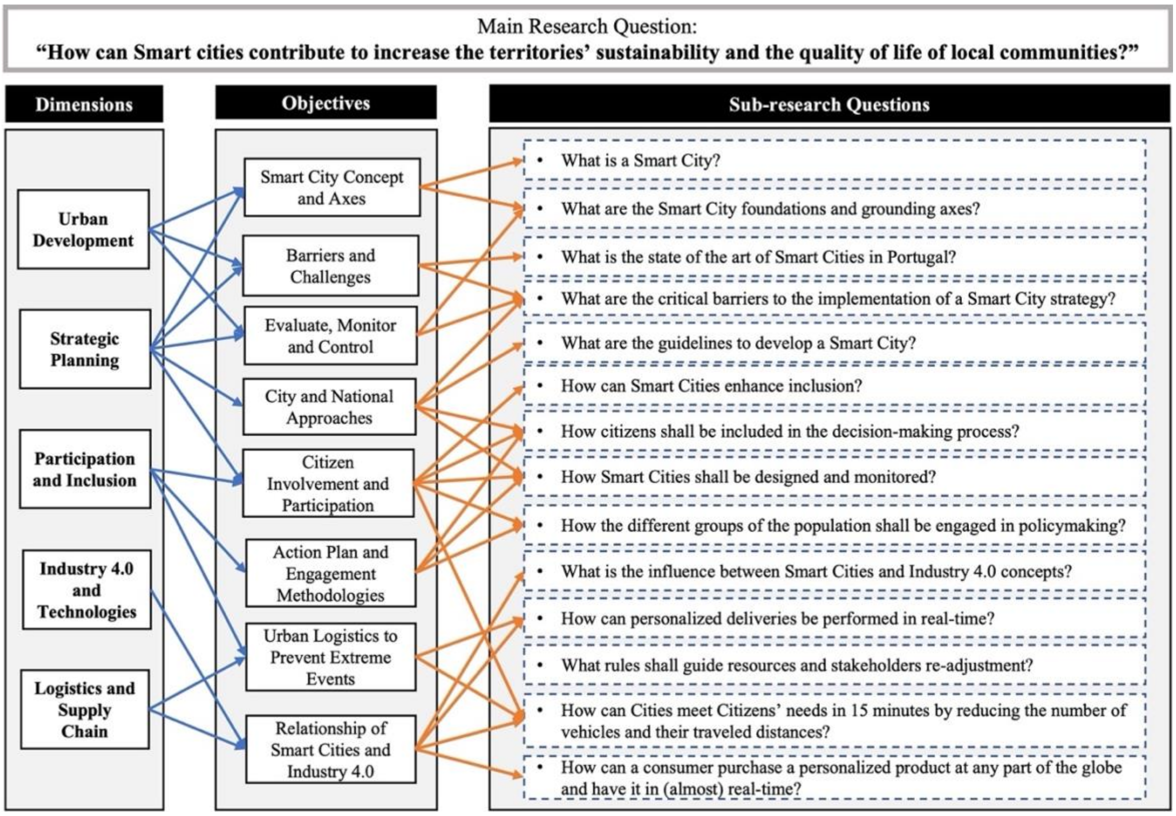


Figure 1:1 Dimensions, objectives, and sub-research questions

1.4.2. Methodology

This thesis followed the methodological approach of Design Science Research (DSR), usually used in the field of the development of Information Systems (Baskerville, Ga, Pries-heje, & Venable, 2009).

According to Hevner, March, Park, and Ram ((2004), DSR can be defined as a process or method that aims to design and propose an artefact to improve or solve a current issue.

Furthermore, DSR starts by describing and explaining the observed phenomenon or object and the concepts, constructs, and frameworks on which the outcome of the DSR will be based to ultimately design an artefact (Iivari, 2007).

Therefore, three cycles must integrate the artefact's development stages: (i) the relevance cycle - positioning the research environment, determining the problem, its application context, and limitations; (ii) the rigor cycle - analysis and justification of the knowledge base selected to construct the artefact, theoretical foundations, and methodology; and (iii) the design cycle – main activities to construct and evaluate the artefact (A. Hevner, 2007).

Figure 1.2 sketches the DSR applied to the present doctoral thesis. On the Environment is presented the context in which this research is inserted, the Knowledge area refers to the foundations that support it, and the Design reflects the methodology performed to give the literature theoretical contribution and the environment the practical ones.

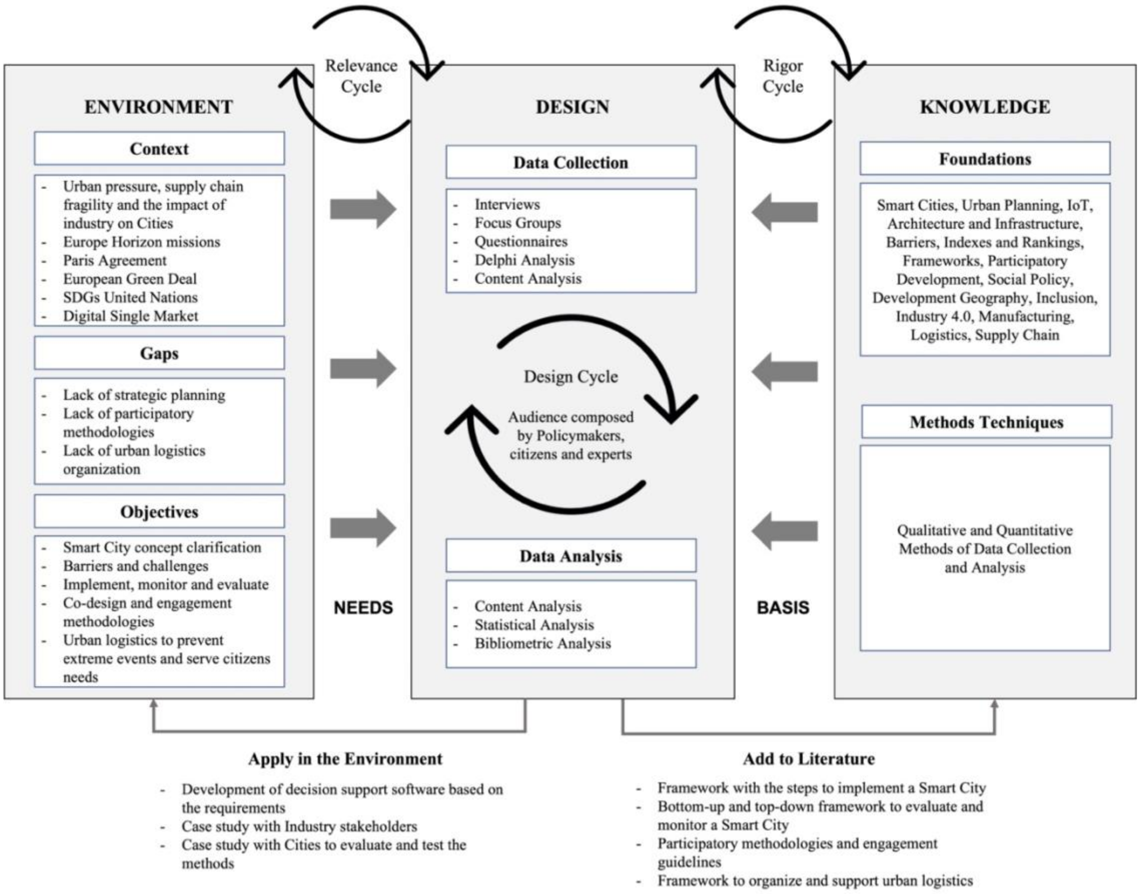


Figure 1:2 Design Science Research applied to the present research

1.4.2.1. The Environment - Relevance cycle

The relevance cycle refers to this research context, enunciating existing gaps in the environment to support the proposed objectives. Thus, as mentioned before, the development of Smart Cities is intrinsically linked to urban planning and improving inhabitants' quality of life. Supported by technologies, decision-makers are challenged to promote citizens' well-being while contributing to cities' sustainability.

The Covid-19 pandemic and the blockage of the Suez Canal raised awareness about the fragility of the traditional supply chain and the need for the cities to be prepared to answer citizens' needs.

Horizon Europe’s five missions, the Paris Agreement, the European Green Deal, and the Sustainable Development Goals of United Nations all point in the same direction, and with the same ambition to adapt and combat climate change and address significant climate hazards and extreme events, by decreasing emissions and promoting sustainable initiatives. Furthermore, the aim is to promote green transportation, reduce the number of vehicles and their traveled distances, thus pushing the industry to a clean and circular economy. On top of this, is the aim to reduce inequality within and among countries and to make cities inclusive, safe, and resilient. In addition, Single Digital Market, promoted by the European Commission, wants to boost digital skills across society and develop innovative business models to break private companies’ silos and break communication barriers within the continent.

Moreover, urbanization and globalization are pressuring urban environments. These are also caused by the phenomena of e-commerce and the increase of last-mile logistics activities. Therefore, cities must find ways of including citizens in decision-making to guarantee that the bottom-approach is considered, while understanding how innovative logistics models can combat isolation and meet citizens’ needs in real-time.

Therefore, as enunciated above this thesis acknowledges several objectives, such as: clarification of the Smart City concept clarification; the identification of barriers and challenges; the reflection on how to implement, monitor and evaluate a Smart City strategy, considering citizens co-design and engagement methodologies; and understanding how to organize urban logistics to prevent extreme events and serve citizens’ needs.

Thus, there is the essential to have mechanisms that allow the collection and analysis of data and the creation of methodologies that engage citizens to co-create cities.

1.4.2.2. The Knowledge - Rigor cycle

This cycle was conducted through literature review on Smart Cities, Urban Planning, IoT, Architecture and Infrastructure, Barriers, Indexes and Rankings, Frameworks, Participatory Development, Social Policy, Development Geography, Inclusion, Industry 4.0, Manufacturing, Logistics and Supply Chain.

Additionally, this cycle recommends a deep analysis of the main methods that can be used in the research process. Thus, was sought in the literature the information on the various methods and techniques, to make the respective comparison, and conclude about the methods that could give the best response to study the desired phenomena.

When selecting the methods and techniques of empirical research, the options usually are quantitative, qualitative, or mixed methods approach.

Quantitative methods are used to quantify and measure a given phenomenon statistically and compare the match level with the previously formulated hypothesis (Heigham & Croker, 2009). This type of method is usually applied to get the perspective of a concrete target audience (Creswell & Creswell, 2017).

Qualitative methods are drawn by the understanding that everyone has their own understanding, which depends on specific context and circumstances (Merriam, 2002; Patton, 2014). These are usually applied to get individual perceptions and experiences of a topic without preconceived ideas and formulated hypothesis since the aim is to explore a phenomenon and not to prove a hypothesis (Ivankova & Creswell, 2009).

As the name indicates, mixed method aims to employ both approaches (Johnson & Onwuegbuzie, 2007). This shall be placed according to the timing to conduct each method, the priority, and how the mixed data is analyzed.

Moreover, qualitative methods were sought to allow a detailed view of policymakers' opinions and gather experts to reflect and converge to the definition of a solution. Quantitative approaches were used to get broader direct perspectives of general audiences, such as citizens or policymakers, to compare them with the previous hypothesis. Both approaches were mixed when it was relevant to compare detailed opinions with broader responses.

1.4.2.3. The Design Cycle

Based on the theoretical foundations about the related topics and methods presented before and the context in which this doctoral thesis was developed, this section aimed to detail the research methodology and the journey that was performed.

a) Research Methodology

The methodology was based on mixed-method research combining quantitative and qualitative approaches. This allowed to understand the phenomena further, compare with previous hypotheses, and complement with in-depth perspectives of critical stakeholders. Moreover, the triangulation of data to increase the rigor and the quality of the findings was considered. Several examples can be found in the chapters of Part II, Part III, and Part IV.

Moreover, to find the critical Smart City barriers **(Chapter 5)** it started by performing a thematic analysis of existing literature studies to base the following Delphi Analysis - combining a two-round questionnaire and a focus group with Smart City experts.

Regarding participatory guidelines, first, interviews were conducted with Portuguese policymakers to understand their perception of citizens' involvement to co-create Smart

Cities. Second, a questionnaire to citizens to ascertain whether there was evidence to support some of the policymakers **(Chapter 10)**.

Questionnaires were also performed to policymakers to get an overview about cities capacity to meet citizens real-time needs. Quantitative analysis was performed to closed questions and qualitative analysis to the open ones. These supported the following focus group of industry experts to define the features and requirements of a tool to support decision-makers **(Chapter 14)**.

Another example was the study of the steps necessary for implementing a Smart City **(Chapter 6)**. The thematic analysis of literature studies served as the backbone to formulate the policymakers' objectives that inspired the further discussion over a Smart City experts' focus group. A focus group with Industry experts was also used in **Chapter 15**.

The state of the art of Smart Cities in Portugal used the thematic analysis of a secondary source, a national magazine, and complemented with interviews with policymakers **(Chapter 4)**. Interviews with policymakers were also conducted in **Chapter 8**.

The methods of data collection and analysis are summarized in Table 1.1.

The questionnaires were made through google forms and shared via social networks or email, depending on the audience. In the case of the questionnaire to policymakers, the questionnaire composed of closed and open questions was sent individually to the emails publicly available. When the intention was to target a general audience to get the opinions of different representative groups, social media was used, with particular attention to ensuring transparent and unbiased results. In addition, online focus group and structured and semi-structured interviews were performed to get detailed views of experts and policymakers.

Finally, secondary sources with historical data were considered to allow detailed information about a concrete topic that otherwise would not be possible to base the empirical evidence.

Several techniques of qualitative analysis, as text mining (Choi, Kim, & Kim, 2019)) or inductive thematic analysis where codes and themes are developed and associated (Rice & Ezzy, 1999). Moreover, the transcriptions of the interviews and focus group discussions were explored based content analysis.

To contradict the critique made by Webb and Kevern (2001) about the lack of quotes and descriptions from the participants' interventions observed in the focus groups, the discussion's main points are described and transcribed to highlight the contributions and the contradictions.

Table 1:1 Methods

Method	Description
Questionnaire	The questionnaire method allows having a heterogeneous representation. Thus, the target of a general and broad audience is targeted. Also, this method allows the collection of objective data through scale-questions (usually using the 5-point Likert scale) or through the study and quantification of the answers (Mitchell et al., 2020).
Interviews	This research method examines the complex phenomenon and intensively studies a subject based on individual contributions to generalize it to a broader perspective(Gustafsson, 2017).
Focus Group	The focus group joins multidisciplinary experts, promoting an open and flexible discussion with a collective understanding uncovered by individual interviews, allowing the researcher's direct interaction with the experts (Morgan, 1998; Stewart, Shamdasani, & Rook, 2007). In a focus group, it is usually given a set of topics enabling everyone to express their opinion to reach a consensus (Flynn, Sakakibara, Schroeder, Bates, & Flynn, 1990).
Delphi Analysis	The Delphi Analysis summarizes the opinion on emerging concepts and the development studies that lack empirical data and intend to objectively obtain experts' responses (Gordon & Pease, 2006). This method usually considers several and consecutive response rounds (Rodríguez-Mañas et al., 2013). In each round, the answers are collected. The disagreements are analyzed and highlighted to ground the following round to converge the group's answers (Marques et al., 2009). The systematic and participatory process combined with moments of discussion and confrontation of perspectives mobilized experts to a possible convergence in a shared vision.
Content Analysis	The data source that aggregates and analyzes multiple stakeholder contributions and allow a retrospective analysis. Otherwise, it would be challenging to obtain detailed historical information. Traditional methods lack a temporal character since data collection is performed at specific moments. This data source allows the study of the evolution of the subject based on the analysis of the direct contributions over the years (Farrell, Oerton, & Plant, 2018).

In addition, quantitative and bibliometric analyses were also used to analyze collected data, mainly from questionnaires or literature reviews (De Jong, Joss, Schraven, Zhan, & Weijnen, 2015; L. Mora, Bolici, & Deakin, 2017; Page et al., 2021).

Data analysis support tools, such as NVivo, SPSS, SocNetV and Excel were used to process and analyze results. Thus, empirical evidence was collected through different data collection methods. Interviews to eight policymakers, three Industry experts and one secretary of state were conducted. In addition, a Delphi analysis contemplating a two-round questionnaire and a focus group was performed to nine Smart City experts. Another focus group was performed to nine Industry experts. Finally, two different questionnaires to policymakers and citizens were done.

Figure 1.3 demonstrates how the different methodological approaches drawing from DSR were employed to answer sub-research questions, and their clear objectives.

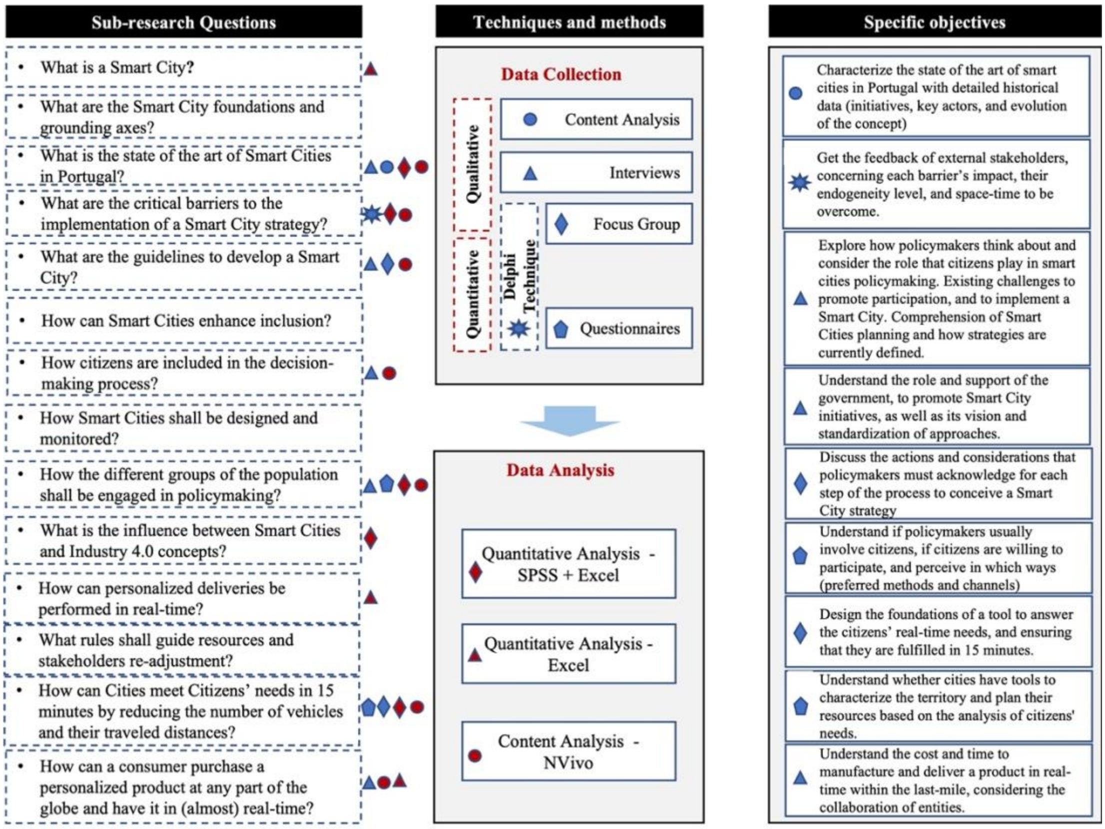


Figure 1:3 Detailed view of the methods used for data collection and data analysis

Several scientific documents were produced to answer the research questions. These are reflected in the following chapters. This doctoral research objective was to present a "thesis by articles". This format differs from the traditional in the sense that each produced scientific document is peer-to-peer reviewed allowing the research to be frequently evaluated. Thus, this process increases the quality of the outcomes and help to orient the research according to the comments and revisions of international experts.

Therefore, the entire methodological process considered a holistic panorama with individual focus. This process requires a continuous reflection about each article's alignment towards the thesis's primary objective to answer the research question.

Furthermore, the most critical literature findings were channeled into the scientific documents that were being drawn. The information would have been lost if it was not thematically analyzed and oriented to a specific goal. Thus, despite being a more challenging process upstream, the downstream result was indeed favorable.

Next sub-section details the roadmap of this research process considering a historical perspective.

b) <u>Roadmap of the Research Approach</u>

This research aimed initially to provide policymakers the guidelines to implement a Smart City. Even though, the overall objective did not change, a lot contributed to improving the rigor of this work. The events that occurred from 2019 until 2021 molded the research process and the imperative need to cross other disciplines.

First, this research wanted to understand the origin of the Smart City concept, reviewing the literature, and searching for the oldest articles existing in the databases where the term is mentioned. The review was handled via Scopus using the combinations of the keywords "smart", "cit*", "concept", and "definition". From this search, 250 papers deserved an in-depth analysis. The evolution of the concept composed of three distinct phases was highlighted. Additionally, through forwarding and backward citation tracking and analysis, other related variations of the concept were obtained. It was performed a thematic analysis to position them with the respective Smart City stage and focus. After this analysis, several variations of the concept were found, with more details in **Chapter 2.**

The fact that the concept evolved from a technological perspective to focus on cities sustainability, the quality of life of inhabitants, and the inclusion of the citizen as co-creator, led this research to look for evidence on how the new paradigm was dealing with the issue of widening inequality and social polarization. Several examples were found of cities that used Smart City initiatives as social actors. The importance of considering social policy literature was pinpointed and more details can be seen in **Chapter 7**. It was clear at this stage, that it could not be possible to keep investigating the Smart Cities topic without emphasizing the social aspect.

Furthermore, it was intended to study how Smart Cities were being monitored, which Policymakers used Key Performance Indicators (KPIs) and standard tools. This helped to figure out the grounding axes that constitute a Smart City. Several studies report some attempts to formulate a methodology to evaluate cities' maturity levels. However, they have not taken properly into consideration indicators' weighting, or the focus of the index was not clear, mixing KPIs of different concepts to provide a more generic tool. The comparison among these frameworks and the conclusions of several reports in the literature allowed to conclude about the three axes that base a Smart City, which are the contributions of **Chapter 3**.

Next, an in-depth study of the existing barriers to implementing a Smart City was performed. Several studies were found in the literature. However, these focused only on identifying the barriers, rather than framing them according to how and when they could be answered. Different dimensions should be considered for each barrier. Therefore, it was studied each barrier according to their endogeneity (within the policymakers' scope), impact (in the implementation of a Smart City), and space-time (to be overcome). Only this way barriers support the definition of a strategic plan, according to their prioritization. From a shortlist of 50 barriers aggregated and organized in 8 distinct areas based on a thematic analysis of a 114 barriers initial list collected in the literature (from narrative and systematic literature reviews), 9 experts participated in the study through a Delphi Analysis. It was found the critical barriers. Empirical evidence helped reinforce the previous reflection about the Smart City concept and highlight the need to assist policymakers with guidelines. The process and results of this study are detailed in **Chapter 5**.

After, qualitative methods were used to explore citizens' role in Smart Cities. Specifically, how it is perceived, whom the actors define the structure of these policy processes are, and who is later involved. It did so by combining a literature review with in-depth interviews conducted with eight policymakers from different Portuguese cities. Thus, the study of the need, type and challenges of citizens involvement was performed. The results show that while Smart City policymakers recognize the importance of including citizens in policymaking, the practical application is still minimal. In fact, although they acknowledge concerns and the need to involve citizens, it was observed a lack of guidance. Moreover, the challenges raised by policymakers are detailed in **Chapter 8**.

In terms of communities' preferences and priorities, the lack of guidelines to combine top-down and bottom-up approaches to help local policymakers plan and assess cities was noted. Moreover, a methodology that allows the definition of structural priorities and contextual preferences while comparing policymakers' statements and citizens' opinions was designed based on the previous axes of Chapter 3. The framework monitors and measures the performance of cities based on standard KPIs and select relevant initiatives towards meeting the defined goals. More details about this theme can be seen in **Chapter 9.**

Even though the Smart City expression has become widely used in the market, there was a lack of examples and best practices. This claimed attention to the fact that the practicality of the concept may be a challenging task. Moreover, there were hidden issues that were delaying the success of this paradigm.

Furthermore, when discussing the problems associated with citizen participation, most Policymakers put the onus on the citizens. However, Policymakers could also be responsible for not motivating the citizens enough or providing them with the necessary information. Thus, through mixed-method research, first, interviews were conducted with Portuguese policymakers to understand their perception of citizens' involvement to co-create Smart Cities. Then, a questionnaire to citizens to ascertain whether there is evidence to support some of the assumptions made by policymakers. Accordingly, on top of the previous findings, further research was performed to understand whether the barriers outlined by policymakers in terms of citizens' involvement in Smart Cities policymaking were supported by evidence. Furthermore, the need for open and dedicated methodologies are highlighted in the sense that they allow for participation to take place in different ways. **Chapter 10** details some of the guidelines that policymakers must consider.

The study of the state of the art of Smart Cities in Portugal was performed to have a general perspective of a territory on this subject. This was done through the content analysis of 25 editions of a Portuguese magazine dedicated to Smart Cities. This data source allows studying the evolution of the subject based on the analysis of the direct stakeholders' contributions over the past years. In addition, were conducted interviews with Portuguese policymakers and a Secretary of State with two main objectives. First, realize the existing challenges for the implementation of a Smart City. Second, understand the role and support of a sovereign body, in this case, the government. It was found discrepancies within the territory and the dependency on European funds to promote Smart City initiatives. **Chapter 4** presents more detail about this topic.

On top of this, interviews with Portuguese policymakers were performed to highlight the existing gap about standard approaches, complemented by an interview with a Secretary of State to acknowledge the role and positioning of sovereign bodies. On the other hand, a focus group is undertaken with Smart City experts to discuss the actions that policymakers must consider in each step of implementing a Smart City strategy. The steps that ground the discussion are based on a thematic analysis performed to existing frameworks in the literature and matched within the Plan-Do-Check-Act (PDCA) cycle. Moreover, it was developed 12-step guidelines divided in 4 phases, with more details in the **Chapter 6**.

Moreover, while consumers demand is pushing for real-time fulfilling, logistics resources are putting pressure on the last-mile. Covid-19 pandemic exposed the inefficiency of traditional supply chains to fulfill citizens needs and accelerated the necessity to re-think cities. Empirical clues were given to the relationship between Smart Cities and the Industry. This evidence led to the deepening of the topic with the main objectives of conducting a systematic review of the literature on the relationship between the two subjects, understanding which were the main points of connection and uncovered literature.

Furthermore, it pushed this research to cross literature and find how Smart Cities influence or are influenced by the development of the Industry, which is directly related to the 4th Industrial Revolution. A rigorous systematic literature review, based on the PRISMA guidelines, analyzes the full text of 42 papers. Quantitative and qualitative analyses are performed. A bibliometric analysis provides information about the age, authors, publishers, sources, and keywords. An inductive thematic analysis develops codes and themes according to the contribution of each paper to aggregate the information and find connections between the concepts. More details about this topic can be seen in **Chapter 11.**

In addition, subjects related to Logistics, Manufacturing and Supply Chain were reviewed. Although it was theoretically notorious that the Industry was striving to allow citizens to personalize products and delivery services, it lacked empirical evidence. The study of 74 Portuguese e-commerce companies performed in **Chapter 12** noted that was not possible for citizens to choose the products' specifications and the exact day and hour they would like to receive the goods.

This evidence inspired further developments, where a framework was developed based on the 5W1H (what, who, where, when, why, how) methodology to set up a supply chain. The goal was to promote the integration and collaboration of stakeholders to answer a specific request. Moreover, since it was noted an evolution to base the supply chain according to the behavior of citizens, assisted by artificial intelligence and deep learning techniques, a reflection emerged about the future of the industry and how the traditional supply chain could keep with future demand **(Chapter 13).**

Thus, last-mile innovative models are emerging. From a sample of 50 products in Alibaba, the minimum quantity order was selected. Data were collected regarding the product's price, its shipping cost, and the lead time and shipping time. Three structured interviews were conducted to build a case study where their collaboration could contribute to organizing a personalized response to local consumer's requests. As a result, it was possible to design a local collaborative model that allowed any company to provide personalized services to their clients in any territory. The innovative concept to disrupt the supply chain is explained in **Chapter 15.**

At this stage, based on current events, such as the Ever-Given blockage on the Suez Canal, it was clear that it lacked urban planning mechanisms and disruptive proximity logistics models to bridge the existing gap to fulfill citizens' needs while promoting cities' sustainability by reducing the number of circulating vehicles and their traveled distances.

Furthermore, through a questionnaire to 285 policymakers recognized the importance to have a tool that enables real-time visualization for placing provisional means (delivery and storage) for the supply of goods. Therefore, a group of experts was joined to discuss the foundations of this tool. Moreover, it shall consider collaborative logistics, contemplating micro logistics operators, flexible and multi-modal modes of transportation, stock storage within the last-mile, the territory's geography, and have the capacity to forecast citizens' needs. Thus, based on the analysis of (historical) data and the use of clustering and stock management rules, it was possible to develop an open tool capable of, for example, conceptualizing an operation to combat the isolation of citizens or identify the storage locations of essential goods for the purpose of extreme events or natural disasters. The foundations of this tool are detailed in **Chapter 14.**

Figure 1.4 helps realize the research path performed throughout the years and the positioning of the next chapters within the historical research framework.

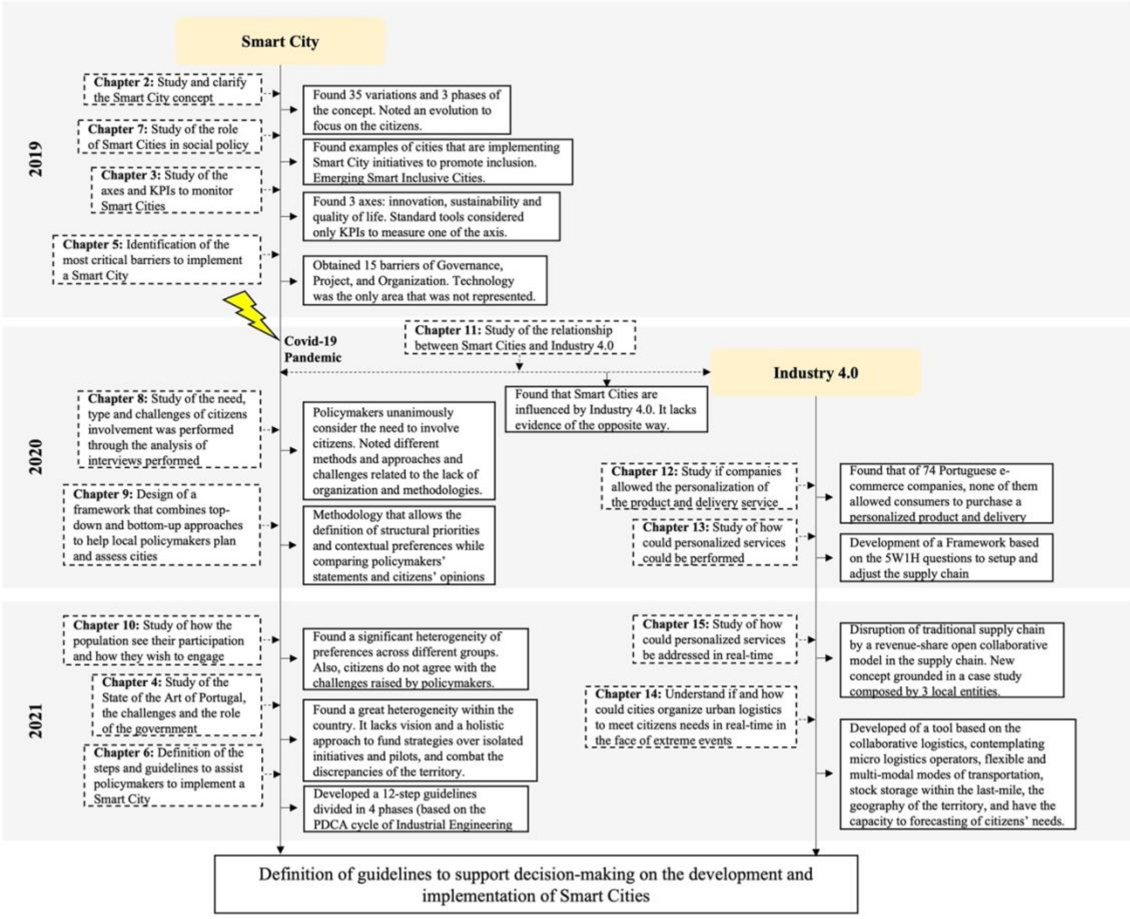


Figure 1:4 Historical perspective of the research journey

1.5. Thesis' Structure

The present thesis is structured in five parts and consists of sixteen chapters. The structure is summarized as follows:

- Part I – Introduction;
- Part II – Strategic planning and urban development (Scientific documents);
- Part III – Participation and Inclusion (Scientific documents);
- Part IV – Industry and urban logistics (Scientific documents);
- Part V – Conclusion.

Parts II, III and IV, corresponding to chapters 2 through 15, compose the core of the research with fourteen scientific papers, including nine articles, four conference papers, and one international book chapter. All sources where scientific documents (article and conference papers) were published and/or submitted for publication are indexed in the main databases (Scopus and/or Web of Science).

Thus, these three parts reflect the answers to the gaps mentioned above about, i.e. (i) the lack of Strategic Planning of Smart Cities, (ii) the lack of participatory methodologies, and (iii) lack of urban logistics organization.

Each chapter ends the respective reflection by proposing frameworks and concrete guidelines to fill the existing gap. Figure 1.5 reflects the organization of the scientific documents, the parts and chapters.

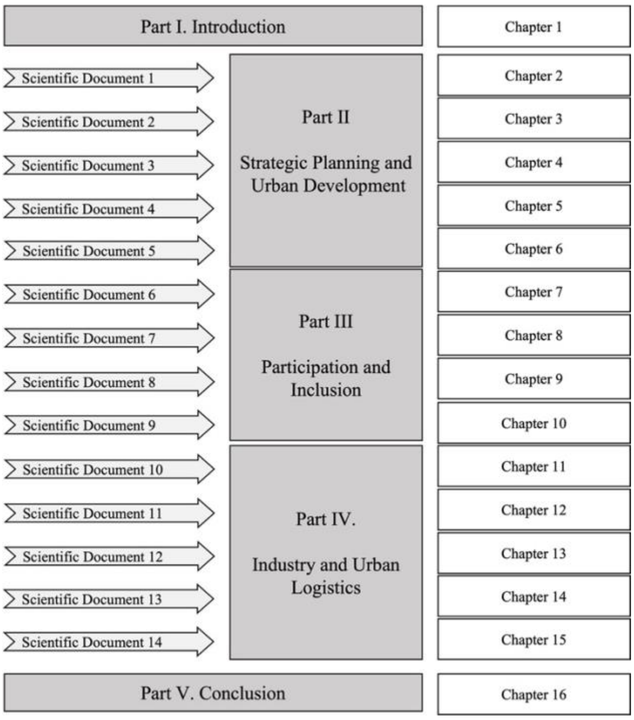


Figure 1:5 Overview of the thesis' structure

A tendency was noted about the Smart City concept include citizens' participation, while Industry had a vital role in the technologies and dynamics implemented in Cities that truly impacted urban pressure and its sustainability.

Since there has not been considered an accepted and widely adopted definition of Smart Cities, the standardization of approaches to design a Smart City strategy has been challenging for policymakers. Moreover, **Part II** includes the papers that review the literature of Smart Cities and propose a unified view as well as the respective guidelines to implement a Smart City.

Part III aimed to understand the role of the citizens and how they could be engaged. This part comprises the articles that study the perception of policymakers and the confrontation with the citizens view about their current inclusion.

The fragility of the supply chain noted by the Covid-19 pandemic and the blockage of the Suez Canal is answered on **Part IV**, where the produced works aimed to design innovative logistics models to meet citizens needs and help policymakers organize urban logistics accordingly to face extreme events.

Figure 1.6 summarizes the frame of the Chapters and gives an overview of the constituting Parts and their relationships within the structure of this thesis.

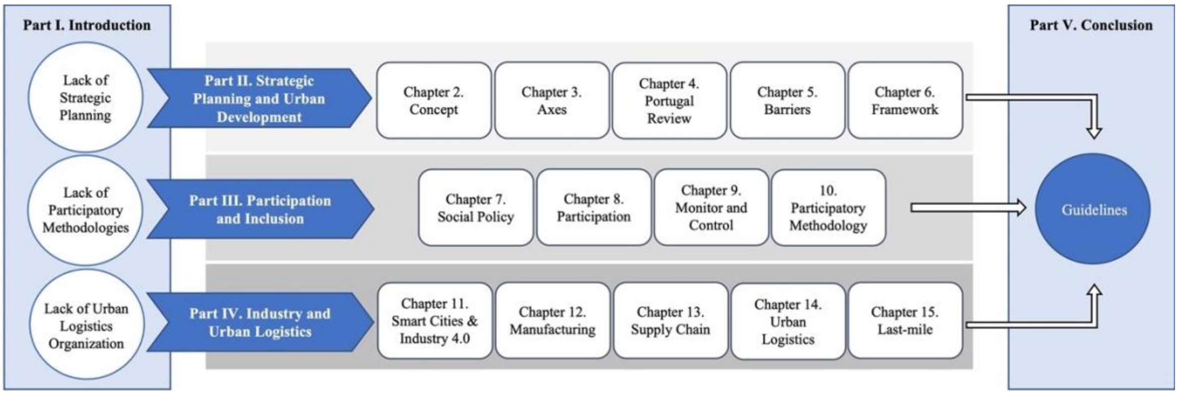


Figure 1:6   Detailed scheme of the thesis' structure

Part I – Introduction includes **Chapter 1**, which corresponds to the relevance and contextualization of the thesis, objectives, methodology and structure. It is divided into five subsections addressing relevance and context (subsection 1.1), the study's gaps and motivation (subsection 1.2), a literature review of the state of the art and related work to highlight the main concepts and topics underlying the thesis (subsection 1.3), the methodology adopted in the thesis (subsection 1.4) and, finally, the thesis structure (subsection 1.5).

Part II – Strategic Planning and Urban Development, comprises **Chapters 2**, **3**, **4**, **5** and **6**, which aim to review the Smart City literature about the concept historical evolution and foundations and the barriers and challenges to implementing a Smart City. The findings will base empirical research to give policymakers guidelines to establish a Smart City strategy ultimately.

Chapter 2 details the evolution of the concept, highlights the associated meanings and terms and proposes a common understanding of the Smart City concept. Although different understandings of Smart Cities had emerged, the evolution is noticeable. The role of citizens has changed to co-creators.

After analyzing different studies in the literature, the lack of a holistic understanding of the KPIs and axes that should ground a Smart City was noticed. **Chapter 3** reviews the foundations that ground the concept to establish its axes.

The evolution of the concept has not been noticed equally throughout countries and their territories. The lack of examples of Smart City initiatives and sharing of best practices in Portugal confirmed the gap in the transference of empirical knowledge and success cases to the scientific literature in this area. **Chapter 4** aims to detail the state of the art of Smart Cities in Portugal by studying the existing initiatives and players complemented by the opinions of Portuguese Policymakers and Secretary of State about the existing challenges and role of the Government. Therefore, the analysis of a secondary data source was considered to provide historical information to portrait the actual state of the art of Smart Cities in Portugal.

Chapter 5 aims to find and characterize the (critical) barriers that have associated a significant influence on the success of a Smart City implementation and are within the control of policymakers. Moreover, it studies the barriers according to their impact to oppose to the development of a Smart City, the capacity of decision-makers to overcome them and the timespan they can do it

Finally, **Chapter 6** proposes a framework inspired by the PDCA cycle to guide and support policymakers on the design and implementation of a Smart City. Moreover, it develops a flexible, participatory framework to define a roadmap with concrete actions considering policymakers strategic goals and the relationship with the initial city stage.

Part III – Participation and Inclusion, comprises **Chapters 7**, **8**, **9**, and **10**, which cross social policy and development geography literature to ground Smart Cities reflection about the development of participatory methodologies based on the engagement guidelines obtained through empirical research. Since the understanding of Smart Cities may differ from territories and communities, the evaluation of cities development and their comparison shall be based on the combination of top-down and bottom-up approaches considering citizens preferences and given importance.

Elements can inform the embracement of the language of inclusion of the literature of social policy. Moreover, a reflection of how Smart Cities can act as social policy actors by promoting technologies that fill the isolation gap was performed in **Chapter 7.**

Chapter 8 found the lack of participatory methodologies to include citizens in the decision-making process. Furthermore, it explored the role of citizens in policymaking by using the knowledge from development geography.

Chapter 9 proposes an approach to fill the existing gap of bottom-up approaches, assisting decision-makers with a methodology to monitor, measure and compare their performance, and to select relevant initiatives defining an operational action plan to achieve their goals. Moreover, cities can be compared based on standard KPIs, while defining specific goals based on the citizens' preferences. This will also allow different understandings of the Smart City concept throughout territories.

Chapter 10 studies how the general population and specific groups (concerning age, gender, and educational attainment) see their participation and how they wish to engage. Furthermore, propose guidelines according to the significance of the results.

Part IV – Industry and urban logistics, comprises **Chapters 11**, **12**, **13**, **14**, and **15**, where Industry 4.0 literature is integrated into the present research to review the development of Industry and study how can innovative logistics models contribute to implementing a Smart City and organize resources in real-time.

Smart Cities evolved to include citizens as co-creators. On the other hand, Industry 4.0 enhances personalized supply chain models arranged according to citizens' wishes. The similarities between Smart Cities and Industry 4.0 deserve further study. **Chapter 11** performs a systematic literature review of the subjects.

Although the Industry strives to allow a comfortable and personalized experience to citizens, **Chapter 12** performed an empirical study. The flexibility of orders in terms of product and service personalization is still a gap in the current market. Delivery is still arranged separately from manufacturing and order's management. Moreover, new logistic models are needed to achieve this paradigm while promoting sustainability.

Chapter 13 highlights the need to promote the interoperability and integration of stakeholders to create a self-organizing omnichannel. It proposes an adapted framework from the 5W1H (Who, Why, What, Where, When, and How) quality management methodology to organize the supply chain based on the citizens' personalized inputs.

Urban planning shall share the created omnichannel to respond to extreme events such as a new pandemic. A questionnaire revealed that although policymakers are confident about their capacity to organize urban logistics, they still lack tools to support real-time decision-making. **Chapter 14 d**evelops a tool to help decision-makers guarantee that all citizens' needs are fulfilled within a timeframe of 15 minutes by placing shared mobile storage points close to citizens while allowing smooth and non-polluting transportation modes to deliver the goods.

Chapter 15 realizes that the traditional supply chain will not keep with the future demand. Therefore, the supply chain will be disrupted by introducing new last-mile concepts, allowing any entity to use a marketplace created by multiple local stakeholders to allow the manufacturing, storage, and delivery of products in real-time, in any region.

Table 1.2 summarizes the references of the papers that constitute each chapter.

Table 1:2 References of the produced scientific documents

Chapter	Reference
2	**Correia, D.**, & Teixeira, L. (2022). From Smart City 1.0 to Smart City 3.0: Deep Understanding of the Smart Cities Concept and Evolution. In D. Buhalis, B. Taheri & R. Rahimi. *Smart Cities and Tourism: Co-creating experiences, challenges and opportunities* **(In press)**.
3	**Correia, D.**, Teixeira, L., & Marques, J. (2020). Triangular Pyramid Trunk: The Three Axes of the Smart City Assessment Tool. *WIT Transactions on Ecology and the Environment*, 241, 79–90. https://doi.org/10.2495/sdp200071
4	**Correia, D.**, Teixeira, L., & Marques, J. (2021). Reviewing the state of the art of Smart Cities in Portugal: evidence based on content analysis of a Portuguese magazine. *Publications*, 9(4), 49; https://doi.org/10.3390/publications9040049
5	**Correia, D.**, Teixeira, L., & Marques, J. L. (2022). Investigating Smart City Barriers: Contribution of Experts based on a Delphi Analysis, *Spatial Planning and Development*, 10(2), 179–199. https://doi.org/10.14246/irspsd.10.2_179
6	**Correia, D.**, Marques, J. L., & Teixeira, L. (2022). Co-creation of a Smart City strategy: A decision support framework based on the PDCA cycle. *Systems and Information Technology*.
7	**Correia, D.**, & Feio, J. (2020). The Smart City as a Social Policy Actor. In International Conferences ICT, Society, and Human Beings. In *Proceedings of the 13th IADIS International Conference ICT, Society and Human Beings 2020*, pp. 236 – 240. https://doi.org/10.33965/ICT_CSC_WBC_2020_202008C031
8	**Correia, D.**, Feio, J., Teixeira, L., & Marques, J. (2021). The Inclusion of Citizens in Smart Cities Policymaking: The Potential Role of Development Studies' Participatory Methodologies. In N. Streitz & S. Konomi (Eds.), *Distributed, Ambient and Pervasive Interactions. Springer Nature* Switzerland AG. https://doi.org/10.1007/978-3-030-77015-0_3
9	**Correia, D.**, Marques, J., & Teixeira, L. (2022). City@Path: A Collaborative Smart City Planning and Assessment Tool. *Transport Development and Integration, WiT Press*, 66–80. https://doi.org/10.2495/TDI-V6-N1-66-80
10	**Correia, D.**, Feio, J., Marques, J. L. & Teixeira, L. (2022). Participatory methodology guidelines to promote citizens participation in decision-making: evidence based on a Portuguese case study. *Cities.*
11	**Correia, D.**, Teixeira, L., & Marques, J. (2022). Study and analysis of the relationship between Smart Cities and Industry 4.0: A systematic literature review. *Technology Management & Sustainable Development.*
12	**Correia, D.**, Teixeira, L., & Marques, J. (2021). The Hourglass Model: From Consumer's Behavior to Delivery. *Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management (IEOM)*, Singapore, March 9-11, 2021.
13	**Correia, D.**, Teixeira, L., & Marques, J. (2022). Smart Supply Chain Management: The 5W1H open and collaborative framework. *IEEE International Conference on Industrial Engineering and Applications, ICIEA 2021*, Kyoto, April 23-26, 2021. https://doi.org/10.1109/ICIEA52957.2021.9436817
14	**Correia, D.**, Vagos, C., Marques, J., & Teixeira, L. (2021). Logistics 4.0 applied to Urban Planning: last-mile fulfillment for sustainable and inclusive Smart Cities. *Logistics.*
15	**Correia, D.**, Teixeira, L., & Marques, J. L. (2021). Last-Mile-as-a-Service (LMaaS): An innovative concept for the disruption of the Supply Chain. *Sustainable Cities and Society*, 103310. https://doi.org/https://doi.org/10.1016/j.scs.2021.103310

Finally, **Part V** presents the general conclusions and highlights the findings with main theoretical and practical contributions are summarized. The limitations of this research are also pinpointed, as well as a brief reflection on the further studies.

Part II

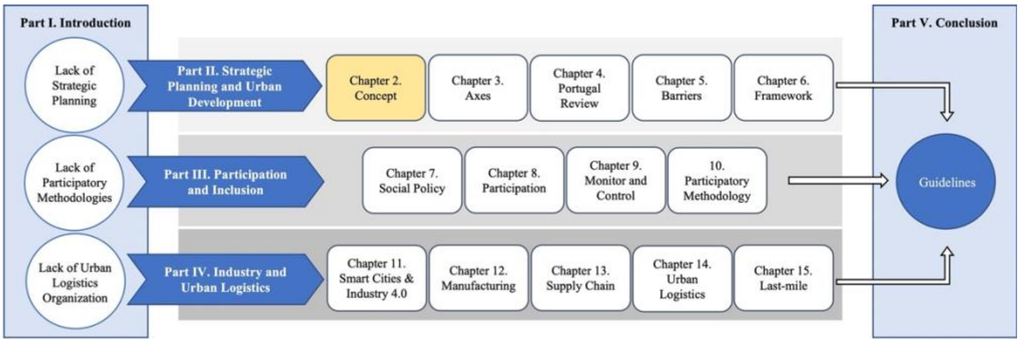
Strategic Planning and Urban Development

Chapter 2

From Smart City 1.0 to Smart City 3.0: Deep Understanding of the Smart Cities Concept and Evolution

Reference

Correia, D., & Teixeira, L (2022). From Smart City 1.0 to Smart City 3.0: Deep Understanding of the Smart Cities Concept and Evolution. *In D. Buhalis, B. Taheri & R. Rahimi. Smart Cities and Tourism: Co-creating experiences, challenges and opportunities* **(In press)**.



2. From Smart City 1.0 to Smart City 3.0: Deep Understanding of the Smart Cities Concept and Evolution

Abstract

The Smart City concept emerged in the 1990s, and after three decades of existence, it is still an ambiguous term. The concept evolved from an initial focus on Information and Communication Technologies (ICTs) to people's well-being and social, economic, and environmental sustainability. Nowadays, it is focused on co-design and co-creation. Since there has not been one widely accepted definition adopted by academia, several variations emerged, making standardization and implementation complicated tasks. In total, there are more than 30 variations of the Smart Cities concept in the literature. Moreover, the fact that there is not yet a clear Smart Cities definition is a gap this paper explores. Therefore, after providing a narrative literature review of the concept's evolution, this paper enunciates the existing variations, underlining how they differ, and proposes a standard understanding of the Smart City concept.

Keywords: Smart City; Concept Evolution; Co-creation & Co-design; Sustainability; People; Technology.

2.1. Introduction

The mobilization of people led cities to rapid growth within a short period. This paradigm brought several issues since cities were not prepared to face the worldwide migration to urban centers. Streets have not grown because of this quick urbanization; green parks have not extended, and city boundaries were kept in the same place. Therefore, cities had a considerable challenge in their hands, i.e., to adapt themselves with no chance to modify their urban structure. Smart Cities emerged to answer these challenges.

In the 1960s emerged the "informational or cybernetically planned cities". In the 1980s, technologies were sought to promote "computable or networked cities" (Gabrys, 2014). In the 1990s, the Smart City concept was associated with information and communication technologies (ICTs) for the first time, expecting them to be in the center of urban management (Aurigi, 2006; Bastelaer, 1998; Gibson, D. V., Kozmetsky, G. and Smilor, 1992; Graham & Aurigi, 1997; Tan, 1999).

Until 2010, the number of Smart City studies reported in the literature was scarce. Only after the emergence of the Smart City projects supported by the European Commission, a proliferation of writings and academic publications on the topic was noted (Jucevičius, Patašienė, & Patašius, 2014). From then onwards, the Smart City expression started to be widely adopted. Moreover, Figure 2.1 portrays the search results of "Smart City" or "Smart Cities" expressions from Scopus.

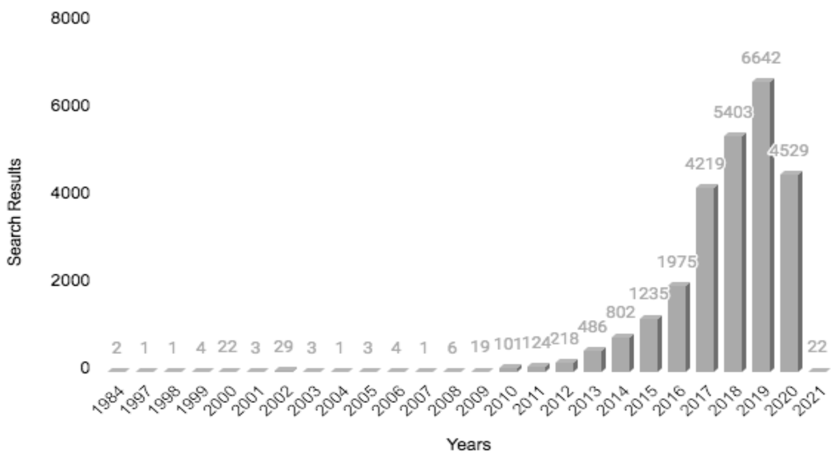


Figure 2:1 Scopus Search Results for "Smart City" or "Smart Cities"

It is apparent in the literature that the concept has been evolving. It is no longer in the first stage where technology companies led research and cities' transformation. Moreover, the focus changed from technology diffusion to meet corporate and economic interests to break silos and focus on people, governance, and policies (Robert et al., 2017). Simultaneously, citizens passed from a passive role to urban development and planning co-creators (Mainka et al., 2016).

Based on a narrative literature review, this paper details the evolution of the concept, highlights the associated meanings and terms, and proposes a common understanding of the Smart City concept.

2.2. Theoretical Background: Smart City Concept Evolution

In the beginnings of the Smart City concept, it was common to associate it with a futuristic city, where technology would be predominant. It is a fact that technology is ever more present in our daily lives. However, what seemed to be a movement to implement technology without any plan quickly changed to a problem-solving ideology.

The first Smart City stage – Smart City 1.0 – was seen as the possibility of providing citizens with information and services via the integration of Information and Communication Technologies (ICT) into the city’s infrastructure. It was provided a techno-centric interpretation of cities, where ICTs were the goal and not the mean (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017).

Cities realized that the vision led by technology companies lacked in the context. Municipalities’ budgets served to test and develop solutions in laboratories and closed rooms, unrelating them to citizens’ real needs. The lack of policymakers’ knowledge to realize cities as open and interoperable systems and the political wish for quick news led them to become dependent on proprietary technological solutions. Over time it created a dependency on private companies, not allowing cities to integrate other stakeholders and systems into their strategy and infrastructure.

After Hollands (2008) criticized cities for not contemplating the people, the concept started to strive for human and social capital (Caragliu, del Bo, & Nijkamp, 2009). Smart City's understanding was inflicted because of the world's financial crisis and population acknowledgment of the global warming effects. These extreme events emerged concerns regarding sustainability and citizens’ quality of life. United Nations' Sustainable Development Goals, and the Green Deal, brought cities a decarbonization mindset, adopting green and sharing-based policies focused on citizens’ quality of life (European Commission, 2019; UN, 2018).

The transition period from the Smart City 1.0 to the Smart City 2.0 between 2008 and 2012 is notorious. The focus shift from “What” to “Why”, from technology to its purpose, from only hardware and software development to answering people’s needs. Thus, it evolved to the understanding of a Smart City as a city that crossed traditional infrastructure with ICTs to collect real-time data and optimize services by integrating and analyzing the information. ICTs turned to be seen as a mean and not an end in itself (Nam & Pardo, 2011).

Recently, due to the emergence of social networks and the constant criticism that policymakers face, they start to perceive the need to design thinking and participatory development methodologies. The emergence of the smartphone and technologies capable of providing citizens with the chance to be more active, reporting real-time occurrences at a distance of one click, and being more informed about the decision-making processes increased the scrutiny of the decisions taken by policymaking. Therefore, municipalities began to involve citizens from the design phase.

Moreover, the concept evolved to the Smart City 3.0, developing collaborative cities in a co-creation perspective (Cohen, 2015). Smart City initiatives are no longer just for the citizen but created with the citizen. It led to adding a new dimension, "co-creation", to the previous ones: technology, people, and sustainability. After 2014, the citizens' role moved to active contributors of the city's strategy, empowering them to be part of the co-creation process at the different stages and enhancing the participatory engagement (Correia & Feio, 2020). Co-creation was first seen as a way for citizens to collaborate with cities to solve specific urban environment issues (Choque, Diez, Medela, & Muñoz, 2019). Then moved to a participatory approach involving citizens and other stakeholders in design thinking. Table 2.1 states and summarizes the evolution of the Smart City concept.

Table 2:1 The three Smart City stages

Stage	Concept	Sources
Smart City 1.0	A city that uses ICTs to collect data to improve its critical infrastructures and services' efficiency.	(Hall, Bowerman, Braverman, Taylor, & Todosow, 2000; Harrison et al., 2010)
Smart City 2.0	A city that starts with the human capital, motivating citizens to create and flourish their lives, using ICT to increase the quality of life and the city's social, economic, and environmental sustainability.	(Ahvenniemi et al., 2017; Angelidou, 2014; Barrionuevo, Berrone, & Ricart Costa, 2012; Caragliu et al., 2009; T. Chen, 2010; Hollands, 2008; Mohanty, Choppali, & Kougianos, 2016; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Rios, 2008)
Smart City 3.0	A city that uses ICT to promote citizen engagement and active participation, allowing continuous interactions, where the strategy is collaboratively created with them and relevant stakeholders.	(Albino, Berardi, & Dangelico, 2015; Trivellato, 2017; Van der Graaf & Veeckman, 2014)

2.3. Methodology

Smart City is an ambiguous concept. Many researchers have discussed its understanding and proposing several definitions (Batty et al., 2012; Bibri & Krogstie, 2017; Hollands, 2008; Nam & Pardo, 2011; Venkat Reddy, Siva Krishna, & Ravi Kumar, 2017).

Narrative literature research was conducted to find and study the variations of the Smart City concept. Two phases were considered. The first aimed to collect as many variations of the concept as possible. In the second phase, each variation was analyzed to understand its specific meaning and relation to the Smart City concept.

Moreover, the review of definitions was handled via Scopus using the combinations of the keywords “smart”, “cit*”, “concept”, and “definition”. From this search, about 4000 papers were obtained. From these, 600 abstracts were read and, 250 of those deserved a more in-depth analysis. Additionally, through forwarding and backward citation tracking and analysis, other related variations of the concept were possible. Every term was taken into consideration. The understanding of each variation was translated in a sentence and was performed a thematic analysis to associate with the respective Smart City stage and focus. The ones which could be identified as having a specific meaning associated with the topic were included in Table 2.2. The others where the definition was not evident deserved a brief mention after Table 2.2. Each concept could have different understandings due to its evolution over the years. This study considered the most up-to-date and closely matched the Smart Cities subject, providing a better input for the discussion.

2.4. Results and Discussion

2.4.1. Variations of the Concept within the three stages

Several authors distinguish a Smarter City from Smart Cities due to the magnitude of ICT embedded in urban systems. A city that integrates advanced IT infrastructure and several information services into urban space for urban planning to improve efficiency, sustainability, equity, and livability (Bibri & Krogstie, 2017; Gangdo, Yazici, Ozguner, & Jinho, 2008). Ubiquitous cities or u-cities are seen as a step forward Smart Cities and the evolution of Digital Cities, considering embedded sensors and interconnected smart devices (Anthopoulos & Fitsilis, 2010). The word ‘ubiquitous’ means to be everywhere at the same time. Therefore, a ubiquitous city allows to access and manipulate information anytime, anywhere, enabling efficient urban management (Cho, Cho, & Park, 2007).

Ambient cities come from the expression “ambient intelligence” (Valigra, 2002). Ambient intelligence is the information given by devices about the surrounding environment, such as people’s names and directions. Cities are gaining a new layer of driven by data stakeholders as sentient beings (Shepard, 2011). They can produce a certain level of transference knowledge through correlation and measurement (Thrift, 2014).

Digital cities combine ICT with a flexible service-oriented infrastructure based on open standards to cover local needs and connect the community, enabling high-speed communication to access information and public services (Anthopoulos & Fitsilis, 2010; E. Ergazakis, Ergazakis, Askounis, & Charalabidis, 2011; Nicos Komninos, 2011; Yovanof & Hazapis, 2009).

The ability to support learning, technological development and innovation procedures differs from digital to intelligent (Nam & Pardo, 2011). An Intelligent City combines digital telecommunication networks, embedded sensors and software, connecting the local community and striving growth, efficiency, productivity, and competitiveness (N. Komninos, 2013; Nicos Komninos, 2009; Mitchell, 2007; Yovanof & Hazapis, 2009).

New technologies and their applications are building new types of urban economy (M. E. Hepworth, 1990). Information technologies have a recognized vital role in supporting economic growth (Newstead, 1989). Aligned with the information revolution, Information Cities are digital environments that collect local community data and make it public via web portals (Anthopoulos & Fitsilis, 2010). They are characterized by two dimensions: a metropolitan economy specialized in production, processing and distribution of information, and a dominant computer and telecommunications' infrastructure (Mark E. Hepworth, 1987).

Sensing Cities use remote sensing techniques and geospatial big data to have a more accurate portrait of city's details, as socio-economic properties based on the activities and movements of residents (Zhu, Wang, Wu, & Liu, 2017).

Virtual cities were born as 2D image maps representations of the city, built up with input data that allows the simulation and modelling of urban developments (Liu & Phinn, 2003; Parish & Müller, 2001). Furthermore, the computational power and communication bandwidth (Ishida, 2002) allows a user interface to the services at home through an accurate 3D model of the city (Linturi, Koivunen, & Sulkanen, 2000).

Contrary to Virtual Cities, Cyber cities do not aim at simulation or modelling but provide a virtual space for city management and control over the urban space (Nicos Komninos, 2011).

E-cities or Electronic Cities provide civic services 24/7 to citizens through ICTs (Tohidi & Jabbari, 2011). E-cities platforms merge e-government and e-planning (Curwell et al., 2005).

Urban development is increasingly seen as technological-based projects and less an architectural debate. Thus, Networked cities are shaped based on data and digital communication of how the city is used and experienced (Sneve Martinussen, 2013). Infrastructure technologies are at the center of technological design and cities' morphology (Monstadt & Schramm, 2017).

With the placing of ICTs into the urban furniture and providing platforms for citizens to give feedback or identify occurrences in the city, cities have become active beings by gathering real-time data from multiple sources and streams. This has allowed cities to build control centers where data is analyzed and actions are taken accordingly, instantaneously (Townsend, 2000).

Innovative Cities are competitive urban areas whose focus is on innovation. How can cities differentiate themselves by adopting policies to combat urban complex problems while keeping or increasing economic growth and wealth creation (Hospers, 2008; Marceau, 2008). Innovation chains are usually under a regional innovation system located in larger cities, attracting the most important companies and centers of investigation primarily due to economic issues (Scheel & Rivera, 2013). Thus, it is usual to see them as innovative cities since usually they are the first receivers of new products and services (S. Chen & Karwan, 2008; Isaksen & Aslesen, 2001).

The proper connection, balance and interaction of the real and virtual worlds create Hybrid Cities (N. Streitz, 2019; Trachana, 2014), where 3D virtual city models and physical reality are closely linked (N. A. Streitz, 2011; Ylipulli, Kangasvuo, Alatalo, & Ojala, 2016).

The usage of ICTs used to provide services to households and businesses is known as Wired Cities (Targowski, 1990). Wired Cities evolve to Wireless cities. These are constituted by wireless infrastructure technologies (such as Wi-Fi, WiMax, and Mesh networks) to make Internet access available to all residents, solving the limitations of wired technologies (Y. T. Chen, 2007; Ganapati & Schoepp, 2008; Hampton & Gupta, 2008; Wang et al., 2016).

Mobile cities are associated with mobile devices and the applications created by developers to enhance life in the city, providing new services and facilitating access to information (Walravens, 2012).

The absence of creative members may explain the lack of the city's success in thinking on creative policies to achieve urban development (Peck, 2005; Vanolo, 2015). Creative Cities define strategies for economic growth and urban revitalization together with local communities. Moreover, they look for interactions with artists, for example, to provide innovative and creative solutions to solve the everyday cities problems, and creating conditions for the emerging creative class (Boulton, Brunn, & Devriendt, 2011; Comunian, 2011; Ponzini & Rossi, 2010).

The involvement of stakeholders (university, city administration, the learning providers) and the encouragement of citizen participation placing innovation and learning at the center builds a Learning City (Juceviciene, 2010; Longworth, 2006).

As the name suggests, Humane City empowers citizens to be in the loop of city decisions fostering a creative and inclusive society with a high quality of life (N. A. Streitz, 2011).

Knowledge cities are integrated cities focused on knowledge economy and human capital enrichment (De Jong, Joss, Schraven, Zhan, & Weijnen, 2015). Cities designed to encourage the nurturing of knowledge and investing in education, training, and research (K. Ergazakis, Metaxiotis, & Psarras, 2004) play a fundamental role in knowledge creation, economic growth and sustainable development (Yigitcanlar, O'Connor, & Westerman, 2008).

The concept has strived to focus on optimizing services and infrastructure, reducing resource demand, providing a better quality of life and promoting city's sustainability (Rogers & Gumuchdjian, 1998).

Moreover, Sustainable cities aim to balance the development of urban areas, environmental protection with economic aspects (e.g. income and employment), and social infrastructure and services (Hiremath, Balachandra, Kumar, Bansode, & Murali, 2013). A sustainable city must encourage social interaction with appropriate walking, cycling, and efficient public transport (Elkin, McLaren, & Hillman, 1991).

The term Sustainable Cities evolved to Smart Sustainable Cities, which can be described as cities that are supported by ICT whose focus is on meeting the needs of citizens without compromising the needs of future generations (ITU, 2015).

Green cities are aligned with the 90s green urbanism conceptual model, which promotes zero-emission and zero-waste urban design to social and environmental sustainability (Lehmann, 2010). The green cities concept emphasizes on greenhouse gases emissions (Sahni & Aulakh, 2014).

The return to a lifestyle in harmony with nature created Eco-cities, where urban planning is based on the next generation of infrastructures and environmentally friendly buildings (De Jong et al., 2015). Kenworthy (2006) defines 10 critical dimensions for eco-cities from the efficient usage of land and protection of environment to the reliability of city spaces and urban design, based on democratic behaviors.

Behind Compact Cities are ideas that stand out to find sustainability through processes that intensify cities' development and revitalize more people (Yang, 2003). Oppositely to urban sprawl, it promotes community-oriented social patterns (Neuman, 2005). Smart Growth is an economic development path where growth is balanced with social inclusion and the careful use of natural resources. It is sometimes associated with compact cities (Artmann, Kohler, Meinel, Gan, & Ioja, 2019).

As a direct response to climate change, the low carbon city (and its variants 'zero carbon city', and even 'negative carbon city') whose focus is on minimizing the "human-inflicted" carbon footprint by reducing or, in the best scenario, eliminating, the use of non-renewable energy resources (De Jong et al., 2015). Moreover, it is a city that takes green practices to avoid the adverse impacts on climate change, promoting a high quality of life (Sahni & Aulakh, 2014).

The ideal state of a low carbon city is a Zero Carbon City (or Carbon Neutral) whose aim is to become a zero-emission city. The management principles in sustainable urban planning are to reduce CO_2 and greenhouse gases, minimizing City's fossil fuel (Kennedy & Sgouridis, 2011).

The resiliency of cities is related to the disturbance they can absorb (integrity), its self-organization (coordination), and the capacity to learn and adapt (self-improvement) in a local environment (Desouza & Flanery, 2013). In addition, Resilient Cities are sustainable networks of physical systems and human communities capable of withstanding an extreme event (Godschalk, 2003; Jabareen, 2013).

Livable or Living Cities express a desire to have a city where citizens enjoy high living standards to attract stakeholders (Mase, 2012).

A city that uses technology to solve social and business need to reinvent cities to develop economy and society to benefit citizens are associated with the term Smart Community (Eger, 2009).

The focus of Inclusive Cities is on the social capital of urban development, whether by promoting inclusion in public services or involving citizens in co-designing (Paskaleva, 2011).

There's the belief that making data available will lead to more effective public oversight (Fox & Pettit, 2015). Open city (open governance) is related to the open data that city makes available for the stakeholders and how the city evolves citizen engagement and participation (Degbelo et al., 2016).

A growing body of literature is emerging arguing that cities' goal is citizens happiness. Happy cities promote citizen engagement in planning and decision-making, empowering them to participate and follow up the implementation of the project (Costa, Machado, & Gonçalves, 2019; Kamel Boulos, Tsouros, & Holopainen, 2015).

In summary, as mentioned before, while in the first Smart City stage the focus was on technology, the second was on people and sustainability. In the third stage, the focus is on co-creation and co-design. Table 2.2 summarizes and aggregates the variations of the literature organized through the three stages.

Table 2.2 corroborates Smart City's initial focus. The embeddedness of technologies and devices into the urban space enabled anyone to access and exchange information at any place and time. Over the years, 2D and 3D digital and cyber tools were made available for policymakers' visualization and simulation.

The technical improvements were accompanied by social concerns reflected in the "Creative City", "Humane City", "Knowledge City" and "Learning City" understandings, which pushed for the involvement of the community. The emerging variations of the Smart City concept also helped to understand its proper evolution. The efficiency of services and infrastructures, reducing resource demand to promote city's sustainability, and combat climate change is patented in the variations that constitute the "Sustainability" phase.

Table 2:2 Smart City concept variations

		Variation	Focus	Sources
Smart City 1.0	Technology	Cyber City	3D virtual model space using ICT as preconditions of practical action and city control	(Nicos Komninos, 2011)
		Digital City	Municipal ICT infrastructure that connects the community and enables access to public services	(Yovanof & Hazapis, 2009)
		E-city or Electronic City	Presenting different civic services 24/7 using ICT	(Tohidi & Jabbari, 2011)
		Hybrid City	The intersection of the virtual with the physical reality	(N. Streitz, 2019)
		Information City	Process and distribution of information through web portals	(Anthopoulos & Fitsilis, 2010)
		Innovative City	Focus on innovation	(Scheel & Rivera, 2013)
		Intelligent City	ICTs and people together to enhance the innovation, learning, knowledge, and problem solving	(Nicos Komninos, 2009, 2011)
		Mobile City	Mobile devices and applications for the provision of services and access to information	(Walravens, 2012)
		Networked City	Technological design and morphology of cities integrated and ordered by infrastructure networks	(Monstadt & Schramm, 2017)
		Real-time City	Real-time actions supported by control centers	(Kitchin, 2014)
		Sensing City	Data collection to provide a portrait of the city's details	(Zhu et al., 2017)
		Sentient City	Cities able to produce some level of transference through correlation and measurement	(Shepard, 2011)
		Ubiquitous City	Devices interconnected, enabling anyone in any place with any device at any time do anything desired	(Anthopoulos & Fitsilis, 2010)
		Virtual City	A user interface to the services through a real 3D model of the city	(Linturi et al., 2000)
		Wired City	Use of computer and communications (C&C) technology for the provision of services	(Targowski, 1990)
		Wireless city	Wireless infrastructure technologies making Internet access available	(Ganapati & Schoepp, 2008)
Smart City 2.0	People	Creative City	Provide innovative and creative solutions together with the local community	(Ponzini & Rossi, 2010)
		Humane City	Sociable, cooperative, and human-centered city	(N. A. Streitz, 2011)
		Knowledge City	The encouragement of the nurturing of knowledge and investing in education, training, and research	(Yigitcanlar et al., 2008)
		Learning City	Involvement of stakeholders and the encouragement of citizen participation placing innovation and learning	(Longworth, 2006)
	Sustainability	Compact City	Growth is balanced with social inclusion and the careful use of natural resources	(Artmann et al., 2019)
		Eco-city	Ecological Preservation - next generation of infrastructures and environmentally friendly buildings	(Kenworthy, 2006)
		Green City	Zero-emission and zero-waste urban design	(Lehmann, 2010)
		Liveable City	Citizens enjoy a high quality of life and standards of living	(Mase, 2012)
		Low carbon City	Minimization of the human-inflicted carbon footprint	(Sahni & Aulakh, 2014)
		Resilient City	Capacity to absorb, learn and adapt	(Desouza & Flanery, 2013)
		Smart Sustainable City	Supported by ICT, meeting the needs of citizens without compromising the needs of future generations	(ITU, 2015)
		Sustainable City	Improvement of the environment quality, social equity, and well-being in the long term	(Hiremath et al., 2013)
		Zero Carbon City	CO_2 and greenhouse gases zero emission	(Kennedy & Sgouridis, 2011)
Smart City 3.0	Co-creation & Co-design	Inclusive City	Social capital of urban development, promoting inclusion in public services or involving citizens into co-designing	(Paskaleva, 2011)
		Happy City	Citizen's happiness, engagement in planning and decision-making	(Costa et al., 2019)
		Open City	City's data available for all the stakeholders and its involvement in the designing process	(Degbelo et al., 2016)
		Smart Community	Uses technology to solve social and business needs to reinvent cities for the development of economy and society	(Mase, 2012)

Nowadays, citizens have been empowered by cities' willingness to build cities for them, whose inclusion and participation became highly relevant to the Smart City strategy's success.

Moreover, it can be noticed that through Smart City 2.0 and Smart City 3.0, the presence of the technology is scarce and used only as a mechanism. The learnings can also explain that from initial mistakes. It is possible to identify the ghost cities' phenomenon in the literature to explain that technology implementation to improve quality of life and sustainability is insufficient. Citizens need to feel part of the process and identify themselves with their surrounding environment and urban development (Calzada & Cobo, 2015). Thus, participatory methodologies are evolving and being applied to urban planning strategies.

Following the clarification of each concept's meaning through qualitative analysis, it lacks an understanding of each one's literature presence. Moreover, a quantitative analysis was followed. On the one hand, each term was searched separately (e.g., "Ubiquitous Cit*"). On the other hand, within the results obtained, were searched the combination with the Smart City concept (e.g. "Ubiquitous Cit*" AND "Smart Cit*"). The results are shown in Figure 2.2.

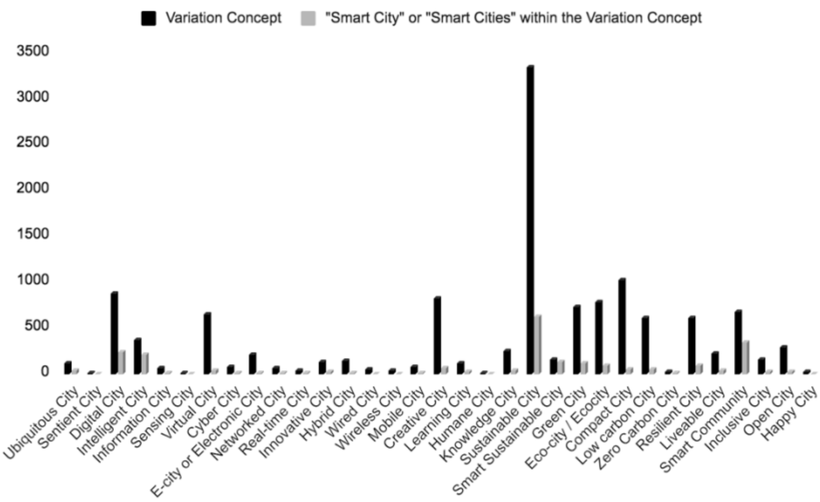


Figure 2:2 Search Results of each variation concept (Black) and the relationship with the "Smart City" concept (Grey).

The detailed search results on Scopus are represented in Table 2.3, divided into three groups: from 0 to 50 scientific articles, from 51 to 500 articles, and more than 500 articles.

From the analysis of Table 2.3, it is noticeable that "Sustainable City", with 623 results, is the term with the most significant number of published papers searching with the "Smart City". However, to have a rigorous perspective on this subject, it is necessary to get the results in relative terms.

Table 2:3 Detailed Search Results on Scopus

Search Results	**"[Variation Concept]"**	**"Smart Cit*" AND "[Variation Concept]"**
0 - 50	Sentient City (12), Sensing City (15), Real-time City (40), Wired City (50), Wireless City (45), Humane City (14), Zero Carbon City (24), Happy City (27)	Ubiquitous City (44), Sentient City (5), Information City (18), Sensing City (5), Virtual City (40), Cyber City (11), E-city/Electronic City (14), Networked City (11), Real-time City (15), Innovative City (25), Hybrid City (19), Wired City (4), Wireless City (7), Mobile City (9), Learning City (25), Humane City (6), Knowledge City (37), Zero Carbon City (9), Liveable City (39), Inclusive City (32), Open City (29), Happy City (5)
51 - 500	Ubiquitous City (122), Intelligent City (377), Information City (68), Cyber City (75), E-city/Electronic City (216), Networked City (65), Innovative City (134), Hybrid City (144), Mobile City (79), Learning City (118), Knowledge City (255), Smart Sustainable City (162), Liveable City (226), Inclusive City (166), Open City (299)	Digital City (245), Intelligent City (214), Creative City (63), Smart Sustainable City (137), Green City (120), Eco-city/Ecocity (88), Compact City (53), Low Carbon City (52), Resilient City (94), Smart Community (354)
+ 500	Digital City (876), Virtual City (655), Creative City (825), Sustainable City (3343), Green City (737), Eco-city/Ecocity (794), Compact City (1029), Low Carbon City (620), Resilient City (621), Smart Community (681)	Sustainable City (623)

Moreover, after detailing the search results, it is possible to make a comparison between searches. It allows the understanding of the most related Smart City variations by analyzing the relationship between the number of results obtained by the Variation Concept and its combination with the term "Smart Cit*". This can be calculated by the following formula.

$$Relationship\ (\%) = \frac{\text{“Smart Cit * ” AND "[Variation Concept]"}\ Search\ Results}{\text{"}[Variation\ Concept]\text{"}\ Search\ Results} \times 100$$

The comparison results of each term given by the previous equation are represented in Figure 2.3. The respective percentage demonstrates the relationship degree between the Variation Concept results and Smart Cities.

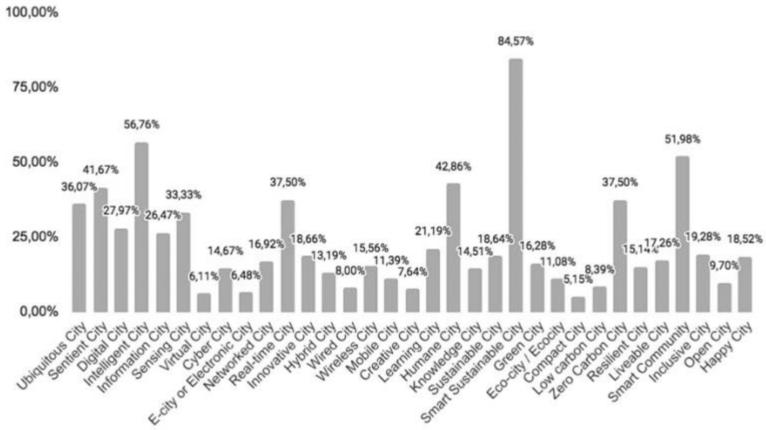


Figure 2:3 Relationship between the Search Results of the Raw Term and within Smart Cit.*

From Figure 2.3, it is possible to note that the “Smart Sustainable City” term is the most related to the “Smart City”, followed by the “Intelligent City” and the “Smart Community”, both above 50 per cent. However, this can be explained by the fact that these are recent terms. Therefore, it was necessary to study when they emerge in the literature and when they were associated with the Smart City term. This would allow understanding if it were already impacted by Smart Cities when the term emerged.

Moreover, Figure 2.4 demonstrates that the “Smart Sustainable City” concept emerged not just after the “Smart City” but was the only one impacted from the beginning.

Considering that Smart Cities emerged in the 1990s, Figure 2.4 shows that most of the various concepts that emerged after that era were impacted shortly after. It also shows that the terms “Digital Cities”, “Intelligent Cities”, Information Cities”, “Virtual Cities” and “Cyber Cities” were the first to be impacted in 2000. Nevertheless, despite their older existence, all concepts after 2010 were associated with Smart Cities. This can be explained by what Figure 2.1 previously showed about the growth of Smart Cities noticed after 2010.

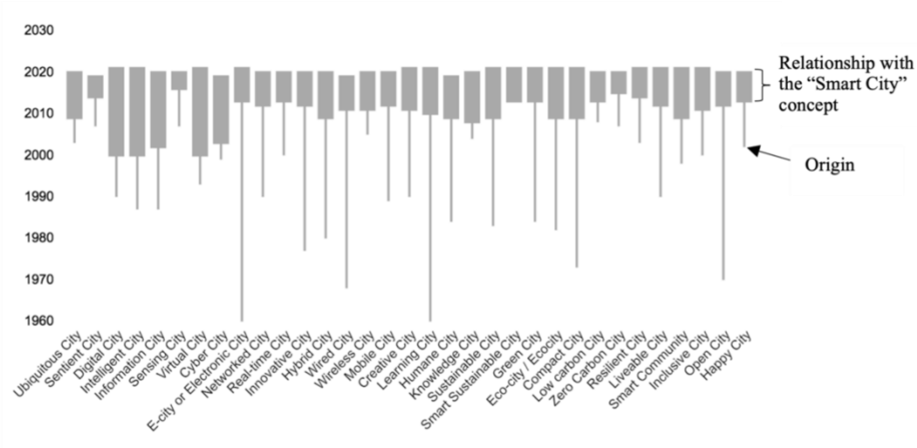


Figure 2:4 Distribution of the search results throughout the years

The literature also mentions other variations in which the meaning is not exact and lacks academic recognition. These are Ambient Cities (Andrejevic, 2005), Cities as Internet–of–everything (Kyriazis, Varvarigou, White, Rossi, & Cooper, 2013), Business City (Cathelat, 2019), Multimedia City (Boll & Utz, 2003), Flexi City, Cyberville (Mohanty et al., 2016), *MESH C*ity, Teletopia (Venkat Reddy et al., 2017), Talented City (Karaköse & Yetiş, 2017), Telicity (Silva, Khan, & Han, 2018), Greentopia, New Media Community (Cheung, 1991), Technocities (Downey & McGuigan, 1999), Cooperative City, Self-aware City, Transient City (N. Streitz, 2019), Slim City, Transition Town, Resilient City, Negative Carbon City (Bibri & Krogstie, 2017), Broadband City/Broadband Metropolis associated to the implementation of broadband technology (Townsend, 2007).

2.4.2. The Future of Smart Cities

The evolution of the concept led Smart Cities to be rooted in three axes: Sustainability, Innovation, and Quality of Life (Correia, Teixeira, & Marques, 2020). The two significant Smart City future developments are the: 1) development of technologies and interoperability between systems, and 2) participatory development methodologies for the engagement of citizens and stakeholders.

Cities are increasingly adopting an open data ideology to enable third parties to develop new applications, emerging new inter-organizational partnerships built around developing and implementing data-driven governance projects (Shelton, Zook, & Wiig, 2015).

Cities realize the potential of integration and interoperability of solutions. However, strategic planning remains a rather abstract idea (Angelidou, 2014). Without planning, cities cannot define infrastructure layers and combat the lack of integration and standardization among sectors. Cities should promote standards to facilitate third parties' integration and application development.

The need for a frame of reference is evident. A collaborative dimension of governance in co-design, co-creation, and co-production has to be considered for more significant crossover information (involving stakeholders) and faster processes (Anttiroiko, Valkama, & Bailey, 2014). On the one hand, the emergence of participatory technological-based methodologies will fill the existing gap between decision-makers and citizens, and the rest of the stakeholders. On the other hand, big data analytics and artificial intelligence will enhance accurate real-time decision-making based on the embeddedness of technology in urban furniture. This will allow the prediction and monitoring of city events and improve planning. 5G, IoT, vehicular communications, cloud, and edge computing will enhance solutions' responsiveness and allow connectivity among cities' infrastructures and devices. On the other hand, data privacy issues and ethics will emerge and the need for blockchain and smart contracts technologies.

In summary, technological advancements of Industry 4.0, shared by Smart Cities, will walk side-by-side with social and ethical constraints, and the improvement of citizen's quality of life concerns.

2.5. Conclusions and Future Work

The Smart City concept has evolved. In the literature can be noted three stages with different focused dimensions: technology, people and sustainability, and co-creation and co-design.

This paper studied more than 30 existing variations of the Smart City concept within the literature and their relationship with the Smart City term. From an analysis of the obtained search results on Scopus, it was noticeable that Sustainable Cities were the most present term in the literature in absolute terms. However, when combined with Smart Cities, the most related concept was Smart Sustainable Cities followed by Intelligent Cities and Smart Community. The year when the concepts emerged and the time they were associated with Smart Cities was also analyzed.

Despite the different understandings and variations, it is vital to promote a standard Smart City concept to guide cities throughout the implementation, following up, and regulation.

Therefore, based on the performed study, Smart Cities are cities supported by ICT, co-designed with citizens, to promote social, environmental, and economic sustainability and improve citizens' quality of life.

Moreover, following the concept's clarification, it is necessary to study the crucial metrics and Key Performance Indicators (KPI) to assess Smart Cities and perform continuous measurements. On the other hand, there are also missing gaps in Smart Cities' strategic planning and participatory methodologies. Therefore, a standard framework must also be developed to guide cities during the Smart City planning and implementation process.

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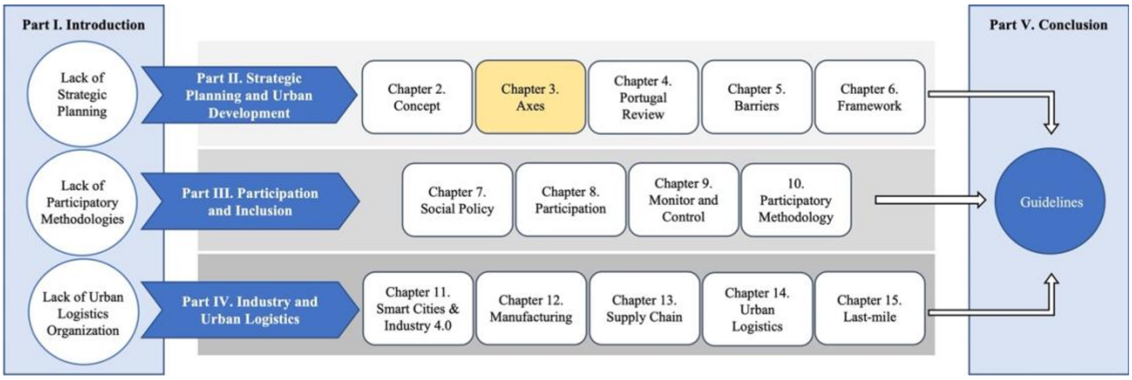
Chapter 3

Triangular Pyramid Trunk: The Three Axes of the Smart City Assessment Tool

Reference

Correia, D., Teixeira, L., & Marques, J. (2020). Triangular Pyramid Trunk: The Three Axes of the Smart City Assessment Tool. *WIT Transactions on Ecology and the Environment*, 241, 79–90. https://doi.org/10.2495/sdp200071



3. Triangular Pyramid Trunk: the three axes of a Smart City assessment tool

Abstract

Smart Cities have changed from a purely technological paradigm to a holistic, integrated strategy, where the citizens play an important role in the decision-making process. Cities begin to understand the potential of integration approaches, interoperability of solutions, and start seeking strategic thinking when addressing new technologies. In this context, to implement a holistic strategy, city decision makers must have a tool that helps them to strategize according to their current state and then understand whether the actions they adopted are having the desired outcomes concerning their previously established objectives. It is not possible to create strategic visions for Smart Cities without a tool to regularly assess and monitor them. In this matter, several studies report some attempts to formulate a methodology to calculate indexes to evaluate cities' maturity level. However, they have either not taken properly into consideration indicators' weighting, or the focus of the index was not clear and mixed up the key performance indicators (KPIs) of different concepts in an attempt to provide a more generic tool. Despite this, the previous studies are used as the basis to support the methodological approach of this research. This article tackles this gap in the literature by providing the most up to data Smart City assessment tool to evaluate cities. While the Smart City concept has different understandings among researchers and academia practitioners, the evolution of the concept has tended to incorporate the axes of Sustainability, Innovation, and Quality of Life. Therefore, these are featured in the present index calculation supported by the ICTs and participatory approaches. Existing standard KPIs and frameworks do not include them, focusing most of the time in one of these axes while leaving the others aside. Thus, this paper proposes to describe the development of a methodology that encompasses every one of these three axes to give cities a tool they can use to monitor their actions.

Keywords: Smart City; Framework; Index; Participatory Development; Indicator; Assessment; Innovation; Sustainability; Inclusiveness; Quality of Life.

3.1. Introduction

Smart is not a consensual term, and what may be Smart for some may be not for the others. The Smart City is a concept that, given its nature of qualitative and at the same time distinct quantitative method evaluation, has not generated consensus in its understanding, sometimes leading cities to completely different approaches and with different ways of assessing their evolution.

The Smart Cities expression emerged in the 90s (Bastelaer, 1998; Mahizhnan, 1999; Tan, 1999) and since the first moment was seen as the solution to address rapid urbanization and urban agglomeration, solving traffic, waste management, air quality, social pressure and inequality, economic speculation, and inefficiency of emergency bodies (Angelidou, 2015; Chourabi et al., 2012). Information and Communication Technologies (ICTs) are increasingly used as tools in the governance and management of cities to promote the integration of the several domains, improve quality of life, achieve sustainable development, and create a more open and innovative urban environment through the participation of the stakeholders (Anthopoulos & T. Tougountzoglou, 2012).

Although there is not yet a widely adopted and precise definition, the Smart Cities concept has been evolving since the first techno-centric understanding (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017; Mora, Bolici, & Deakin, 2017) mainly promoted by technological companies that ICTs would be the solution for everything, to a more human and sustainable point of view where the solutions sought to solve specific citizens' problems (Bibri & Krogstie, 2017; Caragliu, del Bo, & Nijkamp, 2009; Piro, Cianci, Grieco, Boggia, & Camarda, 2014). Nowadays, citizens are seen as part of the process and not just the "customer" of it. Their participation and involvement in the co-design and co-creation of projects and policies is fundamental to support decision-making processes (Mainka et al., 2016), making sure that the solutions will be adopted when implemented (Al-Nasrawi, El-Zaart, & Adams, 2017).

After the implementation of the first projects and the attempt of some authors to establish indicators to assess Smart Cities, being the European Smart Cities Ranking (Giffinger, 2007) the most quoted and used, nearly five years ago there was noticed in the literature a lack of sustainable development in the existing tools to assess the achievement of medium- or long-term goals (Osella, Ferro, & Pautasso, 2016). Before knowing what to do and how to do it is necessary to evaluate the situation to understand what the city's current state is. Only this way, it will be possible to define standardized procedures to cities can make their decisions based on quality data. The success of Smart City initiatives is related to the quality of the data collected and the key performance indicators and tools used to monitor them continually (Marsal-Llacuna, Colomer-Llinàs, & Meléndez-Frigola, 2015).

There is not yet an accepted standard assessment tool to monitor cities among researchers. Therefore, cities have been selecting the tools from themselves. Because there are dozens of rankings available in the literature and those, need expert analysis to be adequately used, it turns this city's task even harder. This choice has extreme importance since it affects city management and decision making directly (Kitchin, Lauriault, & McArdle, 2015).

While the literature shows a diversity of Smart City indexes (Bibri & Krogstie, 2017), what was happening was that the tools were being created for a limited number of cities, and the focus of the indicators was utterly undefined. In particular, it was noticed the lack of ICT enabled-indicators (Liao, Chen, Qian, & Shen, 2017) as well as a confusion generated between the Smart City concept and Sustainable City understandings which caused that many of the Smart City tools defined focused too much on the sustainability component, particularly on social and economic issues (Monfaredzadeh & Berardi, 2015) while the indicators for sustainable cities placed more emphasis on the environmental component (Sharifi & Murayama, 2013). There was also a lack of an assessment tool to measure how smartness enhances sustainability and vice versa (Bibri & Krogstie, 2017).

There has been noticed a notorious work at the level of some entities, such as ISO (International Organization for Standardization) and ITU (International Telecommunication Union), which have played a leading role in establishing indexes with indicators that try to align what is the sustainability of the city with the role of the new ICT (Huovila, Bosch, & Airaksinen, 2019). However, on one hand, there is a lack of a practical component because there are no indicators that consider the objectives of cities and the monitoring of the city's progress (ISO, 2014) and on the other hand indicators are not normalized either given different weights according to its importance for the index's estimation which also creates difficulties to provide cities an efficient tool (Ahvenniemi et al., 2017).

3.2. Theoretical Background

Following an exploratory and unstructured approach, it was conducted research in the literature through Scopus and the Web of Science using the combination of the following key-terms: "Smart Cities"; "indicator"; "ranking" and "index". More than 600 papers resulted from the search. From those, it was read the 300 most cited abstracts, where 130 of them deserved a more-in-depth analysis due to their alignment with the objective of this paper and contribution to the discussion of what has been done to evaluate Smart Cities and how can that be improved.

Based on this literature review it was concluded that, throughout the years, more than 50 assessment tools were developed to evaluate cities. The conclusions of four of the comparison studies which analyze a significant number of those assessment tools are here exploited to help find a standard and common methodology to assess cities.

Thus, Sharifi (2019) selects and analyses 34 sets of Smart City assessment tools. The study concludes that IES-City, SCC, CITYkeys, and ITU-T cover a "large part" of all indicators considered, but it is still less than 50%. Most of them have not developed participatory approaches and there is a lack of strategic planning among the tools. Additionally, they do not consider local needs and conditions and there is a limited consideration of interlinkages and correlations among indicators, dimensions, and sub-dimensions. Flexibility is low, feasibility is not considered and don't have a continuous assessment approach.

Ahyenniemi et al. (2017) analyses 16 sets of city assessment tools (8 Smart City and 8 whose focus is on urban sustainability). Weighting was not considered in the study because weights were not part of most of the tools analyzed. The authors conclude that the Smart City tools are highly focused on social aspects, whereas economic and environmental issues are considered less critical. On the other hand, the urban sustainability ones cover mostly the environmental and social dimensions, whereas indicators measuring economic sustainability are minimum.

Huovila et al. (2019) presents a comparison of 7 sets of assessment for "Smart sustainable cities" and notice that 90% of ISO 37120 and UN SDG 11+ indicators focus on sustainability and that the ITU 4902 assessment tool is the most focused on smartness and the one which has the most impact-oriented indicators.

Finally, Stratigea et al. (2017) takes into consideration 5 city assessment tools and conclude that ICT-enabled indicators are not always presented in the comparing tools and some of them have an inadequate share of indicators assessing the smartness efforts of a city. Additionally, ITU-T has a purely ICT-enabled indicator orientation. The merging task that is done permits a more widely differentiated mix of smart and sustainable indicators.

Although there is not a size to fit in all Smart City models (S. Bhattacharya & Rathi, 2015), a difference in the focus of each of the used tools should be made. Otherwise, we would be mixing concepts and obtaining ultimately decontextualized results from reality. Although one of the goals of Smart Cities is to improve sustainability with the help of technologies, we cannot misunderstand concepts and merge them as it is proposed by Stratigea et al. (2017).

The conclusions of the previous studies' results raise concerns about the validity of the tools considered to assess Smart Cities. The cause could also be the fact of using the same criteria to compare assessment tools that have different goals. Given the evolution of the concept and the trend towards sustainability, it obtained the derivation of "Smart Sustainable Cities" (Bibri & Krogstie, 2017; ITU, 2016a; Kaika, 2017; Kramers, Höjer, Lövehagen, & Wangel, 2014; SSCC-CG, 2015). This fact contributed to the merge between indicators of evaluation (Stratigea et al., 2017) of a concept that points to the short term (Smart Cities) and another to the long term (Sustainable Cities) turning the focus and study of the different concepts extremely confused.

Additionally, Akande et al. (2019) points as gaps:

- Lack of a proper definition of a ranking focus and the misunderstood of concepts;
- Lack of homogeneity (regarding city's population density, economic character, wealth, climate and history) among the selected ranked cities;
- Unreliable data source;
- Weighting without considering the interrelationship between indicators.

Sustainability is oriented to a global approach, and it can be measured the same way for every city. However, the same cannot be applied to Smart Cities since it is somehow a local strategy that needs the inputs of local stakeholders to align the short-term actions. Along the same line, the alignment between Sustainable Development Goals (SDG) targets and indicators to evaluate actions at local scale remains unclear (Wendling, Huovila, zu Castell-Rüdenhausen, Hukkalainen, & Airaksinen, 2018).

Therefore, it is needed a tool with an eye on the short term, monitoring if the results of the actions planned are aligned with the established goals.

3.3. The Triangular Pyramid Trunk

Towards the conclusions of the studies previously highlighted is of relevant importance to develop a methodology that approximates these tools to the strategic axes of a Smart City. Most of the assessment tools has not participatory approaches (do not include the citizen in the creation process) and do not consider local needs and conditions (Sharifi, 2019), ICT-enabled indicators are not always present (Stratigea et al., 2017).

The proposed model, beyond the calculation of a Smart City assessment tool, the objective will be to design a methodology capable of adapting itself with the evaluation of times and not become obsolete.

Only recently, standardized sets of city indicators have been introduced. This international standardization work has been being mostly carried out in the last years by three bodies, i.e., ISO and ITU worldwide and by the coalition of the European standardization organizations CEN, CENELEC, and by ETSI in Europe (Huovila et al., 2019).

Some of the international standardization bodies have recently published six sets of Smart and Sustainable City indicators (ETSI, 2017; ISO, 2018a, 2018b; ITU, 2016b, 2016c, 2016d). The six were compared along with the Sustainable Development Goal 11+ monitoring framework, and it is stated in the conclusions above that ISO 37120, and UN

SDG 11+ indicators are the sets of indicators more appropriate to measure sustainability while ITU 4902 is the most focused on smartness.

Venkat Redy et al. (2017) defines three Smart City Goals:

1. Achieve sustainable development;
2. Increase the quality of life of its citizens;
3. Improve the efficiency of the existing and new infrastructure.

On the other hand, Etezadzadeh (2016) defines as Smart City goals: the preservation of the environment, maintain the quality of life and promote social development, maintain competitiveness, and promote economic development and generalization of attitudes, decisions, and actions.

Sustainability and Quality of Life are agreed goals. The efficiency of processes is not just based on existing infrastructure or have new infrastructure implemented. There are many ways to gather real-time data without having to invest in infrastructure. Moreover, the best way to maintain competitiveness and grow is by creating and investing in innovative processes. Thus, the third goal of Smart Cities must be innovation. Innovation will always be the engine to pursuit new technologies and methodologies. Innovation could be the basis of a Smart City, however, throughout the years, we have been noticing that not even all reasonable solutions or best practices come from disruptive technology. Sometimes it is a matter of simplifying things and optimize processes. The innovation is stated here as a way of thinking, that cities must consider.

On the same line, Barrionuevo et al. (2012) defines four Smart City axes: Sustainability, Social Cohesion, Innovation, and Connectivity (which should already be intrinsic in the innovation axis).

Taking into consideration all the enunciated aspects and the foundations reported in the exploratory literature review, this study defines three Smart Cities axes/dimensions supported by the ICTs and the participation of citizens and the stakeholders with the aim of promoting a Smart City that does not let anyone aside (Figure 3.1). A city from all to all.

Thus, at the basis of the pyramid we can evaluate the smartness adapting to this study the thoughts of Debnath et al. (2014). We may then consider a ranking with 4 levels depending on the capacity to gather data and prevent occurrences with it: i) Offline - not capable of collecting data in real-time; ii) Real Time - collects data in real-time; iii) Predicting - an advance of a potential problem with the-real time data collected; and iv) Preventing - evaluation of scenarios and avoidance of occurrences.

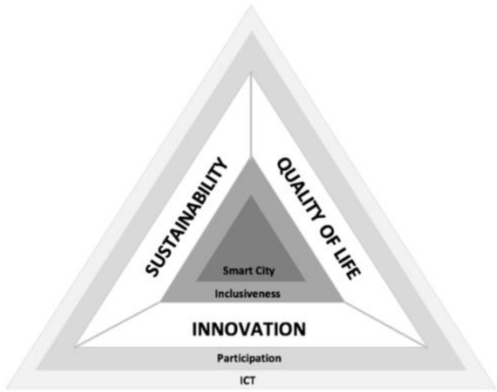


Figure 3:1 The Triangular Pyramid Trunk - the three Smart City axes

1. Sustainability - In the 90s started to be done urban monitoring with the establishment of the Local Agenda 21 (United Nations, 1992), but only ten years ago were associated indicators to monitor sustainability (Marsal-Llacuna et al., 2015). In 2015, the United Nations developed the 17 Sustainable Development Goals (SDGs) (UN, 2018). There was a need to contextualize, align indicators with the SDGs promoting interlinkage among indicators and avoid overlapping of goals and targets (Shrimoyee Bhattacharya, Patro, & Rathi, 2016). According to Ismagilova (2019), the practicability of the Smart City concept can help cities reach UN goals. Public administration has been increasingly using urban sustainable development indicators to assess and monitor their activities (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). The most common assessment tool used to guide them is ISO 37120 (Mohanty, Choppali, & Kougianos, 2016). Therefore, and alongside with the conclusions of Huovila et al. (2019), we will use the ISO 37120 to measure sustainability.

2. Innovation - When researchers investigated sustainability in Smart Cities was missing a focus on ICT (Huston, Rahimzad, & Parsa, 2015). Therefore, it is relevant to study innovation as a separate vertical. The innovation goals are supported by the real-time data that is gathered through online (and offline) tools that permit city decision-makers to make their decisions according to that information. Innovation can be mostly measured by the capacity of the city to collect data and make it available as fast as possible to decision-makers. Innovation is understood as an urban smartness technological driver (Lopez-Carreiro & Monzon, 2018). Huovila et al. (2019), and Stratigea et al. (2017) point the ITU 4902 standard assessment tool as the most suitable to evaluate the smartness. Conducting a deep analysis, it is possible to notice that in a total of 37 indicators only 8 of them are not marked as ICT-specific indicators but indicators focusing on general city sustainability, therefore we shall not consider these

and associate the 80 general indicators from the Global Innovation Index (Soumitra Dutta & Wunsch-Vincent, 2019) or other set of indicators focused on innovation aspects.

3. Quality of Life - On the other hand, sometimes the city's sustainability is misunderstood with the improvement of the quality of life of its citizens. The concept has been worthying the attention not only of the academic community but also of policymakers. There is not yet a single, universal, and consensual definition of Quality of Life given the fact that this is a complex, dynamic and multidimensional concept. Quality of life was initiated by Mercer's annual quality of life survey and the Economist Intelligence Unit's quality of life index (Ahvenniemi et al., 2017). In both cases, data is collected from two different sources: life-satisfaction surveys (to get a subjective view of a population's emotional wellbeing) of citizens and quality of life indicators (objective evaluation) (Marsal-Llacuna et al., 2015).

Each one of the axes ends up, first, having a normative, top-down approach, where there is a selection of KPIs ideal for the classification of that axis, and a quantitative primary analysis is made. Additionally, it must be conciliated with a bottom-up approach, where secondary qualitative data is collected through surveys to citizens. The techniques used may undergo a pairwise comparison, a ranking assessment from 1 to 10 (or another scale), or a distribution of percentages across the various KPIs for the assignment of the weights among indicators. Citizens are different from city to city. Therefore, the weights given will vary. The weight assigned to a particular indicator depends on the relative importance of it to the citizen and local stakeholders.

Additionally, there is an intangible goal that is Inclusiveness, which is usually a very forgettable area. Smart Cities have the responsibility to overcome the challenge of dealing with inequality and social polarization (Hollands, 2008). The literature has been pointed at the need for actions to promote inclusion (Oliveira & Margarida Campolargo, 2015). Smart Cities must embrace inclusivity at the foreground of their agenda, to reduce social learning restrictions and social participation barriers (Silva, Khan, & Han, 2018). Therefore, the city must put its efforts available to every citizen, not letting aside the disadvantaged. Smart Cities must strive open access and strategies, including the inclusion factor, to decrease the digital dividend (Zygiaris, 2013).

To make sure that it is not forgotten, it shall also be made a current assessment to this aspect (since it must be a concrete goal of Smart Cities). Therefore, inclusion can be measured based on the number of people affected by the Smart City initiatives implemented. For each city would be calculated the percentages of people from each social group (or just the minorities inclusion) reached with that initiative and the final city's inclusion value will be the arithmetic mean of the results of each initiative. This will not just allow us to understand the number of the population affected but also which are the social groups that are not being considered.

As said before, citizens passed from a passive role through an active real on the co-creation of Smart Cities. The advances and the diffusion of mobile devices allow people to participate (Kirwan, 2015), avoiding social marginality (Huston et al., 2015; Vanolo, 2014). We are witnessing a change of how decision-makers include citizens into the co-creation and co-designing process. This ideology comes to oppose the risk of cities becoming ghost cities, a concept that emerged from the megalomaniac futuristic projects to create cities from scratch (Carvalho, 2015; Cheng & Hu, 2010; Reiche, 2010) in which citizens did not identify themselves with and therefore, abandoned cities. As soon as the city stakeholders are included in the process, higher is the chance of the city succeeds on the implementation. People must be capable of using technology to benefit from it (Coe, Paquet, & Roy, 2001).

Several authors presented different methodological approaches to define a Smart City index and rank cities. Most of the studies in the literature used the data from the Urban Audit Perception Survey (Statistical Office of the European Union – EUROSTAT). The indicators are usually selected by applying a hybrid research methodology, including a literature review and semi-structured interviews (Shen, Huang, Wong, Liao, & Lou, 2018). Regarding standardization, the most common method used to normalize the gathered data is using z-transformation (Battarra, Gargiulo, Tremiterra, & Zucaro, 2018; Lazaroiu & Roscia, 2012) or through the minimum-maximum method on a scale of defined values (Dall'O, Bruni, Panza, Sarto, & Khayatian, 2017; Lopez-Carreiro & Monzon, 2018). The experts' knowledge is used to define average weights values (Lazaroiu & Roscia, 2012; Lopez-Carreiro & Monzon, 2018), or a technical committee that considers the peculiarities of the territory in which the municipalities are located (Dall'O et al., 2017). There are other options as using the Entropy Method (Shen et al., 2018) or the Analytic Hierarchy Process (Stanković et al., 2017). To accomplish the final equation is used the Multiple-Attribute Decision Making (Escolar et al., 2018) or the Multi-Criteria Analysis (Stanković et al., 2017).

The methodology (Figure 3.2) here taken aims to achieve a final equation capable of currently assess cities taking the three aforementioned axes into account and including the citizens in every step of the process by the allocation of the weights first of all among indicators and secondly to ponder the weight of each axis. It can be summarized as follows:

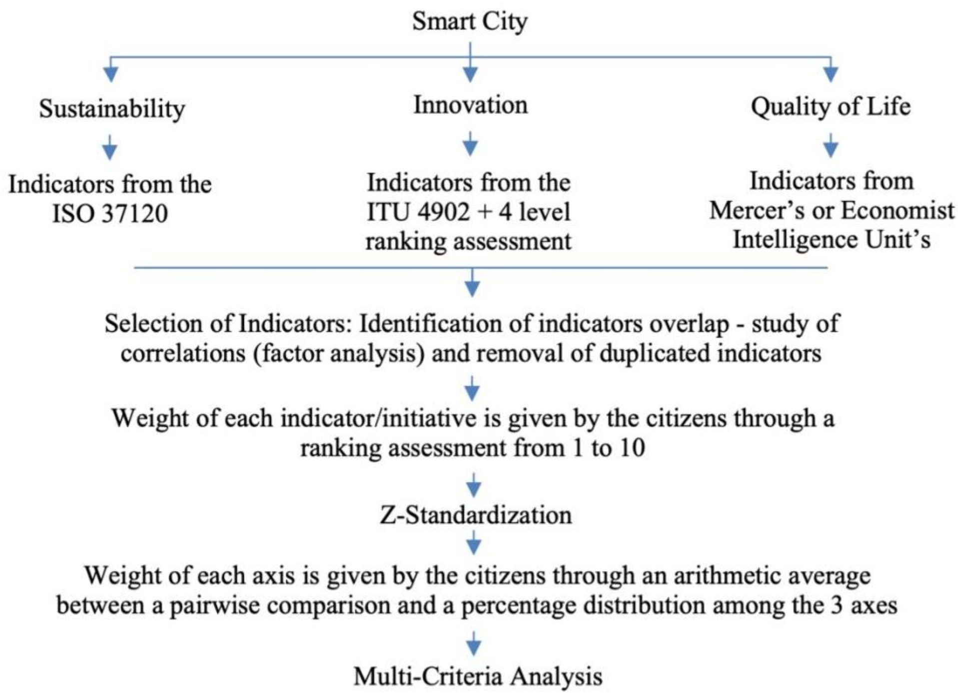


Figure 3:2 The methodology of the Smart City Index

Taking the existing sets of indicators into account for each axis, it is necessary to identify which are overlapped, studying the correlation level among them and, in the end, removing the duplicated.

The success of Smart City development and assessment processes depends on the bottom-up participatory approaches promoted by the city (Hemment, Woods, Appadoo, & Bui, 2016). Smart Cities are not meant to be only top-down, therefore more and more, there is a need to engage citizens and other stakeholders in the co-creating and co-provision of services by a collaborative and bottom-up manner (BSI, 2014).

After the calculation of each one of the axes, as expressed in the previous section, there is a need to normalize the data. Not just vertically from all the indicators of each axis, but also horizontally among the axes of the final equation.

As mentioned before, the participation of citizens is vital to Smart Cities. The inclusion of the citizen on the Smart Cities' co-creation process on behalf of the definition of the weights. Moreover, besides the definition of the weights of all the indicators in each axis, citizens will also assign weights/coefficients to each axis in the final equation. It would be unwise to consider the same values to the coefficients of Sustainability, Innovation, and Quality of Life.

To be able to combine a standardized process with customization, the last must be taken in the latest phase possible. In the end, the standardization of this index will be kept until the moment it is considering the citizens' opinion to define the weights of the KPIs (customizing the index to a particular city). That is what will permit to have a global index at a local scale.

After having assigned the weights, it can be calculated the arithmetic mean (Lopez-Carreiro & Monzon, 2018) of each one and through a multicriteria function obtained the result of the index.

3.4. Conclusions, Limitations and Future Work

The Smart Cities phase we are witnessing takes citizens into the equation to co-design and co-create the cities with the decision-makers. More and more, it is important to create standardise processes so cities can have a focused approach to establish their Smart Cities strategies.

Strategically, the index here developed which contemplates three axes will be fundamental on the future establishment of a Smart Cities framework to provide a decision support tool to help cities, that are mainly in the earlies of the process of becoming a Smart City, understanding the steps they must follow to succeed.

Through the coefficients and the results obtained, policy makers can understand the profile of preferences of its citizens, allowing better planning, investment, and allocation of resources.

The index will not just only permit to have an overview about the current state of the city, but also to see what are the most critical KPIs to reach the city goals, having the chance to look for solutions capable of improving those indicators. The weights dictated by citizens should be kept unchanged over a certain period.

However, we must not forget that the approaches that are taken by comparison or ranking present ambiguities and inconsistencies. These are not easily comprehensible and informative for decision-makers or the community. These types of participatory approaches have a level of uncertainty that can be justified mostly because they are:

1. Supported by human behaviors;
2. Knowledge-dependent;
3. Result from cognitive biases.

Additionally to this limitation, it is not made a differentiation either an indicator correction based on the size of the city (Borsekova, Koróny, Vaňová, & Vitálišová, 2018), and sustainability indicators have limitations due to the lack of systematic interactions and concrete indications on the direction to be followed (Huang, Yeh, Budd, & Chen, 2009).

Although some authors go further from the index evaluation and define a ranking among the evaluated cities, the methodology here taken does not make it possible. The coefficient of each one of the axes depends on the evaluation of citizens what will make each equation unique. Therefore, it does not make sense to compare the result.

Dashboards and software tools can be created with this knowledge to provide cities and citizens an interface for the assessment and the analysis of the result. There must be because must be developed and implemented systems capable of gathering real-time data and access the historical to answer the KPIs, dealing simultaneously, with the structure of logic reasoning, the aggregation of several individual preferences and their transformation into a collective and unified result for each axis and then the calculation of the result.

All the axes are correlated because the goals of each one of them strive to the same Smart City objectives. That can also be measured afterward to understand how the improvement of the result of a certain axis KPI can improve another axis' indicator.

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Chapter 4

Reviewing the State-of-the-Art of Smart Cities in Portugal: Evidence Based on Content Analysis of a Portuguese Magazine

Reference

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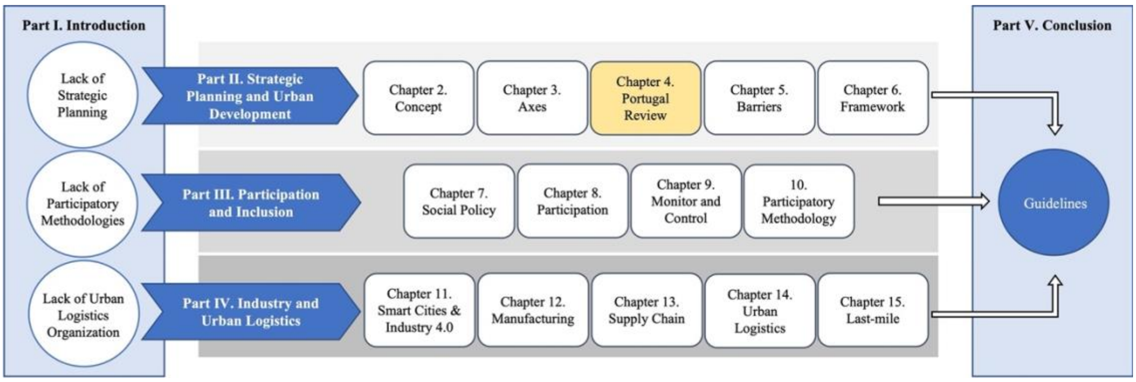


4. Reviewing the State-of-the-Art of Smart Cities in Portugal: Evidence Based on Content Analysis of a Portuguese Magazine

Abstract

The lack of examples of Smart City initiatives and the sharing of best practices in Portugal confirm the gap in the transference of empirical knowledge to the scientific literature in this area. The Smart City concept has passed through three stages. However, its evolution has not been noted equally throughout countries and their territories. The literature only provides information about specific projects implemented in a few cities. Therefore, the aim of this paper was to study the state-of-the-art of Smart Cities in Portugal by analyzing 25 editions of the most relevant national-wide Smart Cities magazine. First, the objective of analyzing the magazine was to study each Portuguese city in terms of the subject areas and types of existing initiatives in order, ultimately, to frame cities within their respective Smart City phases, as per the literature. Second, the aim of the paper was also to provide information about the evolution of the concept through analyses of embedded experts' quotes. The results of the first are complemented with the analysis of interviews with policymakers to provide information about the existing challenges to implementing a Smart City and to understand the role of government therein. Qualitative and quantitative analyses were performed on the case study. The findings suggest that the three Smart City phases are perceived in slightly different ways in Portugal and heterogeneity within the country can be noted from the lack of strategies and a standard framework.

Keywords: Smart City; Empirical evidence; State-of-the-art; Portugal.

4.1. Introduction

There is little evidence in the literature to help understand the state-of-the-art of Smart Cities in certain countries. Often, the practices and implemented initiatives are not found in the scientific literature but rather in empirical sources. This is the case for Portugal, for which a quick search for the terms "Smart Cit*" and "Portugal" only returned 84 results in Scopus and 66 on the Web of Science. Moreover, it represents a lack of significant practical contributions to support new theoretical directions and future studies (Kitchin, 2015; Tomor, Meijer, Michels, & Geertman, 2019). This is mainly the case for topics whose actors are not directly linked to the scientific field. Therefore, their contributions generally occur in informal data sources. Nevertheless, empirical knowledge should not be neglected, because it often means a comprehensive collection of information focused on a specific topic of interest.

With the lack of existing scientific knowledge, also explained by the novelty of the topic, it is vital to consider empirical sources of information to provide academia with the premises for further developments. Therefore, the aim of this paper is to detail the state-of-the-art of Smart Cities in Portugal by studying the existing initiatives and players. Serving this purpose, content analysis of the most important Portuguese magazine dedicated to the field of Smart Cities, with reported practical implementations and contributions from experts, is performed (Smart Cities, 2021). The case study was addressed by editorial choice and dissemination needs.

First, a narrative review of the literature is conducted to detail the evolution of the Smart Cities concept within the Portuguese context that served as a starting point to conceive the objectives of the analysis of the magazine. Second, a methodology to answer the research and sub-research questions is further detailed. The results are reflected in the third section. Quantitative and qualitative analysis are performed to give an overview about Portugal, the area and type of existing initiatives, the roles, and entities of the experts, and summarize the evolution of the understanding of Smart Cities based on interviews and opinion articles in the magazine. Furthermore, to complement the analysis regarding the understanding of the challenges of implementing a Smart City, as well as the role of the government in the process, the results of the interviews performed with Portuguese policymakers and a secretary of state are also detailed. Finally, the discussion section portrays the state-of-the-art of Smart Cities in Portugal, by positioning each city within the respective Smart City stage and comparing the obtained results with the literature.

4.2. Literature Review

Smart cities emerged in the 1990s and have passed through three different stages (Cohen, 2015): i) Smart City 1.0—technology companies led and encouraged the adoption and implementation of new solutions; ii) Smart City 2.0—local administrations used technological solutions as a way to improve sustainability and citizens' lives; and iii) Smart City 3.0—co-creation models and collaborative approaches have emerged, wherein policymakers and citizens work together to find the best strategy for and solutions towards a common vision.

The first technological perspective led cities to become dependent on proprietary solutions. Over time, it created vertical silos that did not allow for the interoperability of cities or the integration of third parties. In addition, it left less space for citizens' participation. Moreover, the lack of city context and Hollands' (Hollands, 2008) critics made policymakers acknowledge the need to promote open and interoperable standards. Therefore, the concept focused on human and social capital (Caragliu, del Bo, & Nijkamp, 2009). Today, citizens have been empowered by cities' willingness to co-create. Their inclusion and participation have become highly relevant to the success of Smart City strategies (Diogo Correia, Feio, Teixeira, & Marques, 2021). Therefore, today, the Smart City is in the third stage, where citizens have an active and collaborative role (Trivellato, 2017; Van der Graaf & Veeckman, 2014).

Russo et al. (2014) recall the definition of the Smart City and evolution of guidelines at the EU level. The Europe 2020 strategy was focused on three priorities (European Commission, 2010): sustainable growth (low-carbon economy), smart growth (education, research, and innovation), and inclusive growth (jobs and wealth). The International Organization for Standardization (ISO) and International Telecommunication Union (ITU) have played leading roles in establishing tools with key performance indicators that try to align the sustainability of the city with information and communication technologies (ICT) (ISO, 2014). Several Smart City frameworks can be found in the literature (Barrionuevo, Berrone, & Ricart Costa, 2012; García-Fuentes & de Torre, 2017; Lee, Phaal, & Lee, 2013; Mora & Bolici, 2016; Stratigea, Papadopoulou, & Panagiotopoulou, 2015; Zygiaris, 2013). However, there is a lack of a practical and accepted standard framework to guide and monitor the city's progress (Diogo Correia, Teixeira, & Marques, 2020).

Furthermore, two stakeholder advisory platforms emerged: European Technology Platforms (ETPs) and European Innovation Platforms (EIPs). The latter aimed to bring public and private stakeholders together to accelerate research and innovation. Moreover, through EIP for Smart Cities and Communities (EIP-SCC), the Smart City assumed a relevant role (Francesco Russo, Rindone, & Panuccio, 2016). The two governance bodies of EIP-SCC, the High-Level Group (HLG) and Smart Cities Stakeholder Platform (SCSP) were responsible for defining rules and guidelines for the development of Smart Cities. These can be found in the Strategic Implementation Plan (SIP) (European Commission, 2013), and the Operational Implementation Plan (OIP) (European Commission, 2014).

The guidelines cross i) three specific vertical areas: sustainable urban mobility, sustainable districts and built environment, and integrated infrastructures and processes across energy, ICT, and transport, with ii) eight horizontal themes aggregated into three classes: decisions (citizen focus, policy and regulation, and integrated planning and management), insight (knowledge sharing, metrics, and indicators, open data and standards) and funds (business models, procurement and funding). The intersection of vertical areas and horizontal themes constitutes 24 focus areas to guide strategic planning (Francesco Russo et al., 2016).

Nevertheless, the strategic planning of Smart Cities raises the challenge of matching plans with the policy strategies followed by local decision-makers (Wolf, Borges, Marques, & Castro, 2019). Furthermore, in the breakdown of strategic plans, local decision-makers are challenged to transfer macro guideline scales to micro realities. The challenges of implementing Smart City initiatives also differ depending on the context of each territory and its socioeconomic needs (D. Correia, Marques, & Teixeira, 2021).

Furthermore, Gil-Garcia and Pardo (2005) reflected on the management and organization barriers to implementing a Smart City. The lack of mindset and internal organization moved them to consider a gap in IT skills among the city's structure (Ebrahim & Irani, 2005). Chourabi et al. (2012) brought to the discussion security and privacy issues, the need to promote integration and interoperability between solutions, and their associated operational costs. Later, from a raw dataset of 212 barriers of energy projects, Mosannenzadeh, Di Nucci, and Vettorato (2017) ranked 35 final barriers, in nine categories, based on a quantitative approach. Moreover, insufficient funding and limited access to capital were highlighted, as well as social and legal matters. Recently, with similar dimensions, Rana et al. (2019) and Tan and Taeihagh (2020) have also reflected on this subject.

The evolution and implementation of the concept have not been noticed equally throughout countries and their territories, nor have their associated challenges.

In the case of Portugal, the first reference to a Smart City project present in the literature is made to the PlanIT Valley project in Paredes, a city in the north of Portugal. The vision was to create an environmentally friendly district where IT solutions could be developed, tested, and showcased. The Paredes municipality granted the project the exclusive rights to purchase 1,670 hectares of land at a low price, which provoked political contestation from the community and impacted political support. Together with the difficulties of soliciting private funding and with delays in delivery, the project failed to move forward (Carvalho, 2015; Carvalho & Campos, 2013).

Porto was one of the first cities to address the topic. In 2014, the city was covered by 15 hotspots and carried a project to implement a vehicular network of over 400 buses to provide free wi-fi internet access (Liberato, Alén-González, & Liberato, 2018). In addition, the sensing platform, UrbanSense, of the Future Cities project was implemented to collect critical environmental data from multiple city points to provide third parties with real-time and historical information (Luis et al., 2016). Their active participation in European projects (e.g., Synchronicity), the relationship with the FIWARE community, and the creation of Porto Digital Association to enhance ICT projects have helped the city to innovate (European Commission, 2017).

Lisbon has also been active in the establishment of European partnerships on this matter. For example, in 2016, the Sharing Cities flag project granted Lisbon 24 million euros. The project joined three lighthouse cities (Lisbon, London, and Milan) and three other cities (Bordeaux, Burgas, and Warsaw) to create living labs to test ideas and technologies (Camboim, Zawislak, & Pufal, 2019). In addition, over the years, the municipality made several mobile applications available to address specific needs and two open data portals—Lisboa Interactiva and Lisboa Aberta (Monteiro, Costa, Pina, Santos, & Ferrão, 2018).

Aveiro had the PASMO project, which aimed to provide vehicular communications, regular wi-fi access, and mobility services (parking, bikes, jams, weather). The plan was to install up to 175 parking sensors and four LoRa gateways to communicate with a dedicated platform and two environmental monitoring stations to measure multiple environmental parameters (Ferreira et al., 2017).

Vila Real piloted different public LED lighting solutions to assess and compare the savings level. These solutions could only work during specific periods of the night and when there was the presence of people, with embedded solar panels that charge the batteries of the luminaire during the day (Galvao, Moreira, Ascenso, & Leitao, 2015).

Évora was one of the cities of the project InSMART—Integrative Smart City Planning project—integrated planning framework for developing medium-term strategic sustainable energy action plans (SEAPs) at the city level (Gargiulo et al., 2017). The city of Évora is also piloting the InovGrid project towards a next-generation energy distribution system. An open platform is used for the integration of electric vehicles (EV), micro generations, consumers, producers, demand-side management, public lighting, storage, multi-utility architectures, cyber-security, data privacy, distributed energy resources (DER), and renewable energy sources (RES) (Godinho Matos et al., 2013). The REIVE project headed by INESC Porto aimed to develop a technological framework towards integrating EV in the Portuguese distribution grid, as an extension of InovGrid (Gouveia et al., 2015).

Costa, Machado, and Gonçalves (2019) presented several initiatives that Guimarães has launched. The focus was on inclusive mobile and web applications to break isolation barriers, promote urban sustainability, and conserve the environment and the natural heritage.

Nevertheless, there is insufficient data to design a detailed portrait of the country regarding the state of each city within the Smart City concept and the challenges there faced. The literature only gives information about specific projects implemented in a few cities. Smaller cities are mostly forgotten.

4.3. Materials and Methods

First, the methodology followed in this work is based on the content analysis of a Portuguese magazine dedicated to Smart Cities. This national-wide recognized data source aggregates and analyzes multiple stakeholder contributions. Otherwise, it would be challenging to obtain data to characterize the state-of-the-art of Smart Cities in Portugal with detailed historical information. Traditional methods lack a temporal character since data collection is performed at specific moments. This data source allows the study of the evolution of the subject based on the analysis of the direct contributions over the years. In addition, to complement the analysis and the understanding on the state-of-the-art of Smart Cities in Portugal, interviews with Portuguese policymakers were conducted. The main purpose was, on the one hand, to realize the existing challenges for the implementation of a Smart City, and, on the other hand, to understand the role and support of a sovereign body; in this case, the government, to promote these initiatives, by means of an interview with a Portuguese secretary of state.

4.3.1. Research Questions and Design

To conduct this study related to the state-of-the-art of Smart Cities in Portugal, two main topics of analysis emerge: 1) the study of existing initiatives in Portuguese cities, and 2) the evolution of the understanding of the concept. Therefore, the main research question is: "What is the state-of-the-art of Smart Cities in Portugal?" The sub-questions associated with it are: "What are the existing Smart City initiatives in Portugal?" and "What was the evolution of the understanding of the concept?" Figure 4.1 shows the methodological processes followed to answer each of these questions.

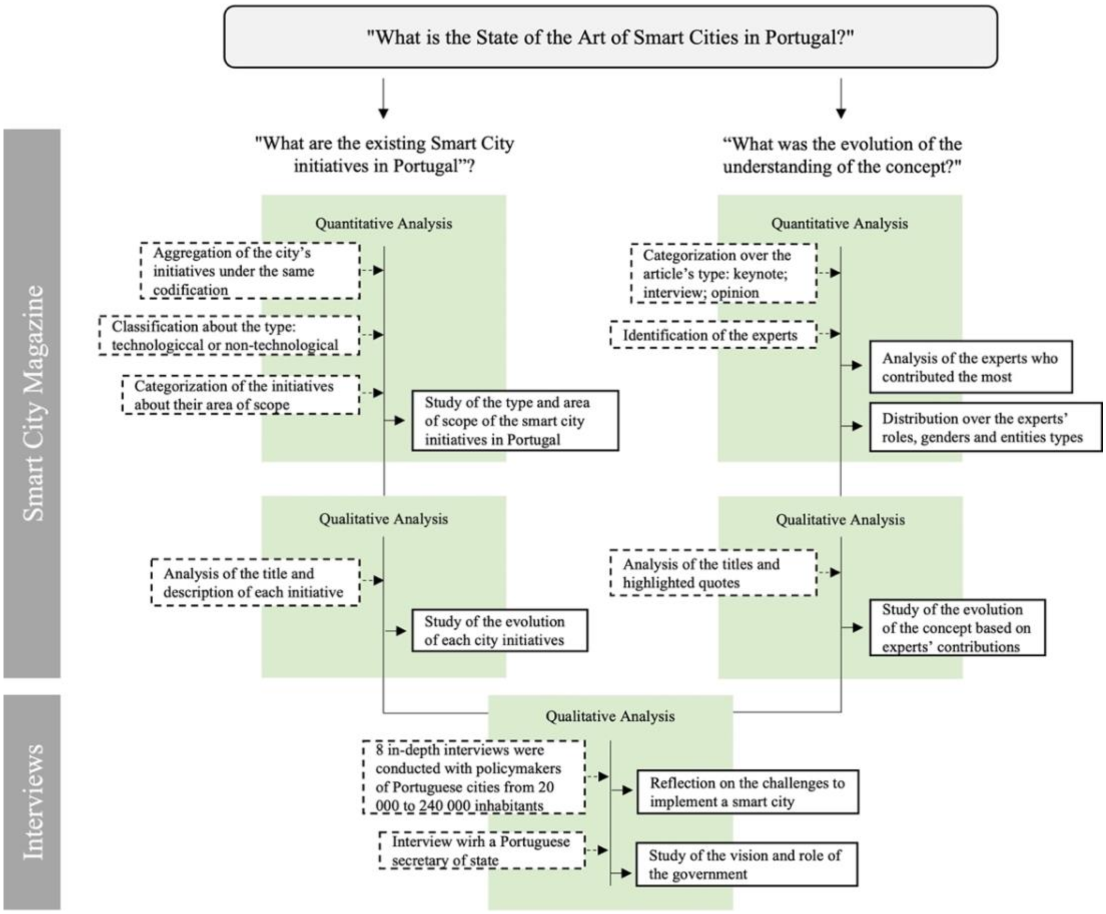


Figure 4:1 Methodology Framework

4.3.2. Sample Characterization

The editions of the magazine (Appendix 4.1) follow a standard structure, where first there is a keynote article and then several opinion articles and interviews.

The magazine is distributed free of charge to all Portuguese municipalities. It is the only journalistic source dedicated to the topic in Portugal. It is a reference publication on urban and territorial sustainability that bridges academia, public entities, and municipalities with companies that develop solutions to improve the management and sustainability of territories. In addition, the magazine aims to provide a channel to share best practices and empirical knowledge based on specialized journalistic work, to help policymakers and other professionals to understand and address urban challenges. Moreover, it is the main dissemination channel for knowledge of existing Smart City initiatives, reflections of critical players, and future perspectives in the area.

The magazine's first issue was released in 2015, and it published six issues per year; in 2016, it changed to its current quarterly format. In total, 25 issues, released between 2015 and 2020, were analyzed. The first three issues were not considered in the present study because they were not available. The magazine is in Portuguese, hence it is also essential to transfer the empirical knowledge to the English language to allow the scientific community to proceed with further research. The editions of the magazine follow a standard structure, where first there is a keynote article followed by several opinion articles and interviews. Until the 14th edition, there had even been a glossary, with terms such as Sharing Economy, eHealth, FabLab, Big Data, Bottom-up, Crowdfunding, Bitcoins, RFID, Gamification, Standard, Hackathon, Elevator Pitch, Unicorn, Millennials, SEO, Influencers, Circular Economy, Hydric Footprint, Fog Computing, and Downcycling/Upcycling. These terms were largely unknown by policymakers at the time. Over the years, the robustness of the projects increased, and the articles about implementations of Smart City initiatives began to dominate. As a result, the magazine moved from an informative and motivational perspective to a showcase for best practices.

In addition, eight in-depth interviews were conducted with policymakers from different Portuguese cities. This covered a range of cities from different regions of the Portuguese territory with different characteristics; the smallest one with around 20,000 people, and the largest one with around 240,000. The characterization of the policymakers' interviewed is given in Table 4.1.

Table 4:1 Policymakers and cities sample data

City	Role	Gender	Area	Population	Location
1	Vice-Mayor	male	environment, mobility and tourism	45,000	south
2	Councilor	male	social policy, innovation and tourism	20,000	center
3	Vice-Mayor	male	innovation, environment and energy	240,000	north
4	Vice-Mayor	female	environment, social and energy	35,000	north
5	Councilor	male	mobility and urban planning	140,000	center
6	Vice-Mayor	male	urban plan ning and mobility	40,000	north
7	Vice-Mayor	male	urban planning, innovation and mobility	210,000	south
8	Councilor	male	mobility and urban planning	190,000	north

The interviewed Secretary of State is male, and his work is related to innovation. A detailed characterization is avoided for ethical and non-disclosive reasons. Furthermore, all the data was anonymized. Participants were made aware of the purpose of data collection. All the necessary steps were taken following General Data Protection Regulation (GDPR).

4.3.3. Data Analysis

A thematic analysis carefully attributed codes and themes to each edition of the magazine. On the one hand, any reference to an initiative of a city was classified under the same code. After that, each city initiative was cataloged according to their scope and area to finally compare the city-state with the stage of the Smart City concept. The summary of the information is detailed in Appendix 4.2. Governmental initiatives, events, awards, and solutions were also coded. On the other hand, it was possible to structure the information about experts' reflections, either through opinion articles or interviews, to study the theoretical evolution of the concept and compare it with the literature. Also assisted by NVivo software (version 20.3.2), each quote was coded and associated with the expert case. The classification of each case allowed a further quantitative study of the roles and entities of the experts. The codification of each author's and interviewee's contributions allowed the prominent experts to be identified. In addition, quotes that had been highlighted, by the magazine, in each article and interview were also collected. This allowed us to build a matrix wherein the quotes were aggregated, according to theme, and by year. Furthermore, because the editions of the magazine were ordered chronologically, it was possible to summarize the chronological evolution of the Smart City concept according to the analysis of the quotes' content.

The interviews performed were also analyzed through content analysis. Data from the interviews was translated to English and analyzed. Furthermore, information about existing challenges was searched for and classified within policymaker feedback. In addition, the data collected from the interview with the secretary of state deserved an extended analysis and description to provide contextualized information and give readers the chance to acknowledge the positioning of the government about this subject.

Moreover, the content analysis of both approaches served as the basis for subsequent quantitative and qualitative studies to support the response to the research questions.

4.4. Results

This section aims to answer the two sub-questions: "What are the existing Smart City initiatives in Portugal?" and "What was the evolution of the understanding of the concept?" Therefore, first it gives an overview of Portugal through a qualitative analysis of the country's evolution, as noted in the magazine and complemented with empirical evidence, and provides the data, coded under governmental initiatives. After that, a quantitative analysis is performed for the area and type of initiatives present in Appendix 4.2, followed by content analysis. Understanding the evolution of the of the Smart City concept is realized through the qualitative analysis of the embedded interviews and content of the opinion articles. Thus, it was possible to perform an empirical study of the evolution of the concept, which closely matches with the literature. Finally, the challenges that Portuguese policymakers face when implementing a Smart City are highlighted, as well as the role and vision of the Portuguese government therein.

4.4.1. Portugal Overview

After a difficult economic period in Portugal, with a low level of investment, the European Union's 2014–2020 program brought a new impetus to cities.

In 2009, RENER emerged, the first Smart Cities network in Portugal. RENER was created under the "Mobi.E" program to prepare cities for electric mobility. The scope of RENER initially included 25 municipalities[1] (later 43). However, the interest in the topic of Smart Cities has only been consolidated since 2012, having gained momentum from the anticipation of existing funding opportunities on the European agenda. In 2013, the Smart Cities Portugal Cluster emerged to promote innovative integrated urban solutions and cooperation between companies, associations, universities, RandD centers, municipalities, public bodies, and civil society. In 2015, the government approved the Sustainable Cities 2020 Strategy. In addition, the Smart Cities section was created, with 136 municipalities, within the National Association of Portuguese Municipalities (ANMP), which replaces RENER, and aims to promote the discussion within five different areas: governance; energy, environment, and patrimony; mobility; society and quality of life; and economy and innovation.

In 2017, the Smart Cities Tour initiative was created to promote an annual roadshow with workshops in different regions of the country dedicated to relevant topics within the scope of Smart Cities, allowing the exchange of experiences and knowledge between participating municipalities. The end of the tour is marked by a formal event, entitled the Mayor's Summit. In addition, an initiative named "Living Laboratories for Decarbonization (LVpD)," an initiative of *Fundo Ambiental* was launched to allow cities to become real living labs and implement technologies, reducing carbon emissions. The projects were implemented in several Portuguese cities, i.e., Almada, Maia, Matosinhos, Águeda, Loulé, Alenquer, Seixal, Mafra, Braga and Évora. However, this was not the only policy to incentivize the development of Smart Cities. The government initiatives promoted to accelerate the adoption of solutions and implement new projects are shown in Table 4.2.

Table 4:2 Portuguese governmental funding initiatives

Year	Initiative	Description
2015	Cidades Analíticas	One international conference, five regional workshops (sharing of best practices and funding opportunities), and one award of a €5000 prize to the best national project in this area.
	Cidades Sustentáveis 2020	Strategy-guiding document aligned with Portugal 2020 and with the territorial options on the strategic instruments of spatial planning policies; establishes a reference framework for sustainable urban development in Portugal.

[1] Viana do Castelo, Braga, Guimarães, Porto, Vila Nova de Gaia, Aveiro, Coimbra, Leiria, Santarém, Torres Vedras, Loures, Sintra, Cascais, Lisbon, Almada, Setúbal, Faro, Beja, Évora, Portalegre, Castelo Branco, Guarda, Viseu, Vila Real, Bragança.

2016	ClimAdapt.Local	1.5 million-euro budget for local strategies to combat climate change.
	2020 National Strategy for the Air	Creation of a 160 million-euro-per-year fund—Fundo Ambiental—to achieve fossil fuel independence by 2050. Living labs focused on combating climate change and was included in promoting a participated and discussed environmental culture.
2017	wi-fi in Historic Centers	1 million euros of funding available for wi-fi in Portuguese historical centers.
	U-Bike	5.3 million euros available to encourage the use of bicycles in universities.
2018	Social Innovation Portugal	150 million euros to finance innovation and social entrepreneurship initiatives.
	Living Laboratories for Decarbonization (LVpD)	12 projects received an average amount of 500 thousand euros from Fundo Ambiental to develop and experiment with technologies that improve citizens' quality of life and combat climate change.
	Participatory Budget Portugal	3 million euros is the yearly amount available for the national participatory budget.
2019	Cidades Circulares	1.5 million euros from the Fundo Ambiental is the total amount allocated for 2019–2021 to support and empower municipalities and their communities to transition to a circular economy. Establishment of partnerships between Portuguese municipalities called Redes Cidades Circulares (RC2) to submit joint applications. Cities and the community find a place to share and disseminate knowledge on these topics on the InC2 portal

4.4.2. Smart City Initiatives in Portugal

Concerning the results obtained (Figure 4.2), it is possible to verify that Smart City initiatives in Portugal are divided into the following areas: cultural (5.62%), economy (3.37%), energy (4.49%), environment (13.48%), governance (8.99%), mobility (23.6%), social (24.72%), strategy (7.87%), and urbanism (7.87%). Furthermore, regarding their type, 70.8% correspond to technological initiatives and 29.2% to non-technological ones.

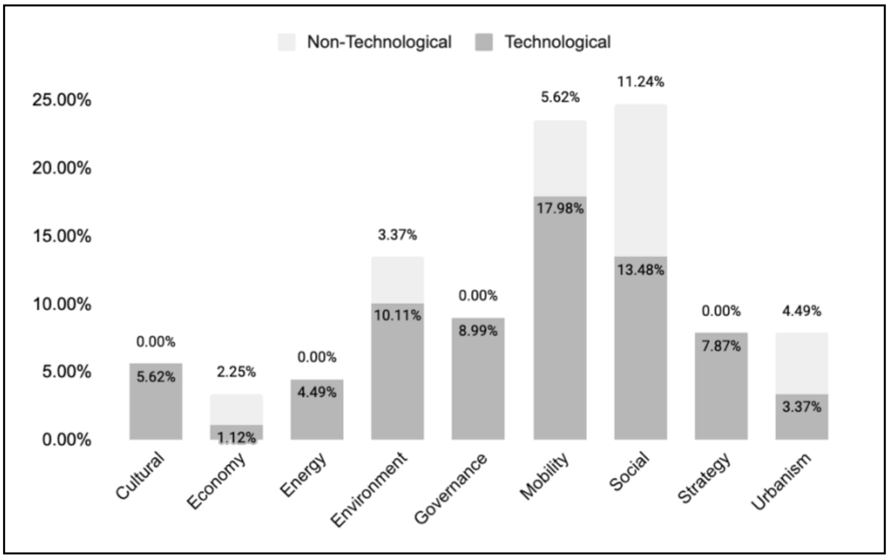


Figure 4:2 Area and type of the Smart City initiatives

For each of the areas, through data harmonization and aggregation, it is possible to understand, in qualitative terms, what the existing technological and non-technological initiatives are. Table 4.3 details the content analysis of the data collected in Appendix 4.2. The initiatives were aggregated by area. For its technological types, the content of each area was sorted from the most technological to the least technological.

Table 4:3 Description of the Smart City initiatives according to their area and type

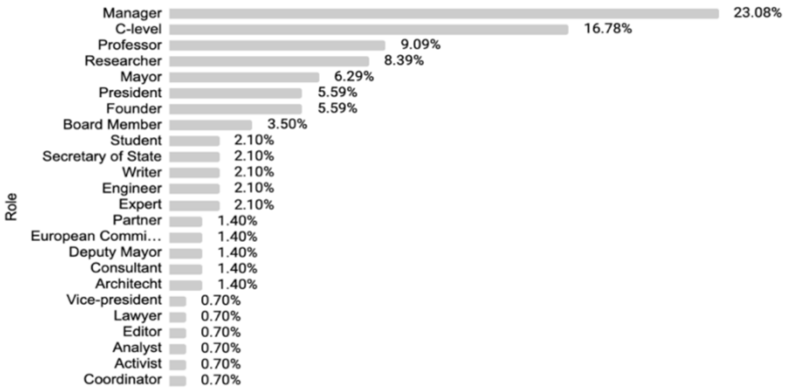
Area	Description
Cultural	• Technological: The implementation of beacons to enable interaction with monuments and the development of mobile applications to guide and provide helpful information to citizens and tourists about the city's points of interest.
Economy	• Technological: A platform for the certification, promotion, sale, and distribution of regional products for local producers. • Non-Technological: Securing the private sector to create conditions for innovation and entrepreneurship and encouraging the creation and maintenance of local commerce through low rents.
Energy	• Technological: Public lighting management platform to collect consumers' consumption data to parameterize usage profiles and remotely control the luminaires (LED); the integration of electric vehicle charging stations.
Environment	• Technological: A latform for reporting environmental events or the need for waste collection. Waste management system with filling-level sensors or pa PAYT (pay-as-you-throw) system with access-card reading allows the weight of waste produced by each citizen to be recorded. Installation of onboard computers in collection trucks for route optimization; the placement of sensors in urban cleaning equipment to monitor the service in real-time; remote real-time management of irrigation in green spaces; the monitoring of air quality and CO2 consumption and emissions in water supply and wastewater sanitation systems. • Non-Technological: The creation of a natural lake, forests, and the promotion of natural regeneration to respond to climate change; the implementation of an observation space of best practices to involve the community; placing green roofs on city buildings for precipitation retention, increasing green areas, and improving thermal comfort and soundproofing, CO2 capture, and lifetime; the separation of domestic waste into waste bags provided by the city.
Governance	• Technological: An urban intelligence platform to support daily operations, public space management, and occurrences, based on the services and sensors installed in the city; an open-data portal; the sharing of information and knowledge with the dissemination of specific solutions in the field of urban intelligence; the dematerialization and streamlining of decision-making processes using a digital platform to enable submission and collaborative work on proposals, consulting the documentation, following up the decision-making process, and executing pending tasks.
Mobility	• Technological: Technological platform aggregating the city's urban transport network with various transport service operators, infrastructures, and equipment; a mobile application with transport schedule, location of docking stations, number of bicycles, and car parks; the integration of payments and user data collection to map urban travel, with the aim of co-building the city, matching mobility policies to actual needs; a multimodal pass for citizens; the implementation of bike-sharing systems (free of charge) with electric and regular bicycles; the acquisition of electric buses; and the implementation of signage with directional plates and charging stations for electric vehicles. • Non-Technological: Building and consolidate green spaces with walking lanes and cycling paths; promoting sustainable mobility by encouraging homework cycling; preventing the circulation of vehicles before 2000 in the city center, and all vehicles on Sundays.
Social	• Technological: Mobile application with direct communication channel between the citizen and the city that allows processes to be streamlined, integrated with the incident management system, ensuring more proximity, and encouraging the involvement in initiatives, events, and decisions of the city; the cemocratization of access to new technologies through the provision of equipment and specialized technical support to the community; creating physical spaces for experimentation and active cooperation provides an innovative and creative environment; an open data platform establishes a dialogue point for sharing ideas and collaboration between citizens, universities/schools, municipalities, and companies; a mobile application for direct communication with emergency bodies, that contemplate the clinical historical information, age, real-time GPS location of the citizen, and the details of an emergency contact; psychological

	evaluations, and motor rehabilitation sessions are promoted, provided through a dedicated platform and free of charge. • Non-Technological: Exercise citizen participation for collaborative diagnosis, presentation of proposals, and experimentation of the solutions by the community; placing technicians to perform exercises that allow the maintenance and development of motor skills in the elderly in the most isolated locations; intensive programming boot camps are paid for only by those who get a job later; facilities prepared and designed to accommodate sports for people with disabilities; the use of environmental education to connect citizens to the conservation initiatives of the natural heritage of the municipality; housing support programs seek to respond immediately to people who experience a sudden lack housing or live-in undignified housing conditions; offering land priced at one cent, with the licensing project fee and education fees paid by the municipality to retain young people.
Strategy	• Technological: The installation of air quality, noise, meteorological and ultraviolet sensors, street lighting technology, traffic measurements, urban waste management, and alarm management associated with civil protection services, as well as in other areas such as mobility, energy, culture, heritage, and urban rehabilitation to predict situations and respond preventively and proactively; a control center to manage data through an urban platform; the implementation of 5G infrastructures; challenges to the local community and creation of urban intervention spaces open (Fablab) to experimentation and co-creation, with the allocation of technology-based types of equipment (such as 3D printers).
Urbanism	• Technological: Dematerialization of submission processes and online consultation of documents, such as licensing of works and urban projects. • Non-Technological: Rehabilitation and standardization of buildings facades and improvement of their internal conditions.

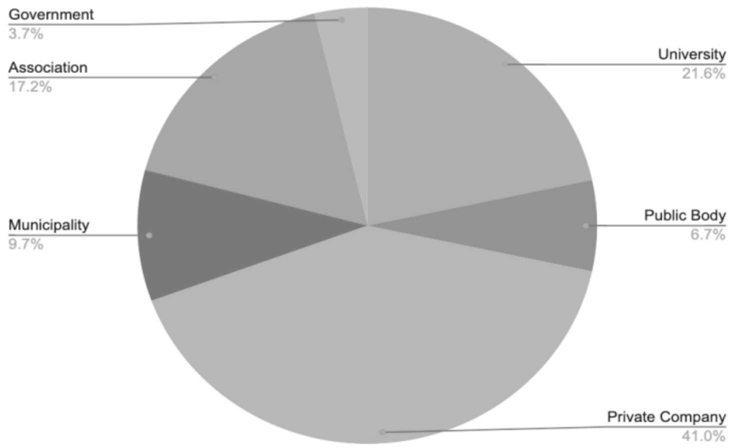
4.4.3. Identification of the Magazine' Contributors

Figure 4.3 shows the distribution of the experts' roles and types of entities. Most are from private entities (41%), which allows a relevant empirical contribution to be obtained that is often scarce in the literature. Nevertheless, a heterogeneous group is represented in the sample. There are people from universities, associations, municipalities, public bodies and with governmental responsibilities. Figure 4.3 also mirrors their high-level and prestigious roles; 23.08% are managers, and 16.78% are C-level representatives, but there are also professors, researchers, mayors, secretaries of state, and European commissioners, among others.

Of the people who contributed the most to the magazine, we identify Paula Teles (five times), Miguel Castro Neto (four times), Ana Fragata (three times), Catarina Selada (three times), and José Gomes Mendes (three times). Although the gender relationship is well distributed among the top five contributors, this is not the case in the overall figure. About 73.4% of the interviewees or authors of opinion articles are men. This fact may reveal little gender equity on the topic. The sample only considered the keynote articles, interviews, and opinion articles. However, there are some individuals – such as Vítor Pereira and Jorge Máximo – deserve mention, as they have periodic columns in the magazine that reflect on current related issues.



(**a**)



(**b**)

Figure 4:3 (a) Classification of the roles of the magazine's contributors; (b) distribution of the entity types of the magazine's contributors.

4.4.4. Evolution of the Concept

In 2015, Horizon 2020 and other dedicated research programs were seen as "essential to reduce differences between regions and ensuring growth across Europe" (European commissioner). Moreover, that Horizon 2020 promoted joint initiatives between entities from different European countries may have changed the decision-makers' mindsets. It enhanced the collaboration between stakeholders and promoted open data cultures for creating innovation hubs for the community and constituting "multidisciplinary teams and collaboration models based on open innovation" (university professor).

The collaborative models were already evident during the technological disruption phase (Smart City 1.0) through additive manufacturing. It was pointed out as the engine of evolution for the self-manufacturing paradigm through the ideology "Do-it-Yourself", to democratize innovation (private company manager). On the other hand, social networks were still adjectivized as "a mobilizing force" (association president).

The evolution of the concept (Smart City 2.0) was noted by the refusal of "technological determinism" (private company manager), studies of the usage of urban services to help policymakers decide which were the "most appropriate technologies towards the defined goals" (university researcher), and a growing concern with the participation of citizens' and cities' sustainability, over the fact that citizens had to have an "environmentally sustainable behavior" (public body director), and the learning experience that when "the goal is a need manifested by the community, things happen" (secretary of state).

Mobility and energy took significant roles to "combat the aging of society and the cost of caring the elderly" (private company founder), and to conciliate the population growth with "policies that responded to a complex and social demanding organization" (university professor). Moreover, the need emerged to "integrate energy efficiency measures in urban rehabilitation processes" (mayor). At the same time "shared mobility was an unavoidable trend" (private company manager), and increasingly seen as a "service and not a product" (public body president), where "autonomous vehicles promised to have a huge impact on urban life" (researcher). At the same time, "equity and inclusion" were reflected upon, in terms of access to transport (writer). Nevertheless, references were also made to other areas, namely health, with regards to the need for the health system to "put people at the center of its activity" (private company C-level), and to simplify legislation (private company manager).

Over the years, several concerns were raised. Among them were data security (university professor); the lack of standards to promote the integration of solutions (private company manager); the fact that rural areas were forgotten (private company C-level); and the creation of non-child-friendly cities (researcher).

Furthermore, it was said that cities needed first to "create the market and not the other way around" (foundation C-level), not forgetting that "people express their happiness through votes" (public body vice-president).

Moreover, there was a growing discussion about citizens' involvement, raised primarily by international experts, namely the need to first "create the debate" (private company president) and to build the foundations of a Smart City strategy with a combination of bottom-up and top-down approaches (association founder). In addition, decision-makers needed to critically reflect on "who belongs, who plans and who makes the city" (sociology expert). Cities should not replace human input or risk being "equal to all other places" (association founder). Therefore, policymakers must not isolate themselves from the people's realities to "build the necessary confidence to lead them participating in the decisions" (mayor).

Participation remained a challenge for cities; citizens only "connected to the government when something was wrong, to understand what the government was doing and why" (private company manager). In the industry, “there are no moral values” (foundation C-level).

Co-creation and co-governance (Smart City 3.0) only became constants in 2019, when it was recognized that “it was necessary to build communities in which everyone participated” (neuroscience expert). Moreover, collaborative ecosystems would facilitate innovation by creating “connections between citizens, governments, companies and educational institutes” (association founder).

Urban and mobility planning (private company C-level) have recently taken an even more relevant dimension with the COVID-19 pandemic and the need for cities to be resilient in responding to urban challenges and citizens’ basic needs. Therefore, a growing trend is to remove road space for traffic and “return it to the city, inviting people to walk” (secretary of state). Allied to this, the perspective of remote work accelerated digitization, raising the need to “create innovative models to overcome the distance” (secretary of state), which is closely related to the evolution of Smart Cities and the need to think about collaborative models and proximity dynamics.

4.4.5. Challenges and the Role of the Government

The main findings of the existing challenges obtained through the qualitative analysis of the interviews are shown in Table 4.4.

Table 4:4 Challenges of Smart City implementation

City	Challenges
1	Finding companies to meet the objectives. High level of bureaucracy in public procurement processes and project definition, which makes the implementation of solutions time-consuming.
2	Lack of knowledge, mindset, and expertise in the organization. Inability to think about and execute projects beyond the guidelines of the existing European funding opportunities.
3	There is a great challenge in the ability to use data, since they are owned by various public and private stakeholders. Moreover, the fact data are not in the public sphere and the fact that there is no concept of information management promoted by sovereign entities to leverage their integration challenges the implementation of Smart Cities.
4	The main challenge is financial; there are not enough internal resources, meaning that it is necessary to subcontract external services, which does not allow for the autonomous development of the projects and difficult access to funds.
5	The biggest challenge is the public procurement code because of the existing bureaucracy and the fact that there is no knowledge of methods for defining the requirements for solutions. Therefore, they are specified according to a specific party solution. Thus, it leads to mistrust of competitors and processes are embargoed for undefined periods, slowing down the strategies.
6	Essentially technological; on the one hand, the training of human resources to operate the new systems and, on the other hand, the high costs and the reliability/uncertain durability (the solutions are constantly being updated). Additionally, the delay in the solutions delivering delays advancement. Maintenance and monitoring are done only by few entities.
7	The greatest challenge is in data integration while respecting data privacy and integrity.
8	The main challenge is the administrative (bureaucratic) component of opening procedures. Susceptibility to litigation and conflict, many delays due to the objection and impugnation. Additionally, financial resources are scarce. Data integration and privacy also pose challenges.

From the interview with the secretary of state, it was understood that Smart Cities are a transversal topic across the various ministries (e.g., economy, digital transition, and environment), meaning there is no dedicated body. The government's main concern is to look holistically to the country rather than urban centers and find the best solutions for each specific case. Moreover, it is stated that the city's strategy is the competence of local authorities. The government is responsible for influencing and making the necessary financial resources available. The secretary of state gives the example of the implementation of bike lanes, "where the government did not support their construction in cities but force their agreement to connect them in inter-city projects."

Furthermore, the national Smart City strategy that is being drawn up for the coming years has the priorities of sustainability and inclusiveness, and is based on three axes: integrated planning (implementation of Smart Cities and efficiency of public spending); scalability (extension of pilot projects), and interoperability (common principles that are shared across borders). With this national approach, the goal is to consider existing projects as best practices and to disseminate them between municipalities. The principles of the strategy are determined within the structure of the ministries. However, it will not fail to reflect the priorities defined by the government. Nevertheless, citizens' participation is not formally contemplated nor is there a formally defined methodology to guide policymakers' actions within the city scope.

4.5. Discussion

The literature enunciates several barriers, from social participation to financial capacity. Furthermore, from the analysis of Table 4.4, a pattern is noted in terms of the existing challenges that Portuguese policymakers face. First of these barriers is the lack of knowledge and skillset within the organization; second, the bureaucracy in public procurement processes; third is the lack of data in the public sphere and capacity of data integration. A final barrier is the scarcity of financial resources and the cost of solutions acquisition and maintenance.

Furthermore, and also noticed throughout the empirical study, were the inexistence of references to the proposals of EIP-SCC and the guidelines for the development of Smart Cities of the Strategic Implementation Plan (SIP) and Operational Implementation Plan (OIP). This reinforces the existing gap between the proposals of sovereign bodies identified in the literature and their translation to concrete local action plans to guide policymakers' decisions.

As noticed above, the interest in the Smart Cities topic increased with the anticipation of existing funding opportunities in the European agenda. European cities have taken advantage of the financing instruments available for these matters. The promoted initiatives are based on partnerships with other European cities, private entities, and academia, contributing to the logic of collaboration and innovation that underlines the Smart City concept. Nevertheless, two interesting instances of feedback were expressed: first, by Policymaker 2, about the inability to think and execute projects beyond the guidelines of the existing European funding opportunities, and, secondly, by Policymaker 3, about the lack of an information management standard approach promoted by sovereign entities. This means, on the one hand, that funds can act oppositely to their intended use if cities have to adjust their approaches to fit in specific demands and, on the other hand, the dependencies that territories feel concern them about concrete guidelines on this subject.

In recent years, Portuguese municipalities have had the possibility of using European funds from programs such as Horizon 2020, COSME, ERDF and ESF, LIFE+. Nevertheless, these resources are not directly related to Smart City projects. Although they focus on research and innovation in the areas of energy, transport, climate action, and resource efficiency, and support the development of skills and expansion of companies, they lack the promotion of initiatives focused on the development of holistic and sustained strategies. Despite the impetus of European Commission programs, two of the main tools for the development of the European Smart City initiatives have been the creation of clusters and living laboratories (Alaverdyan, Kučera, & Horák, 2018). In recent years, many cities, such as Barcelona and Vienna, have become the stages of pilot projects for new solutions, fostering innovation and collaboration between the public sector, companies, and academia. The same happened in Portugal. Twelve cities had 500 thousand euros to implement innovative solutions through the LVpD. Nevertheless, the questions that arose were about the continuity of the projects and the approaches, since neither the Smart Cities section of the National Association of Portuguese Municipalities (ANMP) nor the Smart Cities Portugal cluster that join the remaining stakeholders promoted the design of standard holistic approaches rather than the promotion of the best practices of isolated projects.

In terms of the evolution of the Smart City concept, Horizon 2020 has also helped to adapt policymakers' mindset. Perhaps because the sample data was from 2015 onwards, it is possible to notice from the beginning of an evident concern of citizens, one aligned with the evolution of the concept noted in the literature. However, initially, this reflection was still very much associated with how citizens should behave and the potential of tools to sensitize their participation. The evolution that the concept underwent in the literature from Smart City 1.0 to Smart City 2.0, between 2008 and 2012, is noted in the magazine on Portuguese cities after 2016, where technology started to be employed to solve urban problems towards defined goals, and from which the concern for sustainability and the participation of citizens arose. Co-creation only became a constant in 2019, with the transition from Smart City 2.0 to Smart City 3.0 toward building collaborative ecosystems to enhance innovation and citizen participation.

Despite Figure 4.2 portraying a more significant percentage of technological initiatives, Table 4.4 indicates that there is no clear technological motivation without an association with the aspect of sustainability. At the same time, there seems to be a growing effort to promote civic participation. Moreover, although the literature mentions the existence of three phases of the concept, the first had a purely technical nature led by private entities. The second was associated with promoting sustainability and quality of life and the third was focused on collaboration and co-creation of strategies. In Portugal, they can be perceived in slightly different ways.

As Portuguese Smart Cities did not have initial projections, as in other countries, it is not clear that they experienced the classic Smart City 1.0 phase. That is justified by the lack of deep tech initiatives based on the development and implementation of disruptive technologies. As a result, very few initiatives are mirrored, in Appendix 4.2, from the initial editions of the magazine.

Therefore, Smart City 1.0 is not assumed to have happened, in Portugal, by implementing technologically disruptive solutions but rather by isolated initiatives, largely pilots, without an apparent holistic strategy. While in smaller cities (such as Alcobaça, Alfândega da Fé, Azambuja, Castelo Branco, Lamego, Lousada, Melgaço, Odemira, Vimioso, and Vizela) they focus on implementing specific verticals to address existing gaps, larger cities, on the other hand, have associated a strategic vision for the territory (Smart City 2.0). More than implementing small projects or pilots, the cities are committed to urban digital transformation. On a higher level, the cities of Abrantes, Aveiro, Águeda, Braga, Cascais, Guimarães, Lagoa, Lisboa, Maia, Oeiras, Porto, and Vila Nova de Gaia promote collaboration and co-creation with citizens (Smart City 3.0), as summarized in Table 4.5.

Table 4:5 Portuguese Cities association over the Smart City concept stage

Stage	Summary	Description	Cities
Smart City 1.0	vertical projects	Isolated initiatives, pilots, and proofs of concepts.	Amadora, Bragança, Angra do Heroísmo, Beja, Caldas da Rainha, Coruche, Cuba, Elvas, Fundão, Leiria, Oliveira de Azeméis, Sintra, Setúbal, Santarém and Vila Franca de Xira
Smart City 2.0	integrated strategy	Integrated management supported by technology to promote the quality of life of citizens and city's sustainability.	Braga, Caldas de Rainha, Esposende, Évora, Lagoa, Loulé Matosinhos, Porto, Seixal, Torres Vedras and Viseu
Smart City 3.0	collaboration and co-creation	Promotion of collaborative dynamics and co-creation of strategies with citizens.	Abrantes, Aveiro, Águeda, Cascais, Guimarães, Lisboa, Maia, Oeiras and Vila Nova de Gaia

The differences between cities, regarding their development phase, is noticeable. In smaller cities, the solutions are implemented in specific verticals to increase efficiency with a quick payback. Moreover, in recent years the focus has been given, for example, to changing street lighting to LED sources, and, in some cases, the preparation of the luminaires for the remote control and regulation of their intensity, and to the implementation of electronic systems for measuring the tension and flow of water pipes for anticipating ruptures and controlling leaks.

In larger cities, a concern for holistic and integrated views of the city is noted. Cities are committed to their digital transformations and have a data-driven decision-making logic, where they gather data via an integrated management platform to support policymakers' decisions. The information is processed and transmitted in real-time to this control center and urban observatory to concatenate sensor data in the territory and anticipate problems. In addition, there are already cities implementing gamification-based applications to award citizens whenever they have environment-friendly behaviors, and to promote participation through technological tools that allow instant interaction with citizens in order to receive their suggestions and concerns. Smart cities are increasingly based on a holistic perspective. Moreover, the funding sources will cover the entire strategy rather than isolated projects for each of the verticals. The evaluation of grants should also be carried along the urban development strategy, wherein the evaluation committee would have a multidisciplinary team to ensure strategies have adequate orientation. The strategy could be divided into several stages with clearly defined milestones. This would require the city to promote a collaborative co-creation process with citizens and respond to the heterogeneity of its territory.

Although there is a national Smart City strategy being designed, the goal is mentioned to keep with only high-level guidelines and the dissemination of the existing best practices in initiatives. The issue is the scarcity of holistic strategies in the territory—there are still foundations and standard guidelines that are still missing.

4.6. Conclusions

The present paper reviewed the state-of-the-art of Smart Cities in Portugal through content analysis of a Portuguese Smart Cities magazine, supported, essentially, by empirical knowledge and by interviews conducted with policymakers and a secretary of state.

Our results showed that Smart City initiatives, in Portugal, are mostly from the mobility and social areas, followed by the environment. In addition, 70.8% correspond to technological initiatives and 29.2% to non-technological ones. Nevertheless, there is no clear technological motivation without an association with the sustainability and efficiency aspects. Deep technology and breakthrough solutions are not mentioned. The articulated initiatives aim to promote urban regeneration and development towards meeting citizens' cultural expectations while improving quality of life. At the same time, there seems to be a growing effort to promote civic participation.

This paper also highlighted the contributors to the development of the Smart City topic in Portugal. Our results show that, although gender was well distributed among the top five contributors, the same was not true of the overall figure. About 73.4% of interviewees or authors of opinion articles are men. This fact may reveal poor gender equity within the topic.

By means of qualitative analysis of the content of the interviews and opinion articles, it can be observed that the evolution of the concept closely matched the literature. Indeed, the three stages of the concept can be observed in different cities of the territory. Moreover, the literature mentions the existence of three phases of the concept: the first is of a purely technical nature, led by private entities; the second is associated with promoting sustainability and quality of life; and the third is focused on collaboration and the co-creation of strategies. In Portugal, the three phases are perceived in slightly different ways. Due to the challenge of accessing funds, smaller cities have been only able to establish vertical and isolated projects to respond to pressing challenges (Smart City 1.0). On the other hand, the larger cities are divided into those with integrated projects (Smart City 2.0), and those that have followed the evolution of the concept and are focused on promoting citizen participation (Smart City 3.0). Ultimately, Portuguese cities are framed by their respective phase.

In summary, Portugal did not follow the three Smart City phases; nevertheless, there is great heterogeneity within the country, probably motivated by the lack of funding and knowledge. The portrait of the country is detailed with respect to the positioning of Portuguese cities within the three phases of the concept.

Although the number of initiatives and funding are scarce, it is possible to notice their focus on promoting participation, collaboration, transparency, and, above all, the fight against climate change. However, these initiatives prove not to be inline and integrative, making it challenging to define a Smart City strategy. This may have led cities to adapt their strategies to meet the scope and requirements of each funding opportunity, thereby losing sight of the overall logic that was at their strategies' origins. Moreover, based on the careful reading and analysis of the magazine’s content and the initiatives there enunciated, access to funds has been one of the main drivers of Smart City initiatives in Portugal. Cities with integrative projects have funding from national or European programs in common, concluding that cities are very dependent on financing opportunities to support these investments. It may also reveal the discrepancy between those cities with financial support and those without, which is directly associated with their dimension. This fact puts the continuity of projects at risk, which may be why there is a lack of medium and long-term strategies.

Furthermore, most of the government initiatives were promoted through *Fundo Ambiental*; however, it lacks a holistic approach to funding strategies in isolated initiatives and pilots. The LVpD initiated that vision, but several questions emerged, such as how to address each city's ability to define whatever strategy they wished, and about the follow-up of strategies implemented in living labs. The lack of methodologies and prospective funding can lead to being discredited within the population and to its disregard of future innovative approaches by policymakers. Future work should study the actual state of the projects funded under the European Commission scope and the reasons behind their successes or failures after the end of the projects. In addition, the reflection on the factors and KPIs that dictate and evaluate the success of an initiative may emerge. However, the Portuguese government is aware of the subject and is willing to create a dedicated strategy. Yet it is expected to only give high-level guidelines of the focus areas for establishing projects. It lacks legislation and standard frameworks to help policymakers comprehend and implement Smart City strategies, while the discrepancy between territories is acknowledged and combated with specific policies. In addition, is necessary to promote the discussion of the role of sovereign bodies and legislators, and of how European guidelines can be translated into local actions.

As a limitation of the study, all existing city initiatives may not be portrayed in the magazine, and therefore in this paper. This study serves as a benchmarking effort for academic use of the information about the state-of-the-art of Smart Cities in Portugal in supporting further study. International experts were the first to raise the need to reflect on citizen-participatory methodologies. The COVID-19 pandemic accelerated the urban planning discussions aimed at finding proximity and collaborative models to respond to urban challenges and citizens' basic needs. These topics may also be considered in future work.

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Appendix 4.1 – Smart City Magazine Data

Nr	Date	Title	Subtitle	Keywords on the Cover	Foreword
4	Jan/Feb 2015	Barcelona	Gaudí, Las Ramblas, history, tapas, and football give soul to Europe's Innovation capital. *Benvingut* to Catalonia!	PlanIT Valley reborn; Do we have a Smart Government?; Trends for 2015; Digital health in Europe	Smart Cities: Freedom and Inclusion
5	Mar/April 2015	Urban Art	The streets are colorful, touristic, and supportive. Embraced by cities, street art is revolutionizing public space. Meet the new urban galleries.	To Uber ride; Energy-Producing Citizens; Mobile: The Hyperconnected World; Fiware, APPs for all	Cities with Soul
6	May/June 2015	Do It Yourself	Fablabs are bringing the workshops back to the cities.	Budapeste em Mudança; Há Greve?; Lost Lisbon; Cidades 2020	365
7	Jul/Aug 2015	Do you still use cash?	Payments via the smartphone will give vacation to your wallet. Discover the cashless world.	Internet of Things; Street Food; Technological Coruña; Is your cell phone broke?	The arrogance we lack
8	Sep/Oct 2015	There are tourists in the neighborhood	Millions arrive to get to know our cities. Lisbon and Porto are the world tourism center of attention, but will it be possible to host, in the historical streets, tradition, visitors, and residents?	Art in the City; New Orleans; Autonomous Cars; Tech Giants	What is, after all, a Smart City? Does anyone know?
9	Nov/Dec 2015	Lisbon Hub for innovation	Lisbon is the scene of a creative explosion never seen before, which gives visibility to the city and Portugal worldwide. Irresistible to innovation, the Portuguese capital is convincing.	Fragmented Brussels; Towards Barcelona; Survive the Climate; Amadora in cartoon	The constant that makes the wills move
10	Jan/Feb/Mar 2016	Do you trade with me?	From time banks to Airbnb, a new form of economics wants to change the world. But what is this phenomenon of the Sharing Economy after all?	Around the World; Benita Matosfka; Thinking the light; Smart Homes	Zoom to ZOOM
11	Apr/May/Jun 2016	Vegetable gardens in the City, already have yours?	More and more people are dedicated to urban agriculture, and cities can only gain from it.	Portugal Summit; Sharing Cities; Goal: Decarbonization	Simplicity
12	Jul/Aug/Sept 2016	#Citizen	Collaborating and co-creating are the keywords of today's urban leaders. A new form of citizenship is gaining momentum and they are all summoned!	Right to the city; Venice Biennial; Zoom Smart Cities; Saskia Sassen	Numb European Innovation
13	Oct/Nov/Dec 2016	Cycling in the city	Bicycles are fashionable and exist for all tastes. The two wheels are conquering more fans, and cities are contributing to it.	Urban Identity; Smart Portugal; Industry 4.0	Architechts and Smart Cities
14	Jan/Feb/Mar 2017	Change of life	When it comes to choosing a destination to live in, it is not just the big cities with the upper hand. In an intelligent approach, smaller territories are gaining prominence.	Economy 360; Songdo, U-city; DREAM; Smart@PT	2017, the "year zero" of Smart Cities in Portugal
15	Apr/May/Jun 2017	Old, like us	The aging of the population is one of the most significant challenges of our century. Cities have to adapt to the needs of older people and learn to take advantage of the much they have to offer.	Pedal deliveries; Digital democracy; Urban Melodies	Smart cities um sonho que pode virar pesadelo
16	Jul/Aug/Sept 2017	Where do you train?	From private gyms to public spaces, there is more and more options to choose. Cities are committed to getting their citizens into training.	Bike Holidays; Happiness in the City; The Future of Water	From Matrix to the city you experience
17	Oct/Nov/Dec 2017	Welcome to the Electric Era	Cars, buses, scooters, etc. The era of electric mobility is coming. May this transformation help to return cities to people.	Best Practices; Varanasi, Light City; Klaus Bondam	No room for manoeuvre
18	Jan/Feb/Mar 2018	Cities under pressure	In Portugal, the drought of recent months has soared the bell: water is not a certainty. In our cities, water management goes far beyond saving on tap.	Lisbon Beer District; Chuck Wolfe; Moscow	What is a Smart City?... Again!
19	Apr/May/Jun 2018	Ensemble Music, Art, Territory	More than music shows, festivals are a point of communion between economic development, arts, and territories' identity.	Bettina Tratz-Ryan; Ticketing; New Digital Agreement	Break barriers and abandon old habits
20	Jul/Aug/Sept 2018	Portugal Smart Destination	Smart tourism is a great opportunity, and cities are learning to take advantage of it. Learn how.	Parking; Architechture	Who got the highest card?
21	Oct/Nov/Dec 2018	People on the move	The latest mobility trends bring innovative and more sustainable modes to urban space, but their success always depends on planning.	Human Rights; Urban Mobility; Happiness	Commitment

22	Jan/Feb/Mar 2019	Brake on waste	The circular economy comes not only from the separation and recycling of waste but also from sharing and a new approach to consumption.	Hi-Tech Health; Central Madrid; Smart City Expo	Self-help for sustainability
23	Apr/May/Jun 2019	The City that makes you happy	The secret to happiness is also in cities. Learn how to find it.	Authentic Urbanism; Transports; Charles Montgomery	Cities that generate happiness
24	Jul/Aug/Sept 2019	Electrical mobility connected to the mains	While we change fuel, cities prepare to be the stage of the great energy transition.	Special Mobility; Portugal Smart Cities Summit; Co Project Farm	Act against the "normal"
25	Oct/Nov/Dec 2019	Green, city color	Green spaces bring ecological, economic, and social benefits to communities. Regain the link between man and the nature of urban areas can be crucial to surviving the climate crisis.	From mobility to planning; Urban art	Abandon what no longer serves
26	Jan/Feb/Mar 2020	Can we still inhabit the City?	Learn how real estate pressure and tourism are driving the Portuguese away from urban centers.	Karin Zauner-Lohmeyer; City Changers; Barcelona Fair	A new mission
27	Apr/May/Jun 2020	pos-pandemic: a new urban era?	With the streets empty, the confinement period proved to be an opportunity to rethink the urban space. The future could bring a disruption in the city life as we know it: more technologies, leveraged by the arrival of 5G, and urban planning that claims space to cars, to allow the physical distancing of pedestrians and cyclists.	Innovation to 5G hitchhiking; Urban Mobility; Buy Innovation	Decisions
28	Jul/Aug/Sept 2020	Innovation vs Covid-19	In the fight against the virus, co-creation in technological and social innovation has marked the response of the Portuguese.	Richard Florida; Environmental Justice; Place Healing	From pride to humility
29	Oct/Nov/Dec 2020	The health of our homes	Cold, humidity, lack of natural light, or exposure to outside noise are weaknesses that affect the homes of the Portuguese people. Energy rehabilitation is the key to more comfort and well-being within buildings, while contributing to urban sustainability.	Isabel Ferreira; Regional Innovation; Territorial Cohesion	The discomfort in our homes

Appendix 4.2 – Smart City initiatives in each Portuguese City

City	Population	Area	Type	Name of the Initiative	Description	Edition
Abrantes	39 325	Strategy	Technological	Smart City, Happy City	A strategy focused on the efficient management of existing resources and the citizens: energy and water consumption management; public lighting; waste management; interaction with the citizen; fair local commerce; irrigation management; video surveillance; transports, mobility, and centralized monitoring.	11
		Economy	Technological	Prodfarmer	Certification, promotion, sale, and distribution of regional quality products from local producers, through a free online channel.	11
		Social	Technological	I am a Citizen	Direct communication channel between the citizen and the municipality. It is integrated with the system of incident management of the city, thus ensuring greater proximity and encouraging their involvement in initiatives, events, and even decisions of the municipality.	11
Alcobaça	56 693	Environment	Technological	Praia.comigo	Communication of occurrences and suggestions for beaches preservation.	16
Alfândega da Fé	5 104	Social	Technological	Senior Smile	Through a digital platform, psychological evaluations and rehabilitation sessions are promoted (free of charge), allowing the senior population to maintain an active life, socialize and increase their solidarity.	12
		Environment	Non-Technological	LIFE Adaptate	Creation of a natural lake and multi-purpose forests to promote natural regeneration and combat climate change.	22
Amadora	177 136	Urbanism	Non-Technological	Rehabilitation and Urban Art	Strategy for the rehabilitation and standardization of building facades, and improvement of their internal conditions.	5
		Environment	Technological	Smart Irrigation	Efficient irrigation management project. Installed in two urban parks of the city to monitor irrigation in real-time and interrupt it at any time, via mobile phone or computer.	11
		Mobility	Non-Technological	-	Construction and consolidation of green spaces with walking lanes and cycling tracks.	21

Amarante	56 264	Cultural	Technological	Digital Interaction	Implementation of a beacon network to provide useful information to citizens and visitors, whether related to events, history, or curiosities.	16
		Urbanism	Non-Technological	RUA	Urban revitalization project with three fundamental axes: Public space, ground floor, and housing. It brings together local associations, inhabitants, and merchants in a rejuvenation process that unites political will with citizen participation.	20
Angra do Heroísmo	35 402	Social	Technological	Angra Smart City	City agenda (online platform with information of cultural, sports and social activities), MyAngra (virtual place to request documents and follow-up the requests), Visit Angra (APP for providing information on georeferenced points of interest) and Angra Wi-Fi (ten hotspots to provide free Internet access).	15
Aveiro	78 450	Strategy	Technological	Aveiro Steam City, Aveiro Tech City	(1) Implementation of 5G infrastructure and technologies and creation of an urban data platform; (2) Implementation of Tech Labs in 37 educational institutions to provide schools with technology-based equipment (such as 3D printers); (3) Installation of electric charging stations for boats; (4) Aveiro challenges - challenges of the local community in areas such as mobility, environment, energy, social action, among others, for companies and research centers to propose solutions.	22
		Social	Non-Technological	Civic Lab of Santiago	Exercise of citizen participation to lead the community to identify common problems in a specific neighborhood, to then solve them collaboratively. Examples of initiatives: Vivó Bairro, VivaCidade and Aveiro Soup.	23
Azambuja	21 814	Environment	Non-Technological	-	Regeneration of a river and creation of a local observation space with accessible information to the population.	27
Águeda	46 600	Cultural	Technological	Walkinagueda	Mobile application designed to guide pedestrian visitors through the city’s points of interest and inform the spent calories.	8
		Mobility	Non-Technological	Águeda+B, BeÁgueda	An incentive to home-work travels by bike and restructuring of the city's shared bike system increasing the number of available bikes and the creation of more parks.	13
		Energy	Technological	SInGeLu	The SinGeLu street lighting management platform allows collecting consumption data from different sensors, parameterizing usage profiles, and controlling the luminaires remotely.	14
		Social	Technological	CityFy	Mobile application that gathers all the available applications in the city provides information and allows citizens to interact with decision-makers.	14
		Social	Technological	Águeda Living Lab (ALL)	ALL aims to: (1) Be a place of experimentation and active cooperation, offering a physical space to the community (ALLficina - Robotics, 3D Modeling, and Electronics); (2) Establish a point of dialogue, sharing of ideas, and collaboration between Citizens, Universities/Schools, Municipality and Companies in an open innovation platform; (3) Democratize the access to new technologies by providing equipment and specialized technical support.	23
		Urbanism	Technological	-	Dematerialization of processes. Submission and request of documents related to construction sites and urban operations, such as the licensing of works and urban projects.	28
Beja	152 758	Mobility	Technological	U-bike	Implementation of 80 electric and 120 regular bikes.	13
Braga	136 885	Mobility	Technological	Smart Mobility	Creation of 76 km of cycling tracks and implementation of a bike-sharing system. Acquisition of electric buses. The goal is to reach 18,000 regular bike users by 2025.	14
		Governance	Technological	Control Center	Platform to manage all information obtained through the sensors installed in the city.	15
		Cultural	Technological	Braga Explorer (Braga Green Guide)	Mobile application that helps discover Braga's historical heritage, with audio-guided routes of the main monuments and points of interest of the city. It also includes the green spaces and gardens as well as the principal trees of the municipality.	25
Bragança	35 341	Mobility	Technological	Sustainable Mobility Plan	20 free electric bicycles (Xispas) spread over three parking spaces in the city. Extension and creation of new bike paths. Acquisition of 2 electric buses.	13
		Social	Non-Technological	Senior sport in rural areas	Displacement of technicians in the most isolated locations to perform physical exercises for the elderly.	16
		Mobility	Non-Technological	Moveletur	Promote sustainable mobility in natural and cultural heritage areas, in close connection to preserving the nature and identity of those territories.	20
Caldas da Rainha	51 729	Mobility	Technological	City Guide	A technological platform that integrates different mobile applications, and the city's urban transport network.	6
Cascais	210 889	Governance	Technological	Executive’s Portal	A digital platform that allows to submit and work collaboratively on proposals, consult the documentation, follow up the decision-making process, and execute pending tasks.	10

		Environment	Technological	PAYT	A technological system that allows the record of the produced waste by each citizen. Participants in the pilot can access the historical information of their waste production via web or smartphone app. The initiative is part of the European Waste4Think project.	10
		Environment	Technological	-	Placement of volumetric sensors to monitor the filling level of waste containers. On-board computers to accompany the circuits of vehicles, while containers collection is recorded automatically by reading their RFID.	11
		Mobility	Technological	MobiCascais	Mobility system that integrates transport service operators, infrastructures, and vehicles (buses, bicycles, and scooters). A free multimodal pass gives access to the use of buses and shared bicycles of the county. The associated mobile application gives the transport schedule, docks location, bicycles, and car parks available.	12
		Environment	Technological	-	Sensors in urban cleaning equipments to collect data about the waste collection service. Creation of standards considering the various variables associated, such as wind, rain, and other extreme phenomena, as well as the study of the behavior of human resources.	17
Castelo Branco	56 109	Economy	Non-Technological	CEI	The Center for Innovative Companies aims to welcome and create conditions of innovation and entrepreneurship for the private sector to settle their operations in the region.	15
Coruche	19 944	Mobility	Technological	-	Displacement of electric and regular bicycles supported by a dedicated Mobile Application.	19
Cuba	4 878	Social	Technological	Cuba Alert	Mobile application to inform the municipality of potholes on the roads, failures in water supply, problems in public space maintenance, garbage collection, and street lighting.	14
Elvas	23 078	Cultural	Technological	Interactive Forte da Graça	Through the installation of beacons, citizens and tourists will have the possibility to interact with the monument.	16
Esposende	33 947	Strategy	Technological	Esposende Smart City	Connection to the arts and culture through technology. Installation of sensors to monitor air quality, noise and ultraviolet index, and other areas such as mobility, energy, culture, heritage, and urban rehabilitation to predict situations and respond preventively. Centralized management in a control center.	25
Évora	56 596	Energy	Technological	POCITYF	Implementation of energy-positive buildings and districts (use of renewable energy, implementation of energy efficiency measures on buildings renovation); energy management and storage systems (reusage of batteries from electrical mobility for mobile or stationary applications); social innovation for the citizen (gamification); mobility and mobility-as-a-service (one-way and two-way electric charging, and implementation of Smart Lampposts).	24
Fundão	29 213	Social	Non-Technological	Code Academies	The initiative, designed in the short-term form, with intensive programming boot camps, and in the long term, giving foundations for first cycle students, is based on a sustainable financial model based on the obtained results. After these courses, young people who do not get a job do not pay for training, while those who get a job return 2500 euros.	12
		Mobility	Technological	MUV	Mobile application that puts citizens, merchants, and local authorities collecting data and mapping urban travel, co-building the city by matching mobility policies to the real needs of people.	21
Guimarães	158 124	Energy	Technological	-	Project to modernize public lighting networks using a remote management platform.	7
		Strategy	Technological	DREAM	European consortium where Guimarães is the leader and intends to demonstrate on a real scale innovative ICTs pre-commercial solutions for infrastructure optimization, mobility, and energy efficiency. Combination of three elements – the living lab methodology, the challenges (or transformative projects), and the urban intervention space (i.e. where the pilots will be implemented) – with open space to experimentation and co-creation.	14
Lagoa (Algarve)	22 975	Governance	Technological	Smart City Operations Center	All information generated and collected in real-time by the sensors is transmitted securely through the LoRa network to the Smart City Lagoa Operations Room, where qualified technicians through different applications manage the city's various systems.	20
Lamego	26 691	Energy	Technological		Installation of LED lighting technology in the luminaires.	4
Leiria	126 897	Mobility	Technological	U-bike	Displacement of 220 electric bikes.	13
		Social	Non-Technological	Inclusive Pavilion	Equipment prepared and designed to host sports for people with disabilities.	18
		Urbanism	Non-Technological	Jardim da Almuinha Grande	Amphitheater in an outdoor park.	25
Lisboa	504 718	Governance	Technological	Lisboa Aberta	Georeferenced open data portal.	10
		Mobility	Technological	Gira	Expansion and construction of bicycle paths. Provision of bike-sharing system through a mobile application.	13
		Mobility	Technological	Sharing Cities	Project that contemplates electric mobility, energy requalification of buildings, implementation of smart lampposts, air quality and noise sensors, sustainable energy management systems and data sharing platform.	14

		Social	Technological	Lisboa Participa	Web portal to simplify and facilitate citizens involvement by bringing together, in a dedicated space, the various instruments of participation of the city, such as participatory budgeting and the applications “Na Minha Rua”, “Lisboa Aberta”, “Lisboa em Debate” and “LisBoaIdeia”.	15
		Governance	Technological	COI	City operational center that integrates data from 40 services, such as firefighters, civil protection, municipal police, utilities, public transport, ports, environment, etc...	16
		Environment	Technological		Placement of waste sensors in containers and implementation of a PAYT system with dedicated access cards.	22
		Mobility	Non-Technological	Green Capital 2020	Preventing the circulation of vehicles before 2000 in the city center and all vehicles on Sundays.	26
		Social	Technological	Lisboa.24	Real-time information about the city (traffic, occurrences, events, parking and transport).	27
Loulé	70 622	Environment	Technological		Monitoring, measurement, and assessment of energy consumption and its costs, as well as CO2 emissions in water supply and residual waters sanitation systems	11
		Governance	Technological	Smart Governance	Digitization with the dematerialization and streamlining of decision-making ecosystems.	11
		Mobility	Technological	Loulé Adapta	Bike sharing, electric charging, construction, and extension of bike paths.	13
		Mobility	Technological	LoulÉmobilidade	Mobile application to access real-time information of urban transport schedules and facilitate the parking payment.	18
		Social	Non-Technological	HealthyCities	Project to deepen the relationship between health and the urban environment, developing policies focused on improving the population's health status and assessing their impact.	26
Lousada	47 387	Social	Non-Technological	-	Use of environmental education to connect the citizens to the conservation natural heritage initiatives of the municipality.	26
Maia	135 678	Strategy	Technological	Baze_Living Lab	Urban space (Fablab) for testing, demonstrating, and experimenting with integrated technological solutions in a real context. It intends to be a low-carbon environment, resilient, accessible, participated, and connected. Development of an Urban Management Platform.	23
Matosinhos	175 478	Social	Technological	The Online Citizen Store	Through a platform, citizens can download and submit requirements, make suggestions, complaints, or clarify all their doubts about the city’s activity.	4
Melgaço	9 213	Economy	Non-Technological	Melgaço Pop-up	An incentive to the creation and maintenance of local commerce. In the first three months, the rent is free and, in the following three, the due monthly payment is a symbolic amount of 1 euro per square meter to the owner.	28
Odemira	22 536	Urbanism	Non-Technological	-	Rehabilitation of urban space. New water networks and more efficient luminaires.	19
Oeiras	173 149	Governance	Technological	Smart Cities Platform	A platform for sharing information and knowledge, with the dissemination of specific solutions in the field of urban intelligence.	12
		Social	Technological	OeirasEu.pt	Citizenship web app aims to go beyond simple communication and data analytics to plan and help solve urban challenges. It allows citizens to communicate, in real-time, an occurrence to decision-makers, where a dedicated team in a "command center" does the screening and forwards the occurrence to the responsible stakeholder.	15
		Strategy	Technological	-	Implementation of 5G to increase sensorization and data collection to help city’s management. Installation of meteorological and street lighting sensors, traffic measurements, urban waste management, environmental monitoring, and alarm management associated with civil protection.	27
Oliveira de Azeméis	69 127	Mobility	Technological	BiclAz	Construction of bicycle paths. Acquisition and displacement of electric bicycles.	13
Porto	214 349	Environment	Technological		Buses with Wi-Fi coverage and air quality sensors to monitor environmental parameters.	4
		Environment	Non-Technological	Green Roofs	Pilot project for placing green roofs in city buildings for precipitation retention, increasing green areas, thermal comfort, soundproofing, CO2 capture, and the roof's lifetime.	15
		Social	Non-Technological	Entrance Door and 1st Right	Housing programs to immediately support people who suddenly have deprived themselves of housing and help people who live in undignified conditions.	27
Santarém	61 752	Social	Technological	-	Mobile application with the support of an audio format guide in different languages allows access to local information and news, communicates occurrences, sends suggestions, requests meetings to municipal services, locates points of the territory, and learns more about historical monuments.	10

		Mobility	Technological	Bikes	Bike-sharing with real-time information.	13
Seixal	158 269	Strategy	Technological	Seixal Smart City (LVpD)	Strategy with 17 projects, focusing on improving the quality of life and boosting the riverside area of Seixal and neighboring communities. 1. Intelligent street lighting; 2. Smart water meters; 3. Electric train and renewable energy; 4. Individual electric mobility equipment; 5. Smart parking for electric vehicles; 6. Electric charging points; 7. Photovoltaic sun hats; 8. Mini wind power stations; 9. Energy storage; 10. Smart network; 11. Eco-restaurant; 12. Solar kitchen; 13. Zero-emission room (Ecosystem Monitoring and Information Center); 14. Smart container; 15. Live innovation exhibition for decarbonization technology; 16. Ecosystem database and information system; 17. Ecosystem portal.	19
Setúbal	116 330	Social	Technological	Setúbal SOS	Mobile application for direct connection with the emergency services based on GPS real-time location. Includes clinical historical information, age, and the contact person to be contacted in case of emergency.	13
		Urbanism	Technological	USO	Simplification and streamline of administrative processes, through an online geoportal that integrates geo-referenced information and content of different urban areas.	22
Sintra	381 728	Cultural	Technological	Talking Heritage	Mobile application with information about city's points of interest. Images, texts, videos, or augmented reality technology along the routes.	4
		Environment	Non-Technological	-	Separation of domestic waste using waste bags provided by the city.	29
Torres Vedras	79 465	Mobility	Technological	Eco Urbe	Implementation of directional signs, 18 lampposts, a shadow structure with a solar photovoltaic system, a support infrastructure for bicycles, a passenger shelter with two seats, two conventional mupis, and a dynamic information totem. Implementation of a smart lamppost that uses the sun and wind as energy sources and serves as a telecommunications network station with the capacity to charge devices or electric vehicles and has IP cameras. Acquisition of electric vehicles and bicycles, an extension of bike paths, and implementation of traffic control sensors.	26
Vila Franca de Xira	136 886	Mobility	Non-Technological	Ribeirinho Park	Urban requalification and construction of a bike path.	20
Vila Nova de Famalicão	133 832	Governance	Technological	Smart Center Famalicão	Urban intelligence platform to support daily city operations and management of public space and occurrences.	23
Vila Nova de Gaia	301 496	Urbanism	Technological	Nopaper	Digitization and streamline of urban processes in a dedicated platform.	6
		Social	Non-Technological	-	Collaborative methodology to diagnose, present proposals, and experiment with the solutions by the community.	28
Vimioso	4 669	Social	Non-Technological	-	Lands at one cent, with the offer of the project and the licensing fee, and education fees paid by the city to retain young citizens.	20
Viseu	99 274	Mobility	Technological	MUV	Mobility application allows buying tickets or electronic passes, validating trips, and knowing bus schedules in real-time or parking availability. Construction of bicycle paths. New urban transport network, shared bicycles (electric and regular), on-demand transport service, and a parking system with three new parks with sensors. Displacement of two electric buses and one unmanned electric vehicle.	13
Vizela	23 736	Social	Non-Technological	CittaSlow	Philosophy of slowness to (re)find the idea of well-living and the awareness of the value of life in the local community, emphasize territorial rooting, and preserve the identity of the territory.	12

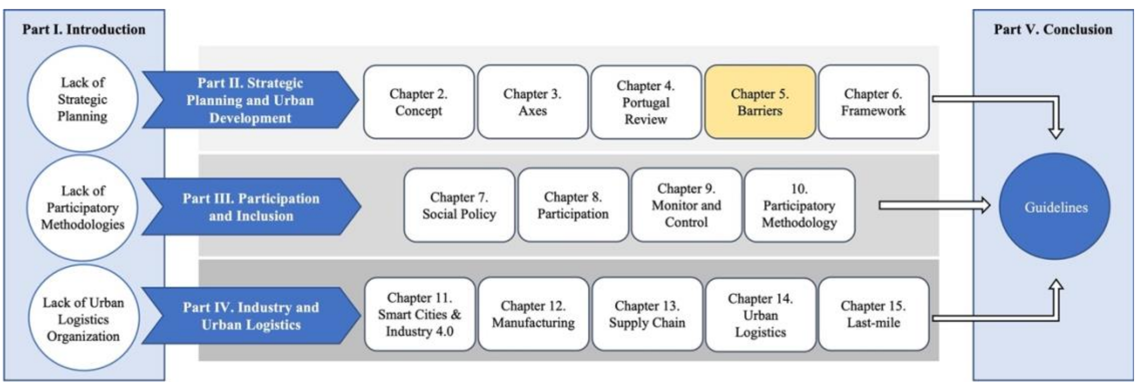
Although briefly mentioned in the magazine, the municipalities of Barreiro, Faro, Funchal, Guarda, Lagoa (Azores), Madeira, Mafra, Oliveira do Bairro, Paredes, Peniche, Ponta Delgada, Portimão, Sátão, São Brás de Alportel, Vila do Bispo, among others, did not contain enough information to be considered in the previous table.

Chapter 5

Investigating the Smart City Barriers: Contribution of experts based on a Delphi Analysis

Reference

Correia, D., Teixeira, L., & Marques, J. L. (2022). Investigating Smart City Barriers : Contribution of Experts based on a Delphi Analysis, *Spatial Planning and Sustainable Development*, 10(2), 179–199. https://doi.org/10.14246/irspsd.10.2_179



5. Investigating the Smart City Barriers: Contribution of experts based on a Delphi Analysis

Abstract

The lack of cooperation between stakeholders and coordination of departments, the absence of systems interoperability, and the resistance to change by policymakers represent some of the challenges that make the Smart City's implementation a complicated task. Nevertheless, it lacks in the literature a broader understanding of the Smart City barriers to help policymakers design and execute their strategies. Therefore, this paper aims to find the (critical) barriers that have associated a significant influence on the success of a Smart City implementation and are within the control of policymakers, based on the empirical knowledge and experience of experts. The study of the temporal aspect in which they can be overcome is also performed to allow a better planning. Moreover, 50 barriers were aggregated and organized in eight distinct areas from a thematic analysis of a 114 barriers initial list collected in the literature. Nine experts participated in the Delphi Analysis which demonstrated that although Smart Cities are usually associated with the technological perspective, the 15 most critical barriers are mainly from the areas of Governance, Project, and Organization. The method combined a two-round survey with a focus group, integrating quantitative and qualitative approaches.

Keywords: Smart City, Barriers, Delphi Analysis, Focus Group, Two-round Survey.

5.1. Introduction

In the 1990s, Smart City concept was for the very first time associated with information and communication technologies (ICTs), forecasting that technology would be at the center of city management (Aurigi, 2006; Bastelaer, 1998; Gibson, D. V., Kozmetsky, G. and Smilor, 1992; Graham & Aurigi, 1997; Mahizhnan, 1999; M. Tan, 1999). Later, it was linked to a new paradigm of solving the problems caused by urbanization and globalization (Angelidou, 2015; Chourabi et al., 2012). The initial techno-centric approach led by technological companies, where ICTs were seen as the solution to every problem - Smart City 1.0 - evolved after the criticism that the focus should not be on the technical aspect (Hollands, 2008). Moreover, the concept started to thrive for a human and social capital perspective (Caragliu, del Bo, & Nijkamp, 2009). The technology was then seen as the means to meet citizens' needs, improving the quality of life and the city's sustainability and not as an end in itself - Smart City 2.0 (Lin, Shen, & Teng, 2021; Mirzaei & Zangiabadi, 2021). Recently, the citizens' role moved towards being contributors of the city strategy - Smart City 3.0 - empowering them to be part of the design and thinking process (Cohen, 2015; Gutiérrez et al., 2016).

Nevertheless, cities' strategic planning depends on their specific contexts, problems, and opportunities (Correia, Marques, & Teixeira, 2021; Tödtling & Trippl, 2005). Moreover, to design an effective action plan, it is necessary to understand what is fundamental to implement and the timing to carry out the implementation process. That reflection is ultimately connected to the prioritization and schedule of the actions to tackle specific challenges based on long and short-term circumstances. Moreover, the consideration of existing barriers is crucial to plan a successful Smart City strategy. The literature is scarce about the meaning of what a Smart City barrier actually is. Generically, authors have associated it to the obstacles and difficulties hindering and delaying a successful Smart City strategy and related projects (Chourabi et al., 2012; Mosannenzadeh, Di Nucci, & Vettorato, 2017; Rana et al., 2019; S. Y. Tan & Taeihagh, 2020). Nevertheless, a Smart City barrier can be defined as a challenge posed to urban development that if not overcome by policymakers (or relevant stakeholders), means a partial or total impediment to the implementation of a Smart City strategy.

The struggles that some face to implement a Smart City approach may be different from the others. There are countries where the topic has still not brought meaningful change and impacted urban policy practices (Varró & Szalai, 2021). Some authors point out that the implementation of Smart Cities has not been possible due to the unsatisfactory level of prosperity of the residents, the difficult financial condition of cities, and unfavorable demographic trends, whereas others to the cultural challenge for community participation (Das, 2017; Jonek-Kowalska & Wolniak, 2021). The heterogeneity within the country between cities is most times associated to the capacity of larger cities to access financing programs (Correia, Teixeira, & Marques, 2022; Smékalová & Kučera, 2020). Thus, scaling pilot projects is widely perceived as a major concern (van Winden & van den Buuse, 2017).

Furthermore, barriers do not have the same impact and priority (Mosannenzadeh et al., 2017; Rana et al., 2019). Thus, it is vital to study their spatiotemporal relevance to understand how can they be surpassed to create an urban environment that combats societal segregation and marginalization, and promotes the inclusion and quality of life of inhabitants (Correia & Feio, 2020; Medved, Kim, & Ursic, 2020; van Gils & Bailey, 2021; Wolf, Borges, Marques, & Castro, 2019).

In the literature several studies that have performed narrative and systematic literature reviews on the topic can be found. Chourabi et al. (2012) aggregated and identified the challenges of Smart Cities. From a raw dataset of 212 barriers of empirical research of 43 communities implementing energy projects, Mosannenzadeh, Di Nucci, and Vettorato (2017) ranked 35 barriers in 9 categories based on a quantitative approach. Rana et al (2019) evaluated the barriers of Smart Cities development in the Indian context, categorizing 31 barriers in 6 key areas. Tan and Taeihagh (2020) listed the barriers associated with the development of Smart Cities in developing countries from a systematic literature review. Additionally, other authors have also pointed out some of the Smart City barriers (Alawadhi et al., 2012; Chatterjee & Kar, 2015; Correia, Teixeira, & Marques, 2020; Ebrahim & Irani, 2005; Gil-Garcia, Pardo, & Nam, 2015; Goyal, Sahni, & Garg, 2018; Mosannenzadeh & Vettorato, 2014; Nam & Pardo, 2011; Neirotti, Marco, Cagliano, Mangano, & Scorrano, 2014; S. Y. Tan & Taeihagh, 2020). However, the consideration of other variables beyond the importance level to represent a significant contribution for policymakers is lacking, such as the impact a specific barrier may have to oppose to the development of a Smart City, the capacity of decision-makers to overcome it, and the timespan they can perform it. Starting from the universality that all barriers are equal and have the same weight, it is vital to perform a more profound study to understand their specific attributes.

Therefore, this paper aims to find the barriers that have a critical influence on the success of a Smart City implementation, and which policymakers can have a decisive role in overcoming them. Moreover, the research question of this paper is: “What are the critical barriers to the implementation of a Smart City strategy?”. For a reasoned analysis, this work considers literature pieces of evidence and empirical experiences (Painuly, 2001). The methodology combines quantitative (questionnaires to assign the weights) and qualitative approaches (discussion over a focus group). It gets the opinion and discussion of Portuguese Smart City experts by performing a Delphi analysis combining a two-round survey with a focus group. This method promotes joint learning and convergence of opinions. The final answer of each participant is made based on the confrontation and perception of contrary points of view.

The methodology is described in the next section, and is divided into three main steps: (A) identification and organization, (B) evaluation, and (C) interpretation. The results are demonstrated and discussed in section 5.4. At the end, conclusions are highlighted about the most critical barriers for a Smart City implementation.

5.2. Methodology

To find the most critical barriers to implement a Smart City strategy, the methodology was divided into three phases: (A) identification and organization – investigation and selection from scientific works the initial barriers and performance of thematic analysis to organize within the areas of scope, (B) evaluation – identification of the experts and development of a two-round Delphi survey to get the feedback of external stakeholders, concerning the defined evaluation criteria, to each barrier, and (C) interpretation – analysis and graphical representation of the final results and translation of their practical meaning. This way it was possible to design a systematic and participatory process combined with moments of discussion and confrontation of perspectives mobilizing the experts to a possible convergence in a common vision. Figure 5.1 summarizes the methodology followed in this study divided into the previously mentioned three phases.

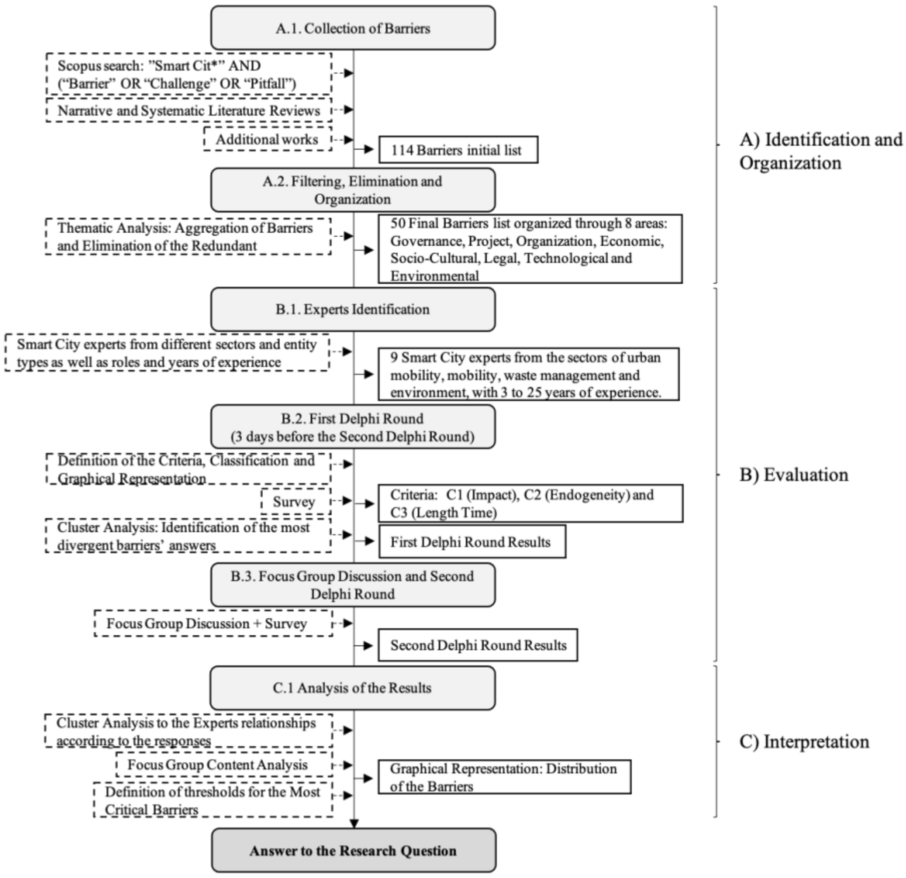


Figure 5:1 Methodology

5.2.1. Identification and Organization

For the initial collection of the barriers, it was searched on Scopus using the following keywords: “smart cit*” and “challenge” and (“barrier” or “pitfall”). From the 370 results, 200 abstracts were read, and from those, nearly 60 deserved closer attention and deeper analysis. The initial barriers of the present work were collected from narrative and systematic literature reviews as previously mentioned in the Introduction section. The goal was to find papers that had already performed studies to find the Smart City barriers.

Furthermore, from the careful analysis of the barriers, a qualitative approach to find patterns within and across the data to find the final barriers list was performed. In this case, inductive thematic analysis was carried where codes and themes were developed and associated by the authors (Rice & Ezzy, 1999).

Moreover, similar barriers were aggregated into the same codes, and the redundant eliminated (see more in Appendix 5.1). Thus, on the one hand, those that did not contain a self-explanatory understanding, or the focus was subjective or discrepant were excluded. On the other hand, those whose understanding could be included in a more generic meaning without losing information were aggregated. The final shortlist constituted of 50 barriers and distributed throughout 8 areas, namely Governance, Project, Organization, Economy, Socio-Cultural, Legal, Technology, and Environment, and is presented in Figure 5.2.

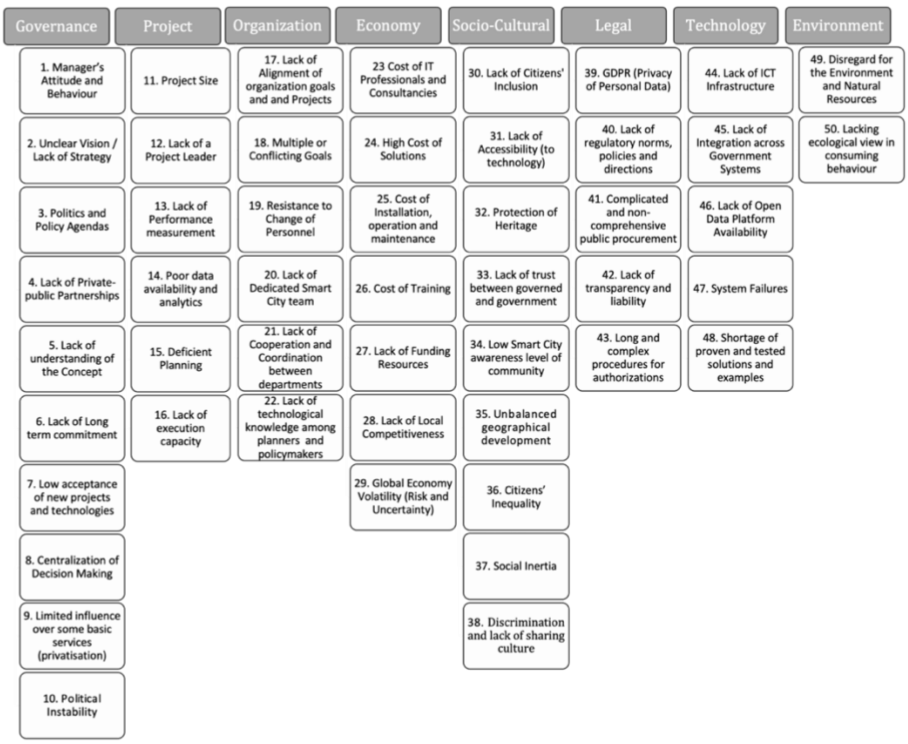


Figure 5:2 Smart City barriers shortlist

5.2.2. Evaluation

After collecting the barriers and performing thematic analysis, a Delphi Analysis approach was followed. This topic's complexity justified the reflection and discussion of experts with different backgrounds and experiences. Moreover, the Delphi Analysis allows each participant to give their opinion while looking for the convergence of the group throughout the iterative discussion rounds. In this case, this method was chosen because the overall goal was to provide policymakers with a conscious and agreed vision of the Smart City critical barriers based on the perspectives of a heterogeneous group of experts.

The Delphi Analysis summarizes the opinion on emerging concepts, and on the development studies that lack empirical data and intend to objectively obtain experts' responses (Gordon & Pease, 2006). This method usually considers several and consecutive response rounds (Rodríguez-Mañas et al., 2013). In each round, the answers are collected. The disagreements are analyzed and highlighted to ground the following round in order to converge the group's answers (Marques et al., 2009).

Given the subjectivity of the topic, a set of experts from various areas and with different years of experience was put together. This group was intended to represent the commonly interested parties on Smart City strategies. Therefore, the group included elements from academia (universities), private companies, and municipalities.

The experts' identification was based on the search of recognized elements based on iterative comparison of the people's opinions in the field. On the one hand, participants were sought from research, planning, regulation, development of solutions, and decision-making roles (planning) and, on the other hand, from urbanism, mobility, waste, and environment sectors (applications).

Moreover, the group of experts was composed of 9 elements (Table 5.1). The group had professionals with the range of 3 years to 30 years of experience in the area. The average elements experience was approximately 12 years.

Table 5:1 Experts' Identification

Identification	Gender	Sector	Entity	Role	Experience
Element 1	Male	ICT	University	Professor	25 years
Element 2	Male	ICT & Electronics	R&I Consultant	President	10 years
Element 3	Female	EC Policy & Strategy	Non-profit Foundation	R&I Department Director	10 years
Element 4	Male	Urban Management	Municipality	Technician	5 years
Element 5	Male	Mobility & Tourism	Private Company	CEO	9 years
Element 6	Female	Climate Action and Circular Economy	Municipality	Department Director	6 years
Element 7	Male	ICT	ICT Cluster	Executive Board Member	30 years
Element 8	Male	Environment and Waste Management	Municipality	Department Director	8 years
Element 9	Male	Urban Cleaning and Waste Management	Private Company	CEO	3 years

In terms of the evaluation of the barriers, three main criteria were established to assess them: (i) the impact of the barrier in the Smart City strategy implementation; (ii) the capacity of the policymakers to overcome the barrier; and (iii) the extent of space-time in which the barrier can be overcome. Figure 5.3 presents the criteria and the associated classification spectrum. The digital survey of the first Delphi round was individually sent to all participants three days before the second round.

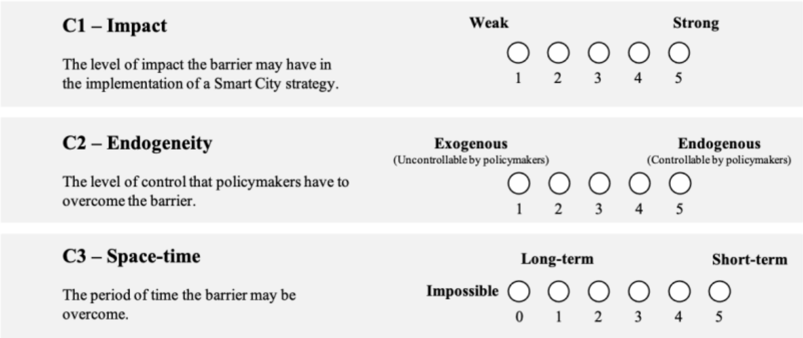


Figure 5:3 Criteria definition, classification, and ranking (Likert Scale)

First, the experts were asked to classify each of the 50 barriers identified in the literature review based on a Likert scale. After the first round of responses, the results were analyzed.

According to each criterion (Impact, Endogeneity, and Space-time), a cluster analysis was performed on the participants' responses to group the barriers whose evaluation matched the most.

The most discordant barrier spectrum of responses (higher standard deviation from the average response) was identified. This allowed uncovering the barriers, which had a more varied range of responses from the experts.

After, a focus group was held where the discussion between the experts was promoted. The focus group was set up to discuss the divergent barriers to ascertain whether the respondents maintained their initial response on the second Delphi round. The focus group followed the approach defended by Morgan (1998) and Stewart, Shamdasani and Rook (2007), characterized by promoting an open and flexible discussion with a collective understanding uncovered by individual interviews, allowing the researcher's direct interaction with the experts. The second survey round followed this approach.

The exercise discipline was taken into significant consideration. The rigid fulfilling of the times and the assertive moderation promoted the objectivity of each intervention. The focus group lasted one hour divided through three consecutive moments, each divided into two distinct parts: discussion and survey. The chronological plan is detailed in Figure 5.4.

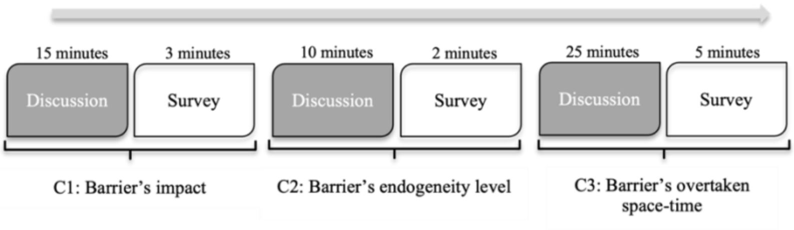


Figure 5:4   Focus group chronological plan

For each of the divergent barriers (with higher standard deviation), one element gave their opinion about why the response was in a particular direction to initiate the exercise. That triggered following participants' interventions with complimentary or contrary perspectives. After the time stipulated for each discussion moment, the elements had a tool (provided in advance) to place their new answer. Each element could see their first Delphi round answer and the average group's response, as demonstrated in Figure 5.5. This way, each participant was aware of its position before the group and could reevaluate the given answer on the first round from the discussion with the other focus group's elements. Thus, the subjective analysis was combined with the objective.

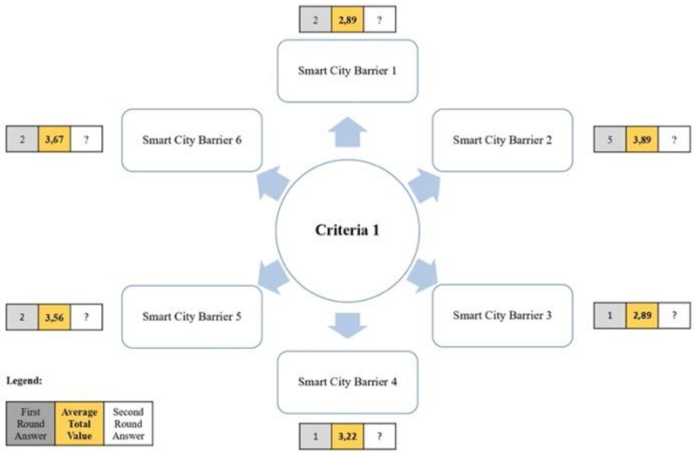


Figure 5:5   Second Round survey scheme tool

The results obtained in the two rounds of the questionnaire were analyzed. Moreover, following the first round of the Delphi Analysis and the quantitative study of the barriers' standard deviations, a cluster analysis was also performed to study the group's relationships. These clusters clarify the experts' positions for a better and most focused discussion in the second round's focus group.

5.2.3. Interpretation

To contradict the critique made by Webb and Kevern (2001) about the lack of quotes and descriptions from the participants' interventions observed in the focus groups, the discussion's mains points are described and transcribed in this subsection to highlight the contributions and the contradictions. Furthermore, the dominance of specific participants' opinions, the relationships among the experts, and the produced consensus is also analyzed.

Following the qualitative description of each discussion moment, the verified changes from the experts' second-round answers concerning the first questionnaire’s responses are also presented.

Ultimately the results are graphically represented according to Figure 5.6. A general view of the path and the considered thresholds along the journey to find the most critical Smart City barriers is also presented.

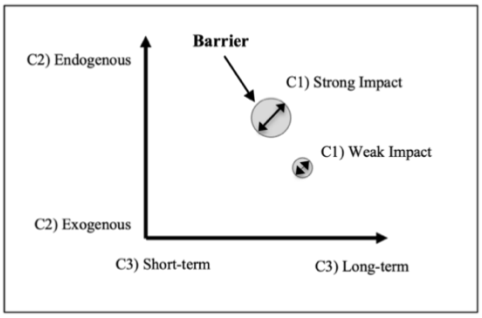


Figure 5:6 Representation of the classification axes.

5.3. Results and Discussion

5.3.1. Two-round Delphi questionnaire results

The average results from the participants of the first Delphi round’s questionnaire are mirrored in Table 5.2, according to each criterion (C1 – Impact; C2 – Endogeneity; C3 – Space-time). Based on the results, the most discordant barriers were identified for the second round of the Delphi analysis. The less consensual barriers are represented in bold in Table 5.2.

Table 5:2 First Round survey average results

Areas	Barriers	C1	C2	C3
Governance	1. Policymakers’ attitude	4,22	3,89	2,44
	2. Unclear vision / lack of strategy	4,33	3,67	2,67
	3. Lack of Smart City-oriented politics and policy agenda	3,67	3,78	3,33
	4. Lack of private-public partnerships (lack of stakeholders’ involvement)	4,00	3,22	3,56
	5. Lack of understanding of the Smart City concept	3,33	4,00	4,11
	6. Lack of long-term commitment	4,11	4,22	**3,22**
	7. Low acceptance of new projects and technologies	3,67	4,11	**3,33**
	8. Centralization of decision making	3,56	4,00	**2,33**

	9. Limited influence over basic services	3,44	3,56	3,44
	10. Political instability	3,56	2,56	2,78
Project	11. Inadequate project size	3,67	3,56	**3,11**
	12. Lack of a project leader	4,00	4,00	3,56
	13. Lack of performance measurement tools	4,00	3,44	3,00
	14. Poor data availability and analytics	4,00	3,44	**2,89**
	15. Deficient or unreal planning	4,33	3,44	**2,67**
	16. Lack of execution capacity skills	4,33	3,44	2,22
Organization	17. Lack of alignment of strategic goals and projects objectives	4,11	4,11	**2,78**
	18. Multiple or conflicting goals	4,33	4,22	3,00
	19. Resistance to change	4,11	3,67	2,67
	20. Lack of dedicated Smart City team	4,00	4,11	3,11
	21. Lack of cooperation and coordination between departments	4,33	3,89	3,00
	22. Lack of IT/technological knowledge	3,89	3,67	3,00
Economy	23. High cost of IT professionals and consultancies	3,44	2,44	2,11
	24. High cost of solutions	3,67	2,33	2,67
	25. Cost of solutions' installation, operation and maintenance	3,89	2,44	2,00
	26. Cost of training	2,38	2,56	**3,33**
	27. Lack of funding resources and financing opportunities	3,50	3,33	2,44
	28. Lack of local competitiveness	2,88	2,67	2,33
	29. Global economy volatility (risk and uncertainty)	**2,89**	2,33	2,13
Socio-Cultural	30. Lack of citizens' inclusion	**3,89**	3,56	**2,67**
	31. Lack of citizens' accessibility to technology	3,67	3,33	2,33
	32. Protection of heritage	3,67	3,11	**3,11**
	33. Lack of trust between governed and government	3,44	3,33	3,33
	34. Low Smart City awareness level of community	3,33	3,11	**3,11**
	35. Unbalanced geographical development	3,11	3,00	2,11
	36. Citizens' inequality	3,67	2,67	1,78
	37. Social inertia	3,11	2,89	2,00
	38. Lack of sharing culture	3,56	2,67	1,75
Legal	39. GDPR (privacy policy of personal data)	**2,89**	**2,67**	**2,89**
	40. Lack of regulatory norms	**3,22**	3,11	**3,22**
	41. Complicated and long public procurement processes	4,11	**2,33**	2,56
	42. Lack of transparency on public procurement	**3,56**	**3,33**	**2,89**
	43. Long and complex procedures for authorizations/licenses	3,56	2,67	2,67
Technology	44. Lack of IT infrastructure	3,78	3,00	2,22
	45. Lack of integration capacity across systems	3,67	3,00	2,33
	46. Lack of a unique data platform	3,89	2,89	2,67
	47. System failures	4,00	2,78	3,00
	48. Shortage of proven and tested solutions	3,22	2,11	**3,22**
Environment	49. Disregard for the environment and natural resources from policymakers	**3,67**	4,22	2,78
	50. Citizens' lacking ecological view in consuming behavior	3,89	3,11	2,44

The most divergent barriers from the first Delphi round's answers were harmonized through cluster analysis. The clusters are represented in Figure 5.7. Cluster number 4 for the Impact, cluster number 4 for Endogeneity and cluster number 2 for Space-time aggregated the barriers where the answers were more discordant (yellow). These groups were obtained based on a standard deviation threshold of 1.3 from the group's average result. It corresponds to a Z-score value of 0.0968, which means that 9.68% of the total information was considered for further analysis on the second Delphi round.

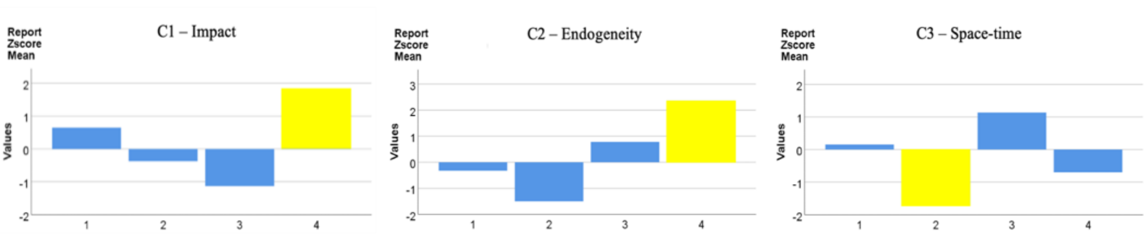


Figure 5:7 Barriers cluster analysis

The cluster analysis was also performed to find the participants' relationships concerning their answers to the first-round questionnaire, as shown in Figure 5.8.

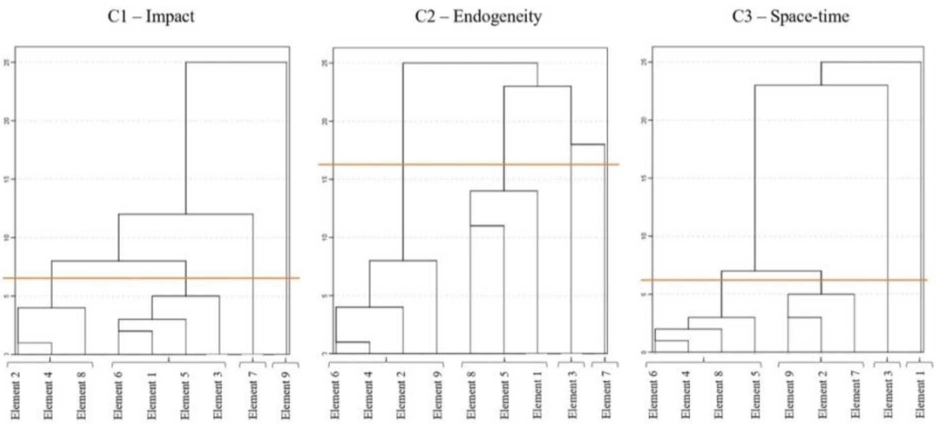


Figure 5:8 Participants cluster analysis

Through this analysis, it is possible to notice that Elements 3 and 7 appear most often outside the clusters created by the remaining elements. This means these two participants had different opinions from the originated clusters. Thus, their views and response pattern did not match any other participant’s.

It can be explained by their accumulated years of experience in the subject and the fact that both elements organize and manage large projects on a European and global scale with the involvement of multiple stakeholders and legislation. As for the others, it was noted that they do not follow a specific pattern for all criteria.

5.3.2. Analysis of the results

The following sub-sections reflect the elements’ response changes observed in each criterion after the second Delphi round. The tables represent the changes on the Likert scale of each participant for the divergent barriers previously identified. The answers have converged to some key participants’ opinions. In terms of regulatory issues, the arguments of Element 3 were decisive to the answer changes of the audience. Element 7 demonstrated his expertise mostly in data privacy aspects. Elements 1 and 2 were followed carefully in terms of their feedback regarding citizens’ inclusion and financing. Elements 8 demonstrated his moderated arguments with regards to the collaboration of public entities with private companies.

5.3.2.1. Barriers' impact

By analyzing Table 5.3, it is possible to verify that the responses to barriers 39 ("GDPR privacy policy of personal data") and 40 ("Lack of regulatory norms") were amended by more than half of the elements. This may be justified by the statement of Element 7, ICT cluster board member, who said that "GDPR is not in itself a barrier but an opportunity" and shared his experience of the existence of companies that "want to come to Europe because of the respectfulness of privacy and ethics".

Element 3, researcher of European Commission innovation policy and strategy, noticed the lack of existing rules and regulation that "delay technologies market entrance" and may have a "strong impact on the implementation of a Smart City" by not keeping up with innovation by being "restricted to an older solution". On the contrary, Element 7 stated that the lack of legislation may be an opportunity and not a barrier because it "gives space for innovation", encouraging other players to join and help later regulatory processes.

The argument of Element 8, who is a municipality's department director, about the fact that "often the use of technology is forced without having a real context for its use by citizens", and that the lack of inclusion has a significant impact on the implementation of a Smart City which may explain the remaining answer changes. To which regarding Element 1, a University professor, agreed by stating that "it is the most critical Smart City barrier" and, therefore, it is crucial to understand their literacy and to promote education because the other way around means that they not become an active participant.

At the business level, Element 9 said that the most significant difficulty is still "opening up mentalities" and combating "the disregard for environmental issues". Element 7 stressed that a Smart City should not only a focus on environmental issues, waste management and mobility. Therefore, the "culture, vocational training, economic development, and the governance aspect" must be considered also. To which Element 5 added that "the denial of the lack of transparency and environmental considerations is the denial of a true Smart City".

Element 2, which deals directly with financing opportunities, stated that in the face of extreme events there is a "reconditioning of the budget to other areas (namely health and social), thereby preventing Smart City strategies from moving forward". Moreover, this can be witnessed by the lack of public investment in Smart Cities during 2020 (because of the Covid-19 pandemics). On the other hand, Element 7 mentioned that it could be seen as a way, with less budget, to think of more optimized forms of participation and progress, because despite the risks and economic volatility, "the digital era represents an opportunity for other cities lagging in the process without dedicated infrastructure".

In Table 5.3, the cells represent the changes respondents have performed in the second round from their first-round answers. As an example, the first cell ("5->4") shows that Element 1 evaluated the barrier "Global economy volatility (risk and uncertainty)" with strong impact (level 5) and downgraded his evaluation to level 4 on the second round.

Table 5:3 Second questionnaire round answer changes (Likert scale) on the barriers' impact by each participant

Barrier	Element								
	1	2	3	4	5	6	7	8	9
29. Global economy volatility (risk and uncertainty)	5 -> 4								1 -> 3
30. Lack of citizens' inclusion		3 -> 4							1 -> 3
39. GDPR (privacy policy of personal data)	5 -> 3	4 -> 3		5 -> 4	3 -> 4				1 -> 2
40. Lack of regulatory norms				4 -> 3	3 -> 5		1 -> 2	3 -> 2	1 -> 4
42. Lack of transparency on public procurement				4 -> 3			2 -> 3		1 -> 3
49. Disregard for the environment and natural resources from policymakers								3 -> 2	2 -> 4

5.3.2.2. Barriers' endogeneity level

Table 5.4 helps to understand the changes made by respondents according to the second criteria – Barrier's Endogeneity Level. Barrier 41 ("Complicated and long public procurement processes") was the one with more changes, all in the same orientation. This can be justified by the arguments of Element 5 and Element 8. The first stressed that "legislation is imposed on decision-makers", and therefore, they can do little in that respect. The same happens to the "delay in public procurement". The second added that "in procurement processes that involve technology there is a huge interpretation to what can be done" which lead to very different proposals and make the evaluation process harder.

As for barrier 42 ("Lack of transparency on public procurement"), Element 9, as a Private Company CEO, stated that because of solutions subjectivity, it is usual that "procurement processes have their specifications conditioned on specific requirements or products", because procurement was previously carried out, and policymakers know the specific solution they want to acquire. However, the changes verified in Table 5.4 may have been influenced by the perspective of Element 3. The expert on European Commission and regulation matters stated that specifications must be "transparent", where those who define the requirements have the opportunity to engage with the community, acquire knowledge through formal and informal methodologies, see and test several alternatives and define the procurement specifications, which are open to everybody. Element 7 added that it is decision-makers' responsibility to improve requirements' definition and bridge the lack of municipalities' infrastructure and technical teams by promoting an "open discussion with the community and other stakeholders (Universities, Clusters, and Associations) in a constant sharing of knowledge".

The cells of Table 5.4 represent the changes that Elements (columns) have performed to each barrier' evaluation (lines) in the second round, from their first-round answers.

Table 5:4 Second questionnaire round answer changes (Likert scale) on the barriers' endogeneity level by each participant

Barrier	Element								
	1	2	3	4	5	6	7	8	9
39. GDPR (privacy policy of personal data)							5 -> 4		
41. Complicated and long public procurement processes					2 -> 4			2 -> 3	2 -> 4
42. Lack of transparency on public procurement							5 -> 4		1 -> 3

5.3.2.3. Barriers' overtaken space-time

The analysis of Table 5.5 shows that the discussion around barrier 42 ("Lack of transparency on public procurement") triggered the change of responses by most elements. Element 8, with a municipality's background, expressed that "there are no proven and properly documented case studies" with accurate data of the solutions' impact on citizens lives", meaning that the lack of transparency may have delayed the process and that "can be solved in the short term". Contrary to this view, Element 2, from a regulatory point of view, stated that "it is possible to quantify, however, the measurements have to consider the context analysis and experience of each person " and that "will not be achieved with a Likert scale of 1 to 10". In the same direction, Element 5, from the private sector, added that it is necessary to ensure that the systems implemented can collect data in real-time "to allow the monitoring and quantification of their benefit".

Additionally, the barriers with more changes were the 8 ("Centralization of decision making"), 15 ("Deficient or unreal planning"), 30 ("Lack of citizens' inclusion"), and 39 ("GDPR privacy policy of personal data"). These may be explained by the arguments presented by Element 2, who refer that "centralization of decision-making will only be solved in the long term". And by Element 4, who gave the example of its municipality's initial difficulty in realizing "the importance of citizen participation". However, as soon as some solutions were implemented, they noticed "that the engagement tripled and public service itself was forced to be improved", which reveals to be in the hands of policymakers. Element 7, also stated that "a major cultural change is needed at various management levels on plans and objectives definition", mapping them in relation to the projects that are being implemented, and that "will not be solved in the short term"; and Element 2 explained that "Smart Cities are still related to short-term agendas" and that implies that "there is no follow-up after the conclusion of the projects financing period", resulting on the lack of long-term commitment. To the last observation, the Element 7 interfered to agree and say that it still happens because of the inadequate size of projects for communication and marketing purposes, concluding that "it will take time to change the mindset".

On the topic of regulation, Element 8 argued that "adequate legislation allows solutions to enter the market by less traditional means" and reduces the need for public investment, which can be solved in the short term. On the contrary, Element 3 shared that in her experience regulation is typically "carried out over the long-term and requires the creation of a joint proposal, or the perception of an existing trend by a sovereign body".

Table 5.5 demonstrates the changes that respondents have performed in the second round. As an example, for the barrier “6. Lack of long-term commitment”, Elements 4, 7 and 8 have changed their initial response.

Table 5:5 Second questionnaire round answer changes (Likert scale) on the barriers' overtaken space-time by each participant

Barrier	Element								
	1	2	3	4	5	6	7	8	9
6. Lack of long-term commitment				4 -> 3			3 -> 2	3 -> 4	
7. Low acceptance of new projects and technologies				4 -> 3			4 -> 3		
8. Centralization of decision making				4 -> 3	4 -> 2		2 -> 1		2 -> 3
11. Inadequate project size					4 -> 2		4 -> 3		
14. Poor data availability and analytics									
15. Deficient or unreal planning	1 -> 2	4 -> 3			3 -> 2				4 -> 3
17. Lack of alignment of strategic goals and projects objectives		2 -> 3		4 -> 3					4 -> 3
26. Cost of training					5 -> 3		5 -> 4		2 -> 3
30. Lack of citizens' inclusion				4 -> 3			2 -> 1	4 -> 3	2 -> 4
32. Protection of heritage					5 -> 4				
34. Low Smart City awareness level of community					3 -> 2				4 -> 3
39. GDPR (privacy policy of personal data)	1 -> 2			4 -> 3	4 -> 3		5 -> 4		
40. Lack of regulatory norms	5 -> 2						5 -> 3	4 -> 3	
42. Lack of transparency on public procurement	5 -> 4	2 -> 3			5 -> 4			4 -> 3	1 -> 2
48. Shortage of proven and tested solutions	5 -> 4						5 -> 4		1 -> 3

Following the analysis of the changes made by each of the experts, it is possible to verify that element 9 was the one that made more changes, having changed 66.7% of their initial answers. This may be because it is the element with less years of experience. Moreover, the arguments and respect for the other elements may have influenced him. Besides, it can also be noted that the two female elements were the only ones who did not make any changes to their first-round responses. On average, the remaining elements changed 40.48% of their responses.

During the focus group discussion, the various positions that supported the response to the first round of the questionnaire were noticeable. Element 7 proved in practice to be the most divergent element of the group. Additionally, the different opinions and contrary positions within the group were noticeable. Private company members had a more assertive with stronger critical opinion, and public bodies parties were more concerned about guaranteeing an open and inclusive mindset. Furthermore, during the Focus Group discussion, the relation between several barriers was perceptible. The qualitative relationships are presented in Table 5.6.

Table 5:6 Qualitative barriers' relationships from Content Analysis

	Barriers	**Evidence**
C1 – Impact	30. Lack of citizens' Inclusion 31. Lack of citizens' accessibility to technology 34. Low Smart City awareness level of community	“Often we force technology without having a real context of its use by citizens" (Element 8) “If citizens lack of literacy and appropriate education they will not be able to understand and be active the initiatives” (Element 1)

	1. Policymakers' attitude 49. Disregard for the environment and natural resources from policymakers	"Decision-makers disregard for environmental matters makes difficult the progress on a large scale" (Element 9) "The denial of environmental considerations is Smart City's own denial" (Element 5)
	27. Lack of funding resources and financing opportunities 29. Global economy volatility (risk and uncertainty)	"In the face of extreme events, as happened with Covid-19 in 2020, there is a budget reallocation to other areas (namely health and social), disallowing strategies' progress" (Element 2)
C2 – Endogeneity	39. GDPR (privacy policy of personal data) 38. Lack of sharing culture	"The cultural context and the sharing culture are essential in a Smart City, and are upstream of the GDPR itself" (Element 1)
	42. Lack of transparency on public procurement 1. Policymakers' attitude 4. Lack of private-public partnerships (lack of stakeholders' involvement)	"Those who define the requirements should engage with the community, acquired knowledge through formal and formal methodologies, seen and tested several alternatives and know the existing solutions in order to define specifications open to everybody" (Element 1) "It is up to the decision-makers to obtain a better definition of requirements, bridging the lack of infrastructure and team's technical knowledge in municipalities opening the discussion to the community and involving other stakeholders (Universities, Clusters and Associations) in a constant knowledge sharing" (Element 7)
C3 – Space -time	27. Lack of funding resources and financing opportunities 40. Lack of regulatory norms	"Regulation requires the design of a proposal or the perception of an existing trend by a superior governmental body to push for the discussion and subsequently mobilize financial incentives" (Element 3)
	14. Poor data availability and analytics 21. Lack of cooperation and coordination between departments 1. Policymakers' attitude	"The change of mindset and the cooperation between departments are mostly related to the policymakers' attitude. The Smart City strategy will only be effective when it is thought in holistic terms rather than vertically or departmentally." (Element 4)
	6. Lack of long-term commitment 11. Inadequate project size	"Smart Cities are still related to short-term agendas" (Element 2) "The lack of long-term commitment is due to project's dimension usually for communication and marketing purposes, rather than smaller and easier to manage, with effective results, captivating citizens, and where the follow-up is not automatically dependent on funding issues" (Element 7)
	32. Protection of heritage 43. Long and complex procedures for authorizations/licenses	"There is great difficulty in implementing a Smart City strategy in historic cities, because of the existing bureaucracy which turns it undesirable for innovation." (Element 3)

These relationships help to understand that although some barriers may have less impact than others, they can be related and indirectly influence more significant barriers. Therefore, that should also be considered by policymakers.

Nevertheless, the results of the second Delphi round are specified in Table 5.7. These shall replace those from Table 5.2.

Table 5:7 Second Round Survey Average Results

Areas	Barriers	C1	C2	C3
Governance	6. Lack of long-term commitment			3,11
	7. Low acceptance of new projects and technologies			3,11
	8. Centralization of decision making			2,00
Project	11. Inadequate project size			2,78
	14. Poor data availability and analytics			2,89
	15. Deficient or unreal planning			2,44
Organization	17. Lack of alignment of strategic goals and projects objectives			2,67
Economy	26. Cost of training			3,11
	29. Global economy volatility (risk and uncertainty)	3,33		
Socio-Cultural	30. Lack of citizens' inclusion	4,22		2,56
	32. Protection of heritage			3,00
	34. Low Smart City awareness level of community			2,89
Legal	39. GDPR (privacy policy of personal data)	2,67	2,56	2,67
	40. Lack of regulatory norms	3,56		2,56
	41. Complicated and long public procurement processes		2,89	
	42. Lack of transparency on public procurement	3,78	3,44	2,78
	48. Shortage of proven and tested solutions			3,22
Environment	49. Disregard for the environment and natural resources from policymakers	3,78		

5.3.3. Discussion of the results

The results are represented in Figure 5.9, which positions the barriers according to the average result in each criterion. The vertical axis positions the barriers according to their endogeneity, that is, whether their resolution is within policymakers' control (endogenous) or not (exogenous), while the horizontal axis reveals the opinion of experts considering the time spacing which the barriers can be overtaken (short or long-term). The diameter of each circle provides information about their level of impact. The smaller circles have less impact than the larger.

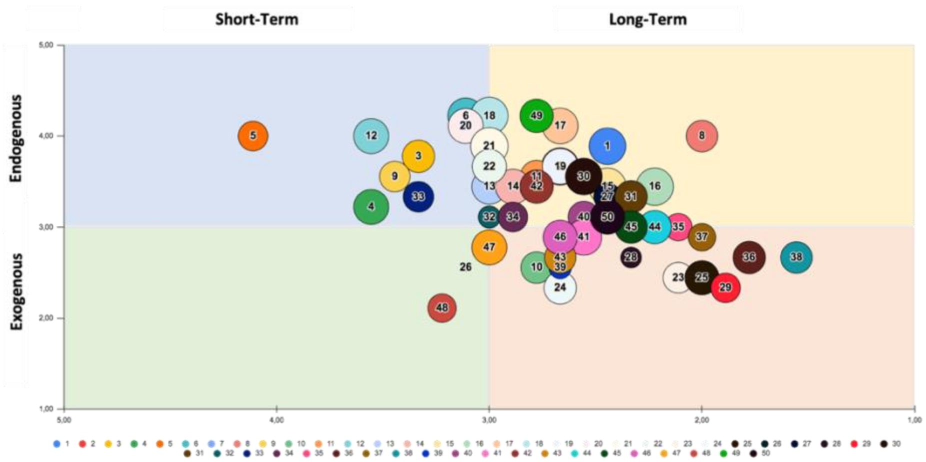


Figure 5:9 Distribution of the barriers according to their average level for each criterion.

Considering that this study aims to provide policymakers the information about the barriers they must acknowledge and prioritize, the attention shall be oriented to the barriers classified as endogenous. Thus, to find the Smart City critical barriers a three step-process followed.

First, the barriers were sorted by their Endogeneity result and divided into Endogenous (if the result was higher than 3) or Exogeneous (lower or equal to 3). After that, the barriers were sorted by their level of impact (from highest to lowest).

Second, because all Endogenous barriers had an impact superior to 3, it was considered a threshold of 4 for the impact to separate those with significant impact. Therefore, the barriers with an impact higher than 4 were considered as "Strong Impact".

Finally, the critical barriers controllable by policymakers with significant impact were divided and sorted (from lowest to highest) for the space-time they can be overcome.

As previously mentioned, the action plan, which shall be the foundation of a Smart City strategy, must contemplate the short-term and long-term actions. The path with the defined thresholds described above to find the critical barriers is represented in Figure 5.10.

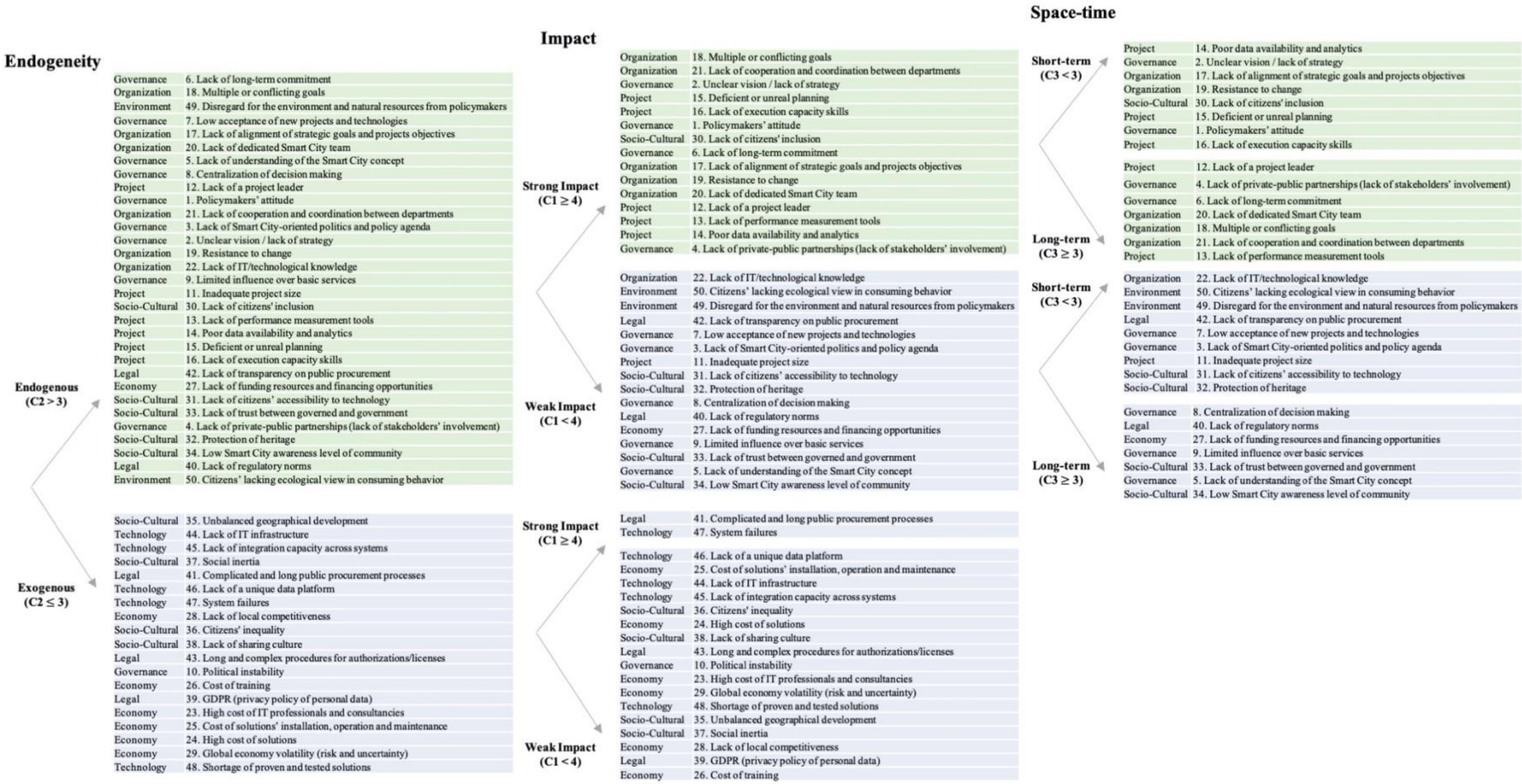


Figure 5:10 Representation of the journey with the respective thresholds for each criterion to find the critical Smart City barriers.

From the literature review, it was noticed that this topic is still unexplored, which can be explained by the lack of measurable results and conclusions from finished Smart City projects. Moreover, by recurring to Smart City experts to evaluating the barriers according to their impact, endogeneity level and space-time, this paper provides an overview to policymakers of how they shall prioritize their decisions and ground an action plan.

The 15 critical barriers, represented on the top right corner of Figure 5.10, are mainly from the areas of Governance, Project, and Organization. Thus, the endogenous barriers, with high impact, ordered by time-priority were: (i) poor data availability and analytics; (ii) unclear vision/ lack of strategy; (iii) lack of alignment of strategic goals and projects definition; (iv) resistance to change; (v) lack of citizens' inclusion; (vi) deficient of unreal planning; (vii) policymakers' attitude; (viii) lack of execution capacity skills; (ix) lack of a project leader; (x) lack of public-private partnerships; (xi) lack of long-term commitment; (xii) lack of dedicated Smart City team; (xiii) multiple or conflicting goals; (xiv) lack of cooperation and coordination between departments; and (xv) lack of performance measurement tools. In summary, these barriers leverage the idea that a successful Smart City implementation depends on the adequate organization, tools to evaluate and analyze data, and a skilled and dedicated team.

Besides, there is only one barrier ("30. Lack of citizens' inclusion") from the Socio-cultural area, which highlights the importance of including citizens. Thus, it provides the literature with significant insights about the need to define frameworks and participatory methodologies to enable the implementation of a Smart City strategy. This fact is aligned with the evolution of the Smart Cities concept. Smart Cities started to be techno-centric and moved to focus on sustainability and the citizens' quality of life, breaking silos and promoting interoperability among solutions, allowing the city to have a real-time and integrated perspective. The placement of the end-user at the center of decision-making is increasingly present and moving them forward. Nowadays, cities are increasingly created with and for the citizen. This reveals the alignment of the experts' understanding with the evolution of the Smart City concept and provides the literature with significant insights about the need to include social literature in Smart Cities environment.

On the contrary, there are not any barriers from the technology area. Moreover, it is the only area that is not represented among the endogenous barriers. This leads to the understanding that although Smart Cities' implementation is most times associated with technological challenges, those are not within the control of policymakers. Despite, from the technological barriers, there is only one with strong impact (47. "System failures").

Additionally, there are not any financial-wise barriers within the endogenous with high impact. This sets apart the thinking that Smart City strategies' successful implementation are dependent on economic and technological capacities pointed by other studies' results (Mosannenzadeh et al., 2017; Rana et al., 2019).

In the overall picture, there are only two exogenous barriers with significant impact, which leads to the conclusion that the success of Smart City's implementation is within reach and is primarily dependent on policymakers' actions.

In summary, to implement a successful Smart City approach, policymakers shall acknowledge different data sources to have useful information to base their strategy for the territory and perform continuous evaluation. After defining the long-term vision with the involvement of the citizens, they shall point a project leader to organize it through smaller projects oriented for the same strategic goals. A team with complementary skills shall be setup for each project, not disregarding the cooperation between departments and public-private partnerships to search for outside valuable skills and know how.

5.4. Conclusions and Future Work

One of the major gaps in the Smart Cities field is that policymakers do not have the basic know-how to plan a successful strategy, which is perpetuated by the lack of empirical knowledge sharing by those who have already experienced the process. Thus, the design of an effective strategic plan is dependent on the correct prioritization of actions to respond identified challenges.

This paper started from an extensive review to find the Smart City critical barriers. This way, policymakers could have vital information to define an action plan to overcome each identified barrier based on its impact, endogeneity, and space-time.

Moreover, 15 critical barriers mainly from the areas of Governance, Project, and Organization were obtained. Besides these, there was only one additional barrier ("Lack of citizens' inclusion") from the Socio-cultural area, highlighting the necessity to include citizens. Technology and Economy are two of the areas that were not represented. Therefore, although Smart Cities are often associated with technological and financial challenges, based on this study findings those are not within the control of policymakers neither are relevant to the success of the Smart City implementation. Furthermore, there are only two exogenous barriers classified with significant impact which means that policymakers and their internal influence have a vital role.

In conclusion, the success of Smart City's implementation depends on policymakers' actions and their capacity to envision a plan with concrete objectives, build relationships, and set a skilled and dedicated team.

The Delphi questionnaire only counted two rounds, almost in a row, to attempt that external phenomenon would not disturb and influence the participants' second response. The fact that there is no unlimited time to give experts the chance to reflect on the topic may present a limitation. However, this was combated from the analysis of their first answers, which allowed a more concrete and assertive discussion on the second round. Although the exercise format was all digital, although it favors the actors' attendance, it may also represent a limitation because of the lack of physical contact for greater openness.

Key stakeholders are often left aside, and studies' conclusions are based on theoretical modules without a broader understanding of empirical evidence. Smart Cities have evolved to include citizens and remaining stakeholders in decision-making. Nevertheless, there still exists the need to develop participatory approaches to combine top-down and bottom-up perspectives.

In summary, based on experts' perspectives, this paper provides a deeper characterization of the Smart City barriers considering their impact on the development of a Smart City, the policymakers' capacity to tackle them and within what period of time. New studies can emerge upon the results to help decision-makers on the Smart City implementation process. The findings significantly contribute to the literature about the importance of including social literature in Smart Cities scope and the need to define frameworks and participatory methodologies to implement a Smart City strategy.

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Appendix 5.1 – Thematic Analysis Literature Barriers

Source	Area	Barrier	Thematic Analysis - Elimination and Aggregation: Area (Theme)	Barrier (Code)
(Gil-García & Pardo, 2005)	Management and organization	Project size	Project	11. Inadequate Project Size
		Manager's attitudes and Behavior	Governance	1. Policymakers' Attitude
		Users or organizational diversity		
		Lack of alignment of organizational goals and project	Organization	17. Lack of alignment of strategic goals and projects objectives
		Multiple or conflicting goals	Organization	18. Multiple or conflicting goals
		Resistance to change	Organization	19. Resistance to change
		Turf and conflicts		
(Ebrahim & Irani, 2005)	IT Skills	IT training programs	Economic	26. Cost of Training
		Lack employees with integration skills and culture	Organization	22. Lack of IT/technological knowledge
	Organizational	Lack of cross-sectoral cooperation	Governance	4. Lack of private-public partnerships (lack of stakeholders' involvement)
		Lack of inter-departmental coordination	Organization	21. Lack of cooperation and coordination between departments
		Unclear vision of IT management	Governance	2. Unclear vision / lack of strategy
		Politics	Governance	10. Political instability
		Culture issues	Socio-cultural	32. Protection of heritage
(Chourabi et al., 2012)	IT infrastructure	Lack of integration across government systems	Technological	45. Lack of integration capacity across systems
		Existing internal systems have restrictions regarding their integrating capabilities	Technological	45. Lack of integration capacity across systems
		Lack of knowledge regarding interoperability	Organization	22. Lack of IT/technological knowledge
		Availability and compatibility of software, systems and applications	Technological	45. Lack of integration capacity across systems
	Security and privacy	Threats from hackers and intruders	Technological	47. System failures
		Threats from viruses, worms and Trojans	Technological	47. System failures
		Privacy of personal data	Technological	39. GDPR (privacy policy of personal data)
		High cost of security applications and solutions	Economic	24. High cost of solutions
		Accessibility	Socio-cultural	31. Lack of citizens' accessibility to technology
	Operational cost	High cost of IT professionals and consultancies	Economic	23. High cost of IT professionals and consultancies
		High cost of IT	Economic	24. High cost of solutions
		Cost of installation, operation and maintenance of information systems	Economic	25. Cost of solutions' installation, operation and maintenance
		Cost of training	Economic	26. Cost of training
(Mosannenzadeh et al., 2017)	Policy	Lack of long-term and consistent energy plans and policies	Governance	6. Lack of long-term commitment
		Lacking or fragmented local political commitment and support on the long term	Governance	6. Lack of long-term commitment
	Administrative	Difficulty in the coordination of high number of partners and authorities	Governance	4. Lack of private-public partnerships (lack of stakeholders' involvement)
		Lack of good cooperation and acceptance among partners	Governance	4. Lack of private-public partnerships (lack of stakeholders' involvement)
		Lack of public participation	Socio-cultural	37. Social inertia
		Lack of institutions/mechanisms to disseminate information	Economic	27. Lack of funding resources and financing opportunities
		Long and complex procedures for authorization of project activities	Legal	43. Long and complex procedures for authorizations/licenses
		Time consuming requirements by EC concerning reporting and accountancy	Legal	41. Complicated and long public procurement processes
		Complicated and non-comprehensive public procurement	Legal	41. Complicated and long public procurement processes
		Fragmented ownership		
	Legal and Regulatory	Inadequate regulations for new technologies	Legal	40. Lack of regulatory norms
		Regulatory instability	Legal	40. Lack of regulatory norms
		Non-effective regulations	Legal	40. Lack of regulatory norms

		Unfavorable local regulations for innovative technologies	Legal	40. Lack of regulatory norms
		Insufficient or insecure financial incentives	Economic	27. Lack of funding resources and financing opportunities
	Financial	High costs of design, material, construction, and installation	Economic	25. Cost of solutions' installation, operation and maintenance
		Hidden costs	Economic	25. Cost of solutions' installation, operation and maintenance
		Insufficient external financial support and funding for project activities	Economic	27. Lack of funding resources and financing opportunities
		Limited access to capital and cost disincentives	Economic	27. Lack of funding resources and financing opportunities
		Economic crisis	Economic	29. Global economy volatility (risk and uncertainty)
		Risk and uncertainty	Economic	29. Global economy volatility (risk and uncertainty)
	Market	Split incentives		
	Environmental	Enerry price distortion		
		Negative effects of project intervention on the natural environment	Environemntal	49. Disregard for the environment and natural resources from policymakers
	Technical	Shortage of proven and tested solutions and examples	Technological	48. Shortage of proven and tested solutions
		Lack of skilled and trained personnel	Project	16. Lack of execution capacity skills
		Deficient planning	Project	15. Deficient or unreal planning
		Lack of well-defined process	Project	15. Deficient or unreal planning
		Retrofitting work in dwellings in occupied state		
	Social	Inertia	Socio-cultural	37. Social inertia
		Lack of values and interest in energy optimization measurements	Project	13. Lack of performance measurement tools
		Low acceptance of new projects and technologies	Governance	7. Low acceptance of new projects and technologies
	Information andAwareness	Insufficient information on the part of potential users and consumers	Socio-Cultural	31. Lack of citizens' accessibility to technology
		Lack of awareness among authorities	Governance	5. Lack of understanding of the Smart City concept
		Perception of interventions as complicated and expensive, with negative socio-economic or environmental impacts		
(Rana et al., 2019)	Governance	Lack of cooperation and coordination between city's operational networks	Governance	4. Lack of private-public partnerships (lack of stakeholders' involvement)
		Unclear IT management vision	Governance	2. Unclear vision / lack of strategy
		Political instability	Governance	10. Political instability
		Lack of trust between governed and government	Socio-cultural	33. Lack of trust between governed and government
		Poor private-public participation	Governance	4. Lack of private-public partnerships (lack of stakeholders' involvement)
		Lack of developing a common information system	Technological	46. Lack of a unique data platform
	Economic	Lack of IT infrastructure and intelligence deficit	Technological	44. Lack of IT Infrastructure
		Lack of competitiveness	Economic	28. Lack of local competitiveness
		Cost of IT training and skills development	Economic	26. Cost of training
		Global economy volatility	Economic	29. Global economy volatility (risk and uncertainty)
		Higher operational and maintenance cost	Economic	25. Cost of solutions' installation, operation and maintenance
	Social	Lack of involvement of citizens	Socio-cultural	30. Lack of citizens' Inclusion
		Low awareness level of community	Socio-cultural	34. Low Smart City awareness level of community
		Geographical diversification problems	Socio-cultural	35. Unbalanced geographical development
		Degree of inequality	Socio-cultural	36. Citizens' inequality
	Technology	Lacking technological knowledge among the planners	Organization	22. Lack of IT/technological knowledge
		Lack of access to technology	Socio-cultural	31. Lack of citizens' accessibility to technology

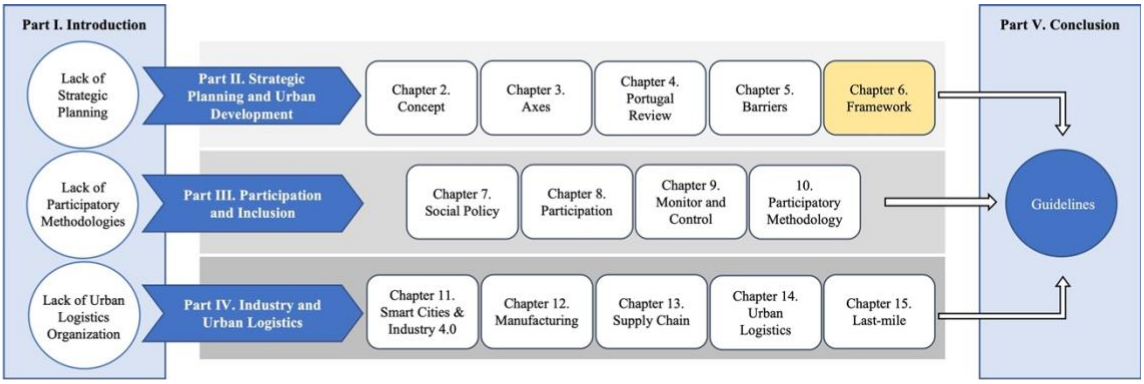
		Privacy and security issues	Legal	39. GDPR (privacy policy of personal data)
		System failures issues	Technological	47. System failures
		Integration and convergence issues across IT networks	Technological	45. Lack of integration capacity across systems
		Poor data availability and scalability	Project	14. Poor data availability and analytics
	Environmental	Lacking ecological view in behaviour	Environmental	50. Citizens' lacking ecological view in consuming behavior
		Growing population problems	Environmental	49. Disregard for the environment and natural resources from policymakers
		Lack of sustainability considerations	Environmental	49. Disregard for the environment and natural resources from policymakers
		Carbon emissions effect	Environmental	49. Disregard for the environment and natural resources from policymakers
		Degradation of resources		
	Legal and Ethical	Cultural issues	Socio-cultural	38. Lack of sharing culture
		Lacking standardization	Technological	45. Lack of integration capacity across systems
		Issues of openness of data	Technological	46. Lack of open data platform availability
		Lack of transparency and liability	Legal	42. Lack of transparency on public procurement
		Lack of regulatory norms, policies and directions	Legal	40. Lack of regulatory norms
(S. Y. Tan & Taeihagh, 2020)		Budget Constraints and Financing Issues	Economic	27. Lack of funding resources and financing opportunities
		Lack of Investment in Basic Infrastructure	Technological	44. Lack of IT Infrastructure
		Lack of Technology-Related Infrastructure Readiness	Technological	48. Shortage of proven and tested solutions
		Fragmented Authority		
		Lack of Governance Frameworks and Regulatory Safeguards for Smart Cities	Governance	2. Unclear vision / lack of strategy
		Lack of Skilled Human Capital	Project	16. Lack of execution capacity skills
		Lack of Inclusivity	Socio-cultural	30. Lack of citizens' Inclusion
		Environmental Concerns	Environmental	49. Disregard for the environment and natural resources from policymakers
		Lack of Citizen Participation	Socio-cultural	30. Lack of citizens' Inclusion
		Technology Illiteracy and Knowledge Deficit among the Citizens	Socio-cultural	31. Lack of citizens' accessibility to technology
(Goyal, Sahni, & Garg, 2018)	Government	Poor policies to promote Smart City development	Governance	3. Lack of Smart City-oriented politics and policy agenda
(Neirotti, Marco, Cagliano, Mangano, & Scorrano, 2014)		Centralization of decision making	Governance	8. Centralization of decision making
(Chatterjee & Kar, 2015)		Limited influence over some basic services (privatization)	Governance	9. Limited influence over basic services
		Technology is still in premature and in precommercial stage	Technological	48. Shortage of proven and tested solutions
(Nam & Pardo, 2011) (Nam and Pardo (2011a))		Public Procurement Processes are rigid and old fashioned (price is the decision factor most of times)	Legal	41. Complicated and long public procurement processes
		Costs (fixed and variable) of technologies and long paybacks	Economic	25. Cost of solutions' installation, operation and maintenance
(Alawadhi et al., 2012)		Lack of a project leader	Project	12. Lack of a project leader
		The lack of IT skills, project managers with knowledge in the area, and a transversal project leader	Project	20. Lack of dedicated Smart City team
(Mosannenzadeh & Vettorato, 2014)		External sources mainly fund cities, and that financial support is insufficient to fund the different initiatives	Economic	27. Lack of funding resources and financing opportunities
(Van Den Bergh & Viaene, 2015)		The mindset is not yet adapted to innovation	Governance	2. Unclear vision / lack of strategy
(Correia, Teixeira, & Marques, 2020)		Lack of Smart City assessment and performance measurement tools	Organization	19. Resistance to change

Chapter 6

Co-creation of a Smart City strategy: A decision support framework based on the PDCA cycle

Reference

Correia, D., Marques, J. L., & Teixeira, L. (2021). Co-creation of a Smart City strategy: A decision support framework based on the PDCA cycle. *Systems and Information Technology*.



6. Co-creation of a Smart City strategy: A decision support framework based on the PDCA cycle

Abstract

Information and Communication Technologies (ICTs) brought a new paradigm allowing policymakers to ground their actions on real-time events. Smart Cities were initially conceived as a technological vision separated from urban planning. As a result, projects were rarely connected between departments, objectives were not aligned with strategic goals, and lacked citizens' participation. Moreover, it was not given proper importance to the process of becoming a Smart City, in the sense of formulating integrated guidelines and participatory methodologies to define a strategy for the territory. This paper proposes a framework inspired by the Plan-Do-Check-Act (PDCA) cycle to guide and support the design and implementation of Smart City strategies. Thus, interviews with nine policymakers are conducted to explore current decision-making processes, specifically if and how Smart City strategies are designed and who are the main contributors to these strategies. Based on these findings, inductive thematic analysis of literature studies to inspire the steps of the proposed framework is performed. Ultimately, these steps are discussed in a focus group with nine Smart City experts who performed an in-depth characterization of each step's guidelines. Policymakers confirm the lack of a standard planning and project management approach. Results describe a flexible, participatory framework that contemplates developed 12 steps divided into 4 phases with dedicated guidelines.

Keywords: PDCA, Framework, Smart City, Guidelines, Participatory Methodologies.

6.1. Introduction

Data has enhanced city management’s decision-making from the beginning of the century (Hall et al., 2000). Embedded solutions enabled the observation of urban systems at a micro-level (Harrison and Donnelly, 2017). Moreover, Internet-of-Things (IoT) allowed the generation and accessibility of data, increasing authorities' responsiveness to city problems and promoting citizens’ awareness and participation in public matters (Mulligan and Olsson, 2013). IoT also had a crucial role in urban planning due to the share of information across different platforms and applications, enabling the building of a common operating picture of the city (Jin et al., 2014). Furthermore, having integrated historical information gathered from the different devices allowed cities to become proactive. Moreover, the increasingly placement of Information and Communication Technologies (ICTs) into the urban furniture and the provision of platforms to get citizens to feedback on cities occurrences have turned them into active elements gathering real-time data from multiple sources and streams. This has allowed cities to build control centers where data are analyzed, allowing actions to be taken instantaneously (Townsend, 2000). Moreover, nowadays the functioning and regulation of a city are based on real time analytics and predictive models built from data aggregation over time (Kitchin, 2014). The tackle of urban challenges depends upon the usage of innovative use of technologies (Meijer and Thaens, 2016). However, cities often implement solutions without having the proper foundation. The lack of strategic vision and participation have delayed Smart Cities implementation.

On the one hand, from an empirical study of 108 Italian cities (with at least one Smart City initiative), Dameri and Benevolo (2016) found that only 20.7% of the cities had formal involvement of political decision-makers. On the other hand, from a multiple case study analysis, Mora, Deakin and Reid (2018) concluded that there is the need to look beyond technology and create a Smart City strategic framework combining the top-down with the bottom-up approach, developing strategies, and supporting the growth of an open, inclusive, and engaging collaborative environment. The collaboration between actors sustains the local government (Nurdin, Scheepers and Stockdale, 2022). Guidelines that assist municipalities and bring together the various stakeholders to provide greater collaboration and information sharing can be vital for a better definition of strategies concerning implementing innovative solutions in cities (Shelton, Zook and Wiig, 2015; Gil-Garcia, Pardo and De Tuya, 2019).

Thus, strategic planning remains a rather abstract and unexplored idea (Angelidou, 2014). Most of the studies reported in the area highlight technological aspects, leaving aside considerations on the management of the city and its policies (Komninos, 2014; Angelidou, 2015). Public bodies still need support to understand the Smart City concept and how to start and keep moving forward in the process (Neirotti et al., 2014; Van Den Bergh and Viaene, 2015; Braga et al., 2021).

Moreover, the literature identifies the need to create frameworks capable of supporting and clarifying the strategic planning of cities (Zygiaris, 2013). Some authors point to this type of tool as extremely important in supporting decision-making on urban development as they can help assess the progress of cities towards the goals previously set (Mohanty, Choppali and Kougianos, 2016). Thus, to help decision-makers along the process, this paper intends to develop a flexible, participatory framework with a specific target. The goal is to define a roadmap with concrete actions considering policymakers' strategic goals and the relationship with the city's initial stage. Therefore, this paper considers a two-step methodology.

On the one hand, interviews with Portuguese policymakers are performed to highlight the existing gap, complemented by an interview with a Secretary of State to acknowledge the role and positioning of the government. On the other hand, a focus group is undertaken with Smart City experts to discuss the actions that policymakers must consider in each step of implementing a Smart City strategy. The steps that ground the discussion are based on a thematic analysis performed on existing frameworks in the literature.

Furthermore, this paper is structured as follows. First, in section 6.2, a literature review is performed to identify the research gap about the lack of concrete guidelines to support policymakers throughout implementing a Smart City. Moreover, the initial focus is rarely given to the existing city since it is often associated only with technological initiatives. Therefore, it does not give the city enough information to guide and define a dedicated roadmap. Moreover, the research question of the present investigation is “What are the guidelines to develop a Smart City?”. Section 6.3 details the methodological procedure starting from interviews to Portuguese policymakers to assess their understanding of the concept and how strategies are currently defined. These are confronted with the view of a Portuguese Secretary of State. The findings base the scope of the following discussion over a focus group with experts. In section 6.4, a framework based on the interviews' results and the focus group's learnings is presented. Finally, conclusions are drawn in section 6.5.

6.2. Literature Review

The Smart City concept has passed three stages (Cohen, 2015; Trencher, 2019). Moreover, it evolved from the focus on technology (Smart City 1.0), to use it as an enabler of city’s sustainability and citizen’s quality of life (Smart City 2.0). Nowadays, these play a crucial participatory role in designing and creating cities (Smart City 3.0).

Russo et al. (2014) recall the Smart City definition and guidelines evolution at the European Union level, highlighting the inclusion of citizens and cities co-creation. The two governance bodies of EIP-SCC, High-Level Group (HLG) and Smart Cities Stakeholder Platform (SCSP), defined the rules and guidelines for developing Smart Cities. These can be found in the Strategic Implementation Plan (SIP) (European Commission, 2013) and the Operational

Implementation Plan (OIP) (European Commission, 2014). Furthermore, strategic planning has the challenge of integrating the needs for urban intelligence with the policy strategies followed by local decision-makers in response to the existing weaknesses of the urban system. This raises the question of if the decisions express citizens' preferences (Wolf et al., 2019; Correia et al., 2021).

Thus, in the breakdown of strategic plans, local decision-makers are challenged to adopt new approaches and instruments to answer complex, territorialized socioeconomic needs. The challenge is to transfer macro guideline strategic plans to micro reality since cities' strategic planning depends on their specific contexts, challenges, and opportunities (Correia, Marques and Teixeira, 2021). Table 6.1 details the existing frameworks present in the literature when searching on Scopus and Web of Science for strategic and urban planning' schemes under the Smart Cities topic.

Table 6:1 Revision of existing studies in the literature

Source	Proposal
(Chourabi et al., 2012)	Framework with two levels of relationships and influences: (i) external factors – governance, people and communities, natural environment, infrastructure, and economy; and (ii) internal factors – technology, management, and policy.
(Barrionuevo, Berrone, & Ricart Costa, 2012)	Defined a process with 10 linear step Smart City divided into 3 phases: Diagnose the Situation (2-5 months); Develop a Strategic Plan (5-12 months) and Take Action (2-10 years).
(Lee, Phaal, & Lee, 2013)	Proposed an 8-phases technological roadmap for Smart City development divided into 3 parts: Preliminary Activity, Development activity of integrated roadmap, and Follow-up activity.
(Zygiaris, 2013)	Established 7 layers for the Smart City architecture that starts from the readiness of the city, the reduction of the carbon footprint and strives to the capacity to have real-time events and integrated urban space.
(Stratigea, Papadopoulou, & Panagiotopoulou, 2015)	Draw a framework based on 4 Smart City stages based on a public participation background contemplating brainstorming and identifying local problems and solutions.
(Mora & Bolici, 2016)	Described the 5 phases development process roadmap of the Amsterdam's Smart City strategy: Starting, Planning, Development of Projects, Monitoring and Evaluation, and Communication.
(García-Fuentes & de Torre, 2017)	Set a 4 phases Urban Regeneration model: City audit, Actions plan, Implementation, and Assessment. The model considers three action sectors: Urban districts and built environment, Urban transport, and Integrated infrastructures and processes.

The previously mentioned studies of Table 6.1 supported this paper's reflection and helped build the path to create a Smart City. Chourabi et al. (2012) raised the concern about the need to contemplate external and internal factors, and Barrionuevo, Berrone and Ricart Costa (2012) to the fact that becoming a Smart City could take more than a decade and should be grounded on a strategic vision. Lee, Phaal, and Lee (2013) highlighted the need of having a unified and standard process, which can be noted in the study of Mora and Bolici (2016) about the city of Amsterdam. Zygiaris (2013) stressed that the process should start from the community's involvement and the guarantee of institutional support to promote an integrated urban planning vision based on real-time events. Stratigea, Papadopoulou, and Panagiotopoulou (2015) claimed attention to the need for context and public participation to co-create the city's strategy. This tendency is perpetuated by García-Fuentes and Torre (2017). They consider citizens and other local stakeholders as enablers of a replicable framework to European cities.

Nevertheless, existing Smart City frameworks do not respond to cities challenges since they refer to the macro dimension, not assisting the definition of an action plan (Kim and Steenkamp, 2013; Berst, Enbysk and Williams, 2014; Hamza, 2016). Moreover, there is a need to create user-friendly representations of the collected data and the design strategy, which should be supported by concrete guidelines (Baccarelli et al., 2017).

In addition, Sharifi (2019) concluded on its comparison study among the existing assessment tools in the literature that only 32% of the tools are aligned with strategic needs. Only 25% of them provide recommendations on how to roadmap and define action points after assessing the conclusions. Moreover, the need for a frame of reference is evident. The collaborative dimension of governance in co-design, co-creation, and co-production has to be considered for more significant information crossover (involving key stakeholders) and faster processes (Anttiroiko, Valkama and Bailey, 2014).

6.3. Methodology and research method

The followed methodology is portrayed in Figure 6.1, starting with interviews with policymakers to explore current processes, specifically if and how Smart City strategies are designed and who are the main contributors to these strategies (Phase A in Figure 6.1). After, to ground the findings of this paper on existing Smart City guidelines studies, the first step of Phase B (Figure 6.1) was conducted. Therefore, a thematic analysis was performed on the frameworks present in the literature. Their guidelines were aggregated and coded. Finally, the harmonization of resulting codes was reflected in categories (themes) that set the proposed framework's structure basis.

After the first analysis, a pattern among exiting frameworks was noted because most of them contemplate a planning phase, a development phase, and an evaluation phase. Moreover, based on the findings, the themes were positioned within a lean planning and control approach (Jünge et al., 2019), the Plan-Do-Check-Act (PDCA) cycle scope, since this framework sets a process that follows the aspirations of continuous improvement. The categorization within the PDCA cycle also allowed better organization for the discussion with experts. Therefore, in the second step of Phase B, a focus group was promoted to join experts to discuss the actions and considerations that policymakers must acknowledge for each process step to conceive a Smart City strategy.

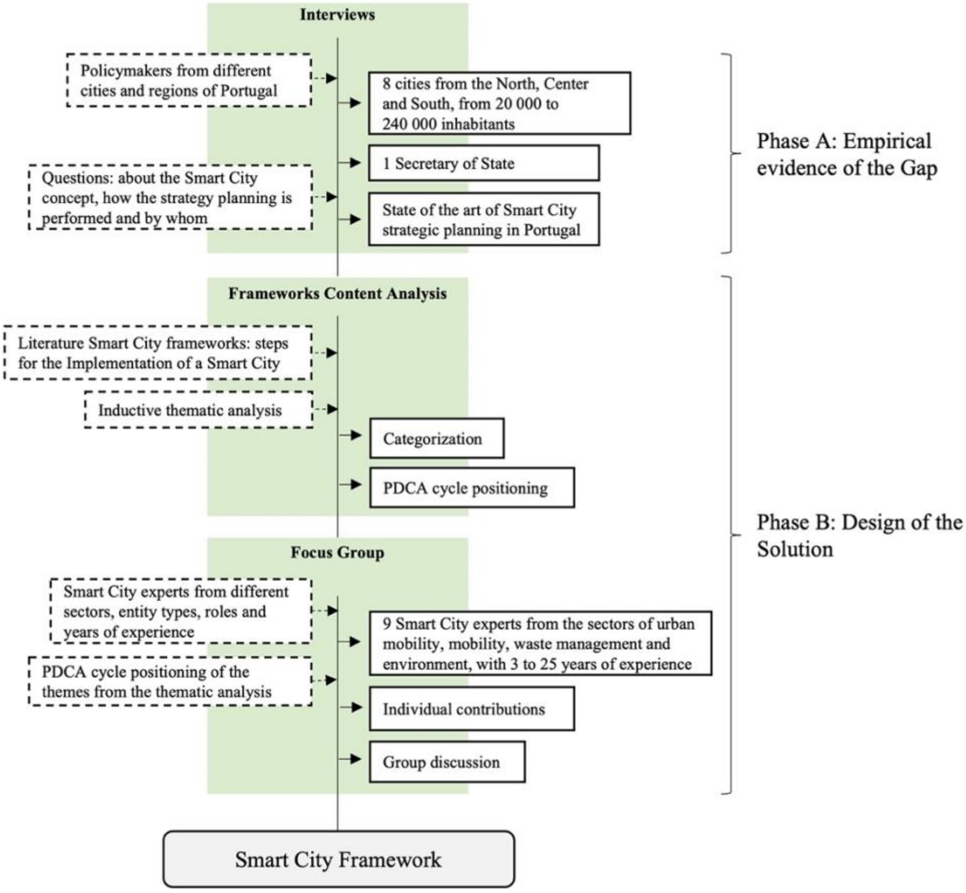


Figure 6:1 The framework of the research method

6.3.1 Interviews

In-depth interviews were conducted with eight policymakers from different Portuguese cities. This covered a range of cities from different regions of the Portuguese territory, with different socio-economic characteristics, the smallest one with around 20 000 people and the largest one with around 240 000. The interviews were conducted via Zoom between January and February 2021. The main questions addressed were: (i) “Is there a Smart City strategy in your city?”; (ii) “How was it developed?”; (iii) “Who was involved?”; (iv) “Was based on a specific methodology?”; (v) “Was there any framework of reference to guide the definition of your strategy?”. In addition, an interview with a Portuguese Secretary of State was performed. This aimed to understand the view of the sovereign body legislator about the definition and standardization of Smart Cities implementation and how the government approaches the concept.

In terms of data analysis, this followed an inductive approach based on main emerging categories that resulted from the analysis of the transcribed interviews.

In terms of ethical considerations, this research's main issue has to do with the anonymity of participants. This is especially the case due to the small number of interviews conducted. Interviews were therefore anonymized. For these purposes, no names of cities or policymakers are referred. Instead, interviewees (policymakers) are numbered, and only this information will be provided below in Table 6.2.

Table 6:2 Policymakers and cities sample data

Interviewee	Role	Gender	Area	Population	Location
1	Vice-Mayor	Male	Environment, Mobility and Tourism	45 000	South
2	Alderman	Male	Social Policy, Innovation and Tourism	20 000	Center
3	Vice-Mayor	Male	Innovation, Environment and Energy	240 000	North
4	Vice-Mayor	Female	Environment, Social and Energy	35 000	North
5	Alderman	Male	Mobility and Urban Planning	140 000	Center
6	Vice-Mayor	Male	Urban Plannning and Mobility	40 000	North
7	Vice-Mayor	Male	Urban Plannning, Innovation and Mobility	210 000	South
8	Alderman	Male	Mobility and Urban Planning	190 000	North
9	Secretary of State	Male	Innovation	-	-

6.3.2 Frameworks Content Analysis

Based on the results of the interviews, guidelines were sought in the literature, and categorized to base the foundations of the proposed framework. Based on an inductive analysis, the initial coding was performed upon the data of existing Smart City frameworks (Kondracki, Wellman and Amundson, 2002). The aim of the thematic analysis was to find patterns within and across the data to build the structure and the focus areas of the framework.

As Smart Cities are a never-ending cyclical process with a continuous improvement background, the themes were ultimately matched with the Plan-Do-Check-Act (PDCA) cycle phases. The PDCA cycle usually is used to develop a new project or upgrade an existing process working towards a continuous improvement methodology (Venkatraman, 2007). Other variants have emerged (Saier, 2017).

Furthermore, the initial codes were ultimately aggregated in themes and later established the relationship with the corresponding PDCA cycle stage. Figure 6.2 shows this procedure.

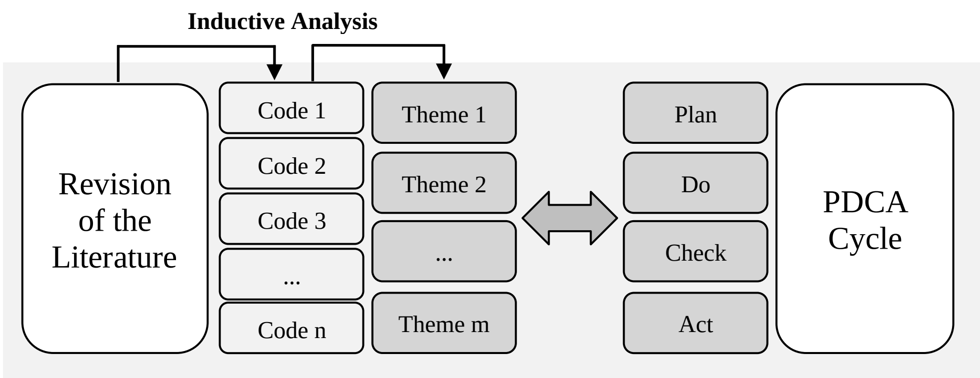


Figure 6:2 Summary of the inductive thematic analysis to the literature existing frameworks

6.3.3 Focus Group

A focus group of multidisciplinary experts (see Table 6.3) leveraged the analysis and discussion of the guidelines starting on the thematic analysis performed to the literature.

The focus group qualitative approach is characterized by having an open and flexible format with a collective point of view uncovered by individual interviews, permitting the direct interaction of the researcher with the experts allowing a broader and clarifying discussion (Stewart, Shamdasani and Rook, 2007).

Every participant had 5 minutes to argue about what policymakers should consider in a specific process step. After each intervention, the group could discuss the subject (*Figure 6.4), and everyone could add insights to the previous thoughts. The methodology followed is detailed in Figure 6.3.

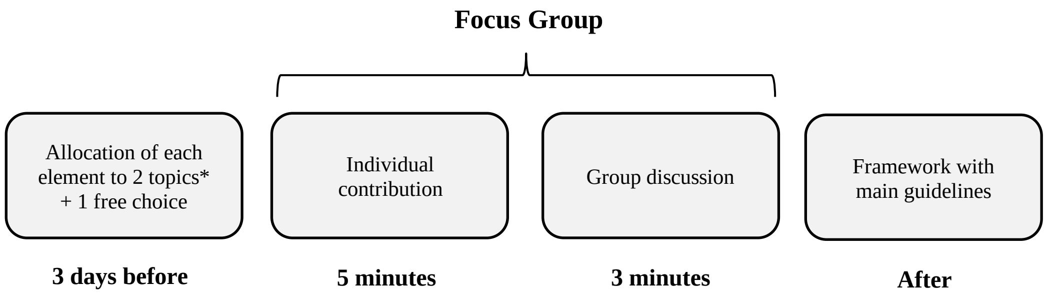


Figure 6:3 Focus group methodology

In a focus group, usually, it is given to the group a set of topics before the gathering. The goal is to enable everyone to express their opinion to reach a consensus (Flynn et al., 1990). Therefore, each participant was assigned with two specific steps of the process, consider their knowledge and practical experience. In general, members of academia and research were allocated to the "Plan" phase. Private companies' participants to the "Do" phase, due to their knowledge in market analysis, choice of solutions and piloting contributions. Finally, elements of City councils that usually analyze the results of pilots and decide whether to scale a pilot or not were allocated to the phase of "Check" and "Act".

The analysis of the focus group considered the list of questions proposed by Stevens (1996) to guide the analysis of the focus group, and the critique made by Webb and Kevern (2001) of, on the one hand, the lack of quotations from the participants' interventions and, on the other hand, the description of the interactions, the findings of the present research are ultimately reported in the form of a framework.

Table 6.3 highlights the characteristics and identification of each participant. Moreover, it was intended to align a group that represented various stakeholders, from different sectors and roles, with leadership or technical positions. Therefore, the joint experts comprised one academic, two private companies' general managers, one consultancy president, one Smart City cluster executive board member, one European policy R&I department director, two city department directors and one technician. Thus, it was possible to bring together people with different backgrounds, from universities, consultants, public entities and private entities, a combination of experienced professionals with others with less experience. Still, the average of years of experience in the topic of Smart Cities was about 12 years.

Table 6:3 Characterization of the focus group sample

Participant	Gender	Sector	Entity	Role	Experience
1	Male	ICT	ICT Cluster	Executive Board Member	30 years
2	Male	ICT	University	Professor	25 years
3	Female	EC Policy & Strategy	Non-profit Foundation	R&I Department Director	10 years
4	Male	ICT & Electronics	R&I Consultant	President	10 years
5	Male	Urban Cleaning and Waste Management	Private Company	CEO	3 years
6	Male	Mobility & Tourism	Private Company	CEO	9 years
7	Male	Environment and Waste Management	Municipality	Department Director	8 years
8	Male	Urban Management	Municipality	Technician	5 years
9	Female	Climate Action and Circular Economy	Municipality	Department Director	6 years

6.4. Results and Discussion

This section presents the results and findings of the methodology. Moreover, it is divided into two sub-sections. First, the results from the thematic analysis of the interviews are presented. Second, the codification of existing guidelines in the literature and the discussion on the focus group are highlighted.

6.4.1 Smart City concept understandings and current strategies

Policymakers initial understanding of Smart Cities was related to the modernization of public administration and the optimization of internal processes.

The Portuguese cities ended up going through the various Smart Cities phases, starting from implementing isolated projects with a political background, and moving to a reasoned and aggregated thinking to improve the city's sustainability and citizens' well-being.

The Vice Mayor of City 7 makes an overview of the evolution of Smart Cities. The first iteration a few years ago was "technology-driven", in which technology guided the city, decision-makers went after the news without a strategy. The second phase was known as "technology-enable", accounting the definition of a strategy with the advantage of technologies. Nevertheless, it did not acknowledge citizens involvement. Therefore, there was only a macro perspective by politicians and consultants. Later, the third version of Smart City emerged, which is "Citizen co-created", hence the importance of participatory dimension and community auscultation, to objectively build the city according to their needs, quickly and sustainably. The citizen is at the center, and implementing a solution is based on an in-depth study of citizens' gains. Thus, the initial challenge that delayed the implementation of Smart City strategies is overcome.

Nowadays, before implementing a playground, policymakers know they must study the ages, children's locations, and many other variables, grounding decisions on evidence and empirical data analysis (Policymaker 3). Moreover, the priority is to understand which technological tools can be implemented to obtain data. (Policymaker 2).

In summary, policymakers assume the tendency is for cities to become democratically co-created with citizens. However, they stress that it cannot lead to the inertia of political action.

Table 6.4 summarizes the content analysis about the understanding of what a Smart City is in the interviewees' words.

Table 6:4 Understanding of the Smart City concept by policymakers

City	Definition
1	Provision of collective intelligence (integration of computer systems) at the citizens' disposal to access municipal services without the need to travel (convenience and reduction of the carbon footprint) and increased sustainability due to more excellent monitoring and remote control of the systems.
2	Dispersion of the Sustainability logic (which was initially only focused on the environment and natural resources), to all axes, namely the connection between technologies and the well-being of citizens.
3	Implementation of an innovative mindset transversal to all city departments, to apply knowledge on improving the available services to the citizen (in all its manners, those who study, work and visit) and their quality of life efficiently.
4	Hold tools and information technologies to collect data to support better and faster decisions.
5	Search for technological solutions that optimize resources, increase sustainability, and improve the services to the citizen. Focus on efficiency and increase the citizen's quality of life and comfort by gathering data to the ground better and informed policies.
6	The first goal is always to serve better the citizens and make their life easier at the lowest cost. Second, the dematerialization of interactions between the citizen and the city, reducing travel times and needs. The efficiency of public services and promotion of city's sustainability.
7	City's intelligence based on the ability to solve citizens' problems (whether by taking advantage of technologies or not) efficiently (in economic, social, and environmental terms) aligned with the citizens' interests.
8	Improved reasoned interpretation of the majority's will, unequivocally with an associated environmental component in the use of Information and Communication Technologies, to govern and plan the future.

By analyzing the content of Table 6.4, it is possible to corroborate the three axes of the Smart City concept proposed by Correia, Teixeira and Marques (2020): innovation, sustainability, and quality of life. Moreover, there is an evident pattern of the understanding of the concept, with its association with technology to improve public services and increase the city's efficiency and sustainability.

Policymaker 7 was the only one that mentioned the citizen's involvement and participation in the strategy's definition. This may be explained by the advanced stage and the fact that the city has gone through the earlier concept stages.

In all cities, it was notorious the lack of a reference framework to guide their strategic planning. Also, the structure of the organization and the methods used to design their strategies are different. Therefore, data were aggregated to highlight the similarities between the interviewees' answers on the existing strategic planning and distinguishing them accordingly to their organizations' structure and methods. Moreover, three cases were found among the cities. Policymakers 5 and 6 demonstrated they had no strategy; Policymakers 1, 2, 4, 7 and 8 said each department defined the strategy; and Policymaker 3 (of the biggest city), recur to an external dedicated team on this subject. The results are detailed in Table 6.5.

Table 6:5 Description of the results of interviews' thematic analysis

Cities	Strategy	Evidence
2, 5 and 6	No strategy	Actions are taken in a reactive and uncoordinated manner (Policymaker 5). In addition, the initiatives are carried out sectoral without an integrated logic (Policymaker 2). For example, bus routes are sometimes changed according to user's direct feedback rather than an in-depth study. The city does not define its strategic vision as implementing a Smart City (Policymaker 6).
1, 4, 7 and 8	Definition by department	Each division defines actions without a specific methodology (Policymaker 1). Each division presents the necessary budget to achieve the desired objectives without any specific Smart City program or plan (Policymaker 8). The definition of initiatives still has an empirical component, not being subject to a specific planning framework. In some cases, although it is a transversal topic to all departments, there is a Product Champions who takes responsibility and assumes the thinking (Policymaker 7). Each division lists the projects that are intended to be implemented with estimates of costs and resources needed and associated capital gains. Later, the respective councilman screening each of the proposals to present to the remaining executive members (Policymaker 4).
3	External dedicated team	Cooperation between an external team and the executive to define and follow up the initiatives. There is not a white document to guide the Smart City strategy. Instead, the internal innovation of the city is at the responsibility of a policymaker who has the support of a public entity dedicated to developing methodologies and implementing digital solutions (Policymaker 3).

Unanimously, the cities do not contemplate methods nor follow specific guidelines. Moreover, it still lacks a reference framework to allow the standardization of the process.

Furthermore, to realize the role of the government and the vision of the legislator sovereign body, an interview with a Portuguese Secretary of State was performed. This interview noticed this topic is a transversal over the various ministries (e.g., economy, digital transition, and environment) without a clear dedicated body. Nevertheless, the government intends to look to the entire country rather than urban centers and find the best solutions for each case since they have different particularities. Among the priorities are sustainability and inclusiveness. The focus is to find flexible solutions with existing misused resources to help the local economy (e.g. taxi drivers). It is claimed the city strategy is the competence of local authorities. The government is responsible for influencing and making available the necessary financial resources. The Secretary of State gives an example of the implementation of bike lanes. The government "did not support their construction in cities but force their agreement on inter-city projects".

Furthermore, the national Smart City strategy that is being drawn up is based on three axes: i) integrated planning (implementation of smart cities and efficiency of public spending); ii) scalability (extension of pilot projects); and iii) interoperability (common principles that are cross-border). With the national approach, the goal is to consider existing projects as best practices and success cases among municipalities. The principles of the strategy are determined within the structure of the ministries. However, "it will not fail to reflect the priorities defined by the government". Furthermore, it does not mean that citizens' participation may not be contemplated. However, it is not formally considered, nor there is a formally defined methodology.

The aim is to make information available to everyone (citizens and businesses), whether to propose new ideas for better decision-making. Therefore, the priorities are decentralization and digitization, covering the territory with concerns to their realities, and providing and sharing information openly for better decision-making and product development.

6.4.2 Design of the Solution

From the literature review, four studies were contemplated to set the structure of the proposed framework since they acknowledged several specific guidelines. Two of the authors paraphrased and established the relationship with the raw data to associate the codes and themes correctly. The final codes and themes and their allocation to the PDCA cycle phase are summarized in Table 6.6.

Table 6:6 Thematic Analysis of literature existing frameworks and match with PDCA cycle

Source	Data	Codes	Themes	PDCA
(Barrionuevo et al., 2012)	Analyze the Key Areas	Key Areas	Identification of Key Areas	Plan
	Assess the Levers of Change	Assess	Evaluation	Plan
	Use indicators	Indicators	Evaluation	Plan
	Benchmark against other cities	Benchmark	Benchmark	Plan
	Identify promising opportunities	Opportunities	Identification of Key Areas	Plan
	Design the City model	City Model	Identification of Priorities	Plan
	Define Strategic Actions	Strategic Actions	Identification of Priorities	Plan
	Create Coordinating Body	Cordinating Body	Selection of Solutions	Do
	Develop Operational Plans	Operational Plans	Action Plan	Act
	Implement Action Plans	Action Plans	Action Plan	Act
(Lee et al., 2013)	Smart city mid- to long-term vision and goals identified	Goals	Identification of Key Areas	Plan
	Definition of roadmap	Roadmap	Identification of Key Areas	Plan
	Critical success factors for the roadmap considered	Success Factors	Study of Barriers and Faciliators	Plan
	Organization of the project team	Team	Team and Organization	Plan
	Identify urban problems	Urban Problems	Identification of Priorities	Plan
	Infer demands and solutions	Solutions	Study of Alternatives	Do
	Smart city services classification	Services	Study of Alternatives	Do
	Analysis of service trends (Delphi)	Trends	Market Analysis	Do
	Smart city device classification	Devices	Study of Alternatives	Do
	Smart city technologies identification	Technologies	Study of Alternatives	Do
	Develop roadmap formats	Roadmap	Action Pan	Act

	Analyze interdependencies between service/device/technology	Interdependencies	Study of Alternatives	Plan
	Develop integrated roadmap	Roadmap	Action Pan	Act
	Roadmap adjustment	Roadmap	Analysis of Results	Check
	Roadmap verification	Roadmap	Analysis of Results	Check
	Development of execution plan	Roadmap	Action Pan	Act
	Execution of plan	Roadmap	Action Pan	Act
(Stratigea et al., 2015)	State of the Art in the Global and European Context	State of the Art	Benchmark	Plan
	Smart City Applications in various urban contexts	Contexts	Study of Barriers and Faciliators	Plan
	Management tools and technologies	Technologies	Study of Alternatives	Plan
	Open Data Platforms	Platforms	Study of Alternatives	Plan
	Public Participation Tools and Technologies	Participation	Selection of Solutions	Do
	Smart City Sectoral Applications	Applications	Selection of Solutions	Do
	Planning for Sustainable Urban Development	Planning	Identification of Key Areas	Plan
	City Context	Context	Evaluation	Plan
	Participatory Vision Building	Participation	Selection of Solutions	Do
	Co-designing and Co-deciding	Co-Design	Selection of Solutions	Do
	Policy Framework Enabling	Framework	Selection of Solutions	Do
	Data Collection, Managing and Planning Tools	Technologies	Study of Alternatives	Do
	Application	Application	Pilot	Do
	Results	Results	Analysis of Results	Check
(Mora & Bolici, 2016)	Decision to transform Amsterdam into a Smart City	Motivation	Benchmark	Plan
	Definition of Initial Motivation	Motivation	Benchmark	Plan
	Planning team composed by working groups	Team	Team and Organization	Plan
	The strategy of the city is analysed and aligned with the priorities for intervention	Priorities	Identification of Priorities	Plan
	Long-term vision, objectives and approach are defined	Vision	Identification of Key Areas	Plan
	The fields of action are selected	Priorities	Identification of Priorities	Plan
	A team responsible for the implementation of the strategy is set up	Team	Team and Organization	Plan
	The procedure leading to the production, selection and implemention of project ideas is defined	Selection	Selection of Solutions	Do
	A monitoring and evaluation methodology is defined	Monitoring	Monitoring and Analysis	Check
	The implementation team is activated and starts activities aimed to implement projects	Team	Team and Organization	Plan
	Project ideas are generated, selected and organized	Selection	Selection of Solutions	Do
	Financial support for projects to be developed is found and project groups are set up	Finances	Identification of Priorities	Plan
	Projects are implemented	Implementation	Pilot	Do
	Progress is monitored and results are evaluated	Monitoring	Monitoring and Analysis	Check
	The strategy is subject to a continuous process of review and adjustment	Review	Monitoring and Analysis	Check
	The strategy is comunicated and promoted worldwide	Communication	Action Plan	Act

The thematic analysis served to design the skeleton of the process represent in Figure 6.4, allowing the experts to have the same foundations for the discussion.

Moreover, each expert had the opportunity to present the arguments about the steps of the Smart City implementation process, which were directly connected with their professional experience and expertise.

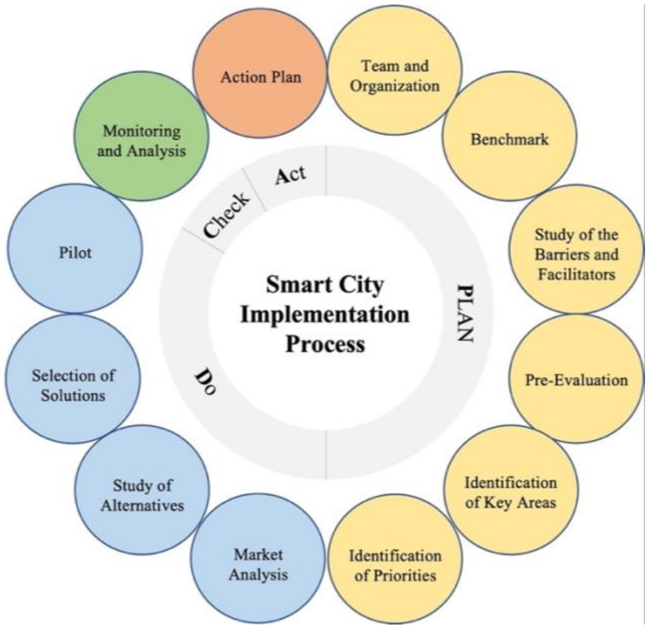


Figure 6:4 PDCA Smart City Cycle

The analysis of the focus group considered the list of questions proposed by Stevens (1996) to guide the analysis of the focus group, and the critique made by Webb and Kevern (2001) of, on the one hand, the lack of quotations from the participants' interventions and, on the other hand, the description of the interactions, the findings of the present research are ultimately reported in the form of a framework.

6.4.2.1. Phase I: Plan

The following Table 6.7 reflects the discussion and findings of the experts for the steps that constitute the "Plan" phase. In this phase, were mainly contemplate the feedback of research and academic-related elements.

Table 6:7 Thematic Analysis of the focus group about the steps of Phase I "Plan"

Step	Evidence
1. Team and Organization	The typical organization chart of the Executive is not adequate to the challenge of ICTs integration because divisions have cross-domains (Element 1). The solution may be to have a dedicated team with elements of each department that implement the solutions designed and discussed at the strategic level with citizens. In this sense, is advised the creation of an autonomous local council of the municipality related to the evaluation and monitoring of new projects (Element 9). This council shall acknowledge periodic meetings motivated by a discussion with players and experts of the sector. As a result, the municipality can understand the developments of the market and research guidelines to frame their thinking and territorial strategy. The board, constituted by representatives of different stakeholders (Universities, private companies, public bodies, and residents), allows the territory's co-creation with impact on the engagement of the community to think of the city future initiatives (Element 9).
2. Benchmark	There is an initial need of understanding the context, size, and organic structure of each municipality to make a correct analysis (Element 1). Cities should ground their strategies on comprehensive references and frameworks that later may converge to specific objectives. Also, it is necessary to resort to clusters with skills to conduct co-creation processes under the penalty of not being done correctly (Element 2).
3. Study of the Barriers and	It is vital to cross-check with other examples, realizing which barriers they faced and contaminating with the results obtained by others' experiences and give voice to local and regional actors (including

Facilitators	citizens and companies). These shall criticize and propose actions beyond what is published, documenting, and standardized so that others can reuse the knowledge acquired in the process (Element 1).
4. Pre-evaluation	Tools that monitor current performance are important, but even more vital, is to perform a correct initial evaluation (Element 4). The current state assessment allows cities to understand their positioning phase of the process and the needed level of investment, particularly at the level of basic infrastructure. Cities can use ISO 37120 (or similar) to start identifying priorities (Element 1).
5. Identification of Key Areas	Identifying the key areas has the purpose of each city understanding its reality and context, studying what enhances the region and solves the emerging problems (Element 1). On the one hand, these should consider the long-term priorities of the European Commission (or sovereign international entities). On the other hand, their unique context to strategically find their positioning according to the interests of their citizens and shared goals (Element 3). In defining key areas and priorities, it is essential to promote a broad debate on a consensus basis among stakeholders where the existing budget is known (Element 4).
6. Identification of Priorities	Financial resources are scarce, and policymakers rely mainly on external funding for innovation issues. Thus, it is necessary to align priorities with the strategic umbrella promoted by international sovereign bodies (Element 3). Nevertheless, it is necessary to constantly analyze the context because sovereign entities are also dominated by lobbying with specific corporate interests. Key areas can be seen as more than just urgent actions but rather a long-term vision of training and retention of specialized human resources that promote the community's competitiveness in specific areas (Element 4).

6.4.2.2. Phase II: Do

The following Table 6.8 highlights the discussion and findings of the experts for the steps that constitute the “Do” phase. In this market approach phase, mainly were heard the voices of private companies’ participants.

Table 6:8 Thematic Analysis of the focus group about the steps of Phase II “Do”

Step	Evidence
7. Market Analysis	It was from the general agreement that for the adoption of a solution in a particular vertical of a city are needed the following three points: (i) real-time data collection systems (e.g., sensors or cameras); (ii) connectivity (networks and communication protocols available on the region) platform; and (iii) applications (mobile or web) to make the integrated data available to system administrators and end-users (mainly citizens). Market analysis has been summed up to the presence of international events to promote and market solutions (Element 5). National level discussion groups and associations are needed to fostering contact between the various stakeholders, and cities have to shift for an enthusiastic attitude exposing the problems to the market and seeking to identify the best options (Element 5).
8. Study of Alternatives	Because solutions have good results in a laboratory, they will not succeed in a natural environment. Moreover, it is necessary to study their impact and engagement because if people do not identify themselves or understand the solution, they will not use it, and the whole process will fall apart. A cost-benefit analysis could be used to demonstrate financial feasibility and justify the short, medium. Long-term costs and benefits also consider the installation and maintenance costs that are often left behind (Element 7).
9. Selection of Solutions	The involvement of citizens in the solutions’ choice is vital. There are various platforms of civic participation (e.g., Maptionnaire) in which any question that the city wishes to ask can get a real-time response from citizens (Element 6). Furthermore, it must be performed with the safeguarded that cities are not hostages to solutions. There must be a democratization of space and public attention to various players (Element 7). In addition, the market sometimes should organically find the solutions and provide them directly to the citizen, since not everything is about public procurement, as it happened with micro-mobility (Element 7). Cities should also give opportunity and space for the integration and development of solutions rather than the typical method of public procurement (Element 1). Open data culture is promoted with universities based on cooperation protocols to develop new solutions to specific city problems (Element 8).
10. Pilot	It is essential to monitor and evaluate the interaction and usability of citizens" so solutions can be adjusted to increase the engagement (Element 7). Living Labs are essential to test what new technologies will entail for society and affect existing regulatory standards (Element 3). Element 3 gave the example of electric mobility where "it is necessary to study the impact on the electricity grid, on consumers at home and how they interact." Pilots are not implemented as final projects. Usually, given their versatility, they should be tested in different contexts, studying all existing variables for better conclusions (Element 9).

6.4.2.3. Phase III: Check

Table 6.9 mirrors the discussion and findings of the experts for the steps that constitute the "Check" phase. The Elements that are related to the City structure and that usually monitor the results of the implemented initiatives had a significant role in this phase.

Table 6:9 Thematic Analysis of the focus group about the steps of Phase III "Check"

Step	Evidence
11. Monitoring and Analysis	Usually, pilot projects are implemented in a specific location of the city. Of the general agreement, two learnings were highlighted: (1) pilots have better results in smaller cities because they can deal with shorter installation times; (2) larger cities have the advantage of people density and, therefore, more insights and experimentation of solutions. The change of behavior assessment, the engagement achieved and expected return are the main decision factors for scaling the initiative (Element 9). On the other hand, there is a lack of formal and documented methodologies for assessing the performance of pilots who are often based on colleagues' opinions and satisfaction surveys (Element 8). Their findings and analyzed data should be disseminated for a more excellent perception of the solution' benefits. Moreover, it is necessary to have webinars or clarification sessions to promote greater literacy and raise the awareness of children and young people to communicate with their families. The pilot needs to be framed on the current city state (Element 9). In addition, data mining and analytics carried out are stimulating for the citizens and the companies that provide the solutions because they allow them to study the user experience and develop new functionalities (Element 6).

6.4.2.4. Phase IV: Act

Table 6.10 reflects the discussion and findings of the experts for the steps that constitute the "Act" phase. Moreover, in this phase, mainly were contemplate the opinions of City's Elements, which usually analyze pilots' results and decide whether to scale a pilot.

Table 6:10 Thematic Analysis of the focus group about the steps of Phase IV "Act"

Step	Evidence
12. Action Plan	Communication increases the awareness of the population. The participatory process is fundamental to design the initiatives (Element 7). Nowadays, citizens play a crucial role in the co-creation of Smart Cities. The lack of knowledge to use modern technology is sometimes associated with a citizen's barrier, but that also occurs due to the lack of assistance and training. Moreover, besides the political background, it is necessary to understand the cultural context. The involvement and engagement of citizens make them experiencing and generate healthy discussions among the community that feeds curiosity and promotes innovation and large-scale adoption (Element 9).

6.4.3 Proposed Framework to guide the co-creation of a Smart City

Previous literature studies highlighted the importance of a unified view that considers external and internal factors, promotes a long-term vision, and includes citizens as co-creators.

The analysis of the interviews with policymakers reflected the lack of a methodology to help them implement a Smart City strategy. Although the government is drawing a national strategy, the interview with the Secretary of State clarified it would be primarily a definition of the umbrella topics and guidelines towards a shared vision. The focus is not on the creation of a reference framework. Therefore, policymakers' existing challenge on translating subjective high-level directives into specific actions will not be answered.

In a nutshell, cities will still be responsible for defining their Smart City approach and citizens' role in it.

Since Smart Cities are based on data collection of the different areas, departments' independent actions shall be replaced by a unified view. This shall base the definition of the architecture and detail the infrastructure needs. Therefore, a team must be constituted. This can be an external team followed closely by a regulator body, a local council represented by experts from the different sectors and areas of expertise.

This must also serve to combat the need for European calls' funding and promote the development of dedicated solutions towards the cities' needs. The transparent communication of the budget and procurement timings will allow the creation of clusters and initiatives to help the city achieve the proposed milestones.

Moreover, the city strategy must be defined and monitored based on reference frameworks. The solutions acquisition shall be based on the network requirements and standards to break silos and avoid dependence on private companies. On top of this, territories can define joint initiatives to overcome discrepancies and optimize network infrastructure investments. Top-down approaches and the follow on of the executive must be combined with a bottom-up perspective. Community's involvement shall be considered based on dedicated participatory methodologies according to their individual and group characteristics.

Moreover, the territory shall define a branding strategy and a specialization of their human resources towards their qualification with a specific goal. The community must also be educated regarding the topic to prepare themselves for more excellent debates. Close relationships with schools must also be considered educating youngers about the need for sustainable urban planning, their current role, and what is expected from them. Therefore, the study of current problems, the alignment of international sovereign bodies priorities and citizens preferences shall base the roadmap.

Bureaucracies of public procurement processes shall be reduced by the quality of the evaluation and transparent criteria definition. Moreover, a specialized external body shall transparently analyze the solutions. Furthermore, the study of scenarios must be acknowledged to ensure that pilots have a follow-up path regardless of their results. Definition of specific KPIs to continuously monitor the population engagement. The communication of the results and the knowledge sharing with academia and third parties, and the community will base an open data culture that will strive to create an innovative surrounding environment.

In summary, this research proposes guidelines to base city's strategic thinking while contemplating a co-creation process. The steps are grounded on the thematic analysis of the focus group of sub-section 6.4.2.

Furthermore, Figure 6.5 summarizes the actions that policymakers must acknowledge to co-create a Smart City.

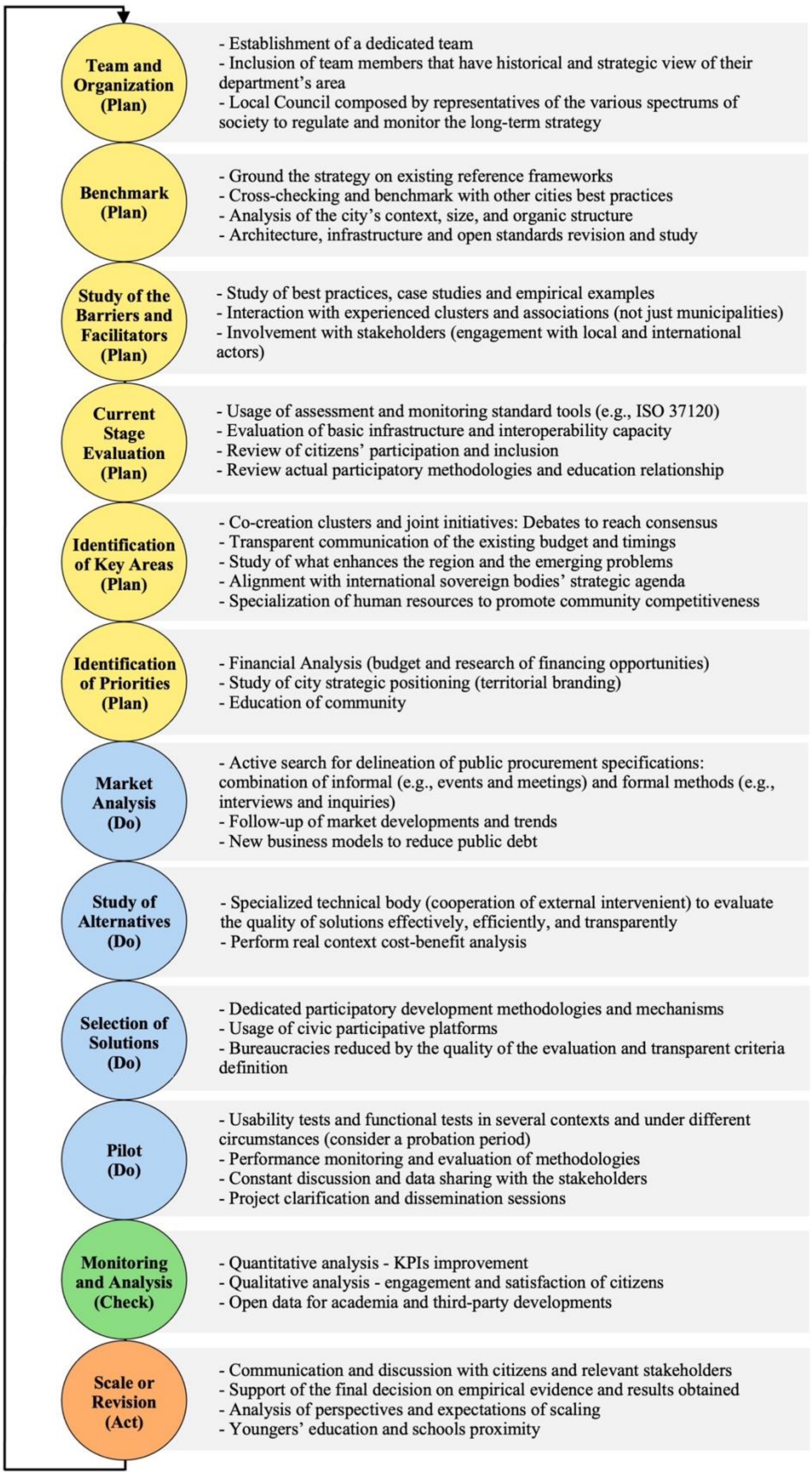


Figure 6:5 Smart City guidelines

6.5. Conclusions and Future Work

Policymakers are challenged on translating subjective high-level directives into specific actions. The thematic analysis of the interviews demonstrated the inexistence of a standard structure or method to implement a Smart City strategy. The study found three groups of cities. The first does not have a strategy defined. In the second group, Smart City initiatives are solely defined by each department. The third recur to an external dedicated team to the topic. In addition, the interview with a Secretary of State allowed to perceive an apparent lack of a unified approach to the topic over the ministries. The focus is not on creating a reference framework that promotes co-creation since the government sees it as a responsibility of local authorities.

This paper aimed to detail a continuous improvement process based on the PDCA cycle to detail the steps that policymakers must acknowledge to design a Smart City strategy. Moreover, from an empirical study based on identifying the problem through semi-structured interviews and the design of the solution through a focus group, was developed a 12-step methodology divided into 4 phases.

The framework proposed in this article aims to give policymakers the guidelines to help them on the implementation of a Smart City strategy. The goal was not to replace decision-makers but to support their decisions. These guidelines would help cities maintain focus and not let political changes affect the strategic plan defined previously. The resulting framework is valuable to policymakers without knowledge in the matter and to regulatory bodies to promote a unified vision over the topic.

Despite the limited number of interviews, which can be pointed out as a limitation of the study, the results can support the definition of the requirements to prototyping a technological tool. This can portray the city's current situation and guide it throughout the process, guaranteeing monitoring and execution. Furthermore, this can be extended to the assessment of the countries towards finding their current development phase.

As future work, participatory methodologies can be further studied to provide policymakers with how and when they should include the stakeholders in the process. Further discussions and research can also be undertaken to understand the role of sovereign bodies in regulating and harmonizing approaches in this topic.

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Part III

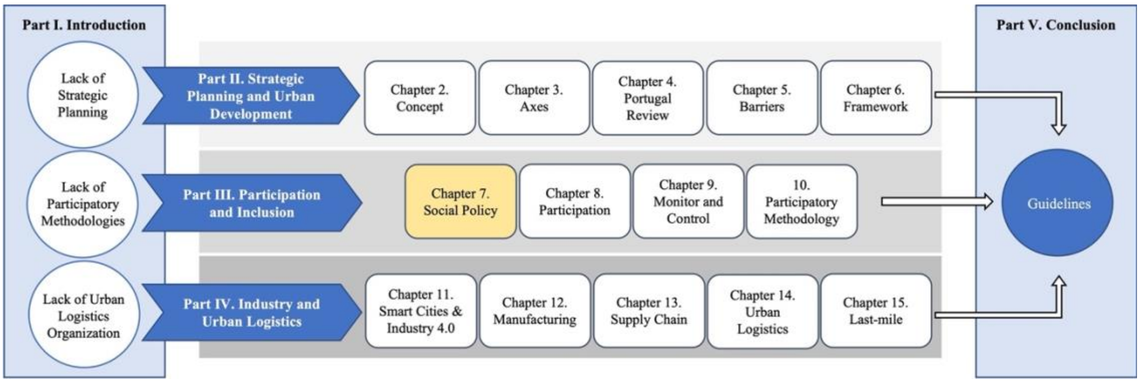
Participation and Inclusion

Chapter 7

The Smart City as a Social Policy Actor

Reference

Correia, D., & Feio, J. (2020). The Smart City as a Social Policy Actor. In International Conferences ICT, Society, and Human Beings. *In Proceedings of the 13th IADIS International Conference ICT, Society and Human Beings 2020*, pp. 236 – 240. https://doi.org/10.33965/ICT_CSC_WBC_2020_202008C031



7. The Smart City as a Social Policy Actor

Abstract

Smart City literature has started focusing on new technologies that are being developed to improve cities' inner processes. Nowadays, it moved into considerations of the role of citizens in these improvements and ways to adapt new technologies to fit their needs. Smart Cities are, therefore expanding. It can be noted both in numbers and in scope. For the former, investment and interest in the topic has been growing as more and more cities aim to be considered "smart". For the latter, with more and more technological developments, the possibilities for the areas in which cities can be "smart" has increased. This has led to Smart Cities increase in the scope of action. Social participation and inclusion are taken in consideration, creating the Smart Inclusive City. Moreover, this article argues that Smart Cities are emerging as new social policy actors. Concepts from the social policy literature such as welfare regimes, intersectionality, and gender mainstreaming become relevant to Smart City scholars.

Keywords: Smart Inclusive Cities; Social policy; Citizens; Inclusion; Intersectionality; Welfare regimes.

7.1. Introduction

Smart Cities, and especially Smart Cities technologies, are seen as the solution to create new ways to solve these emerging problems such as urban pressure, air pollution, congestion, waste management, and human health (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017). However, it is difficult to find ways to finance a Smart City initiative if it is not possible to monetize its benefits, which happens, for example, in social impact projects. Which lead them not to be a priority to policymakers. There are huge disparities within cities. While some authors discuss for how long the world will continue living without the autonomous vehicles, there are still cities that are not even coherent in obliging buildings to have access for disabled people.

Nowadays, a change is being witnessed in how decision-makers include citizens in the co-creation and co-designing processes. We are in the Smart Cities 3.0 stage (Cohen, 2015). Smart Cities are more and more seen as cities for people, created and designed with the citizens instead of focusing on the technological approach. However, there must be ensured that all voices are heard, not letting the most needed out of the equation.

A real change in paradigm is still to come, and the literature on Smart Cities still lags. In the next sections, it is argued that in the next phase of its development, the concept of Smart Cities should embrace the language of inclusion. Moreover, elements of the literature of social policy that can inform this move are outlined.

7.2. Time of Changing the Paradigm

The latest technological advances in the field of Information and Communication Technology (ICTs) supporting a citizen-centric urban development for cities can have a tremendous effect on future cities. ICTs can be a fundamental help to cities in every stage: in diagnosing problems, devising solutions, and the analyzing results.

After Hollands (2008) criticized the fact that the focus should not be on the technological side, the concept evolved from the technical point of view and has been hardly discussed. Technological companies were the ones to push for innovation and the quick implementation of solutions. These were most of the times not prepared to install in the urban furniture. Cities started to understand the benefits of implementing ICTs to gather real time data to increase the awareness of the cities' problems and act quickly. During the last years, the focus changed from the technology and economy, where the citizens were had a passive role to a focus on people, governance, and policy where citizens act as co-creators and contributors for the citizen (Trencher, 2019). We are now in the time of the "Smart City 3.0" (Cohen, 2015), where citizens have an active role in the establishment of the strategy and associated policies. Smart Cities are now seen as the final stage of urban development, representing a conceptual urban development model, using human, collective and technological capital (Angelidou, 2015), where the adoption of technology is not an end. Still, a more vital thing is the management and policies behind the use of the technology (Nam & Pardo, 2011).

7.3. Smart inclusive city

Smart Cities face the challenge of dealing with the issue of widening inequality and social polarization (Hollands, 2008). Special attention has started to be noted in the literature of having policies that shall promote the inclusion of citizens in cities by including them in the process of decision making as one of the interested parties (Oliveira & Margarida Campolargo, 2015).

Cities of the future are seen as sustainable cities where all residents (with no exception) live well and the attraction of cities is preserved (Thuzar, 2011). Cities will have to provide conditions for a healthy and happy community under the challenging conditions that global, environmental, economic, and social trends may bring. Cities encompass an efficient, technologically advanced, sustainable, and socially inclusive city (Pereira, Macadar, Luciano, & Testa, 2017).

Smart Inclusive City is a city that puts innovation available and working to everyone and whose policies are made with and to improve the quality of life of every citizen, not letting aside the disadvantaged. Moreover, it is a city whose aim is to reduce social learning restrictions and social participation barriers (Silva, Khan, & Han, 2018).

The role of citizens in Smart Cities, passed from a passive role to one where they are seen as a "source of data". Nowadays, they are much more than that, and citizens now understand that it does not make sense to build a city without including the main stakeholder in the equation (Cossetta & Palumbo, 2016; Healey & Gonza, 2005), helping on the planning and design (Cowley, Joss, Dayot, & Cowley, 2018; Sadoway & Univerisity, 2018). Moreover, social innovation can be understood as a 'design– by-doing' process (Brown, Ehn, Associates, & Hillgren, 2012). Citizens are more and more the center of cities. However, cities of today are not seen as inclusive as they should be since there still a lot to do in this matter to accomplish the basic needs of every citizen, as identified above.

Smart Cities must consider a global vision to develop and implement a set of policy-mechanisms through an alternative institutional governance model to change this scenario (Lee, Hancock, & Hu, 2014). Inclusion is something that should be promoted by city policymakers. A City can no longer be smart without being inclusive.

Therefore, several points must be considered by cities. First, cities must incentive companies to develop technologies to everyone or dedicated to solving a specific problem dictated by citizens. Second, cities must consider previously implemented technologies and best-practices and make the match between these and the needs of the city.

7.4. Smart cities as social policy actors

We argue that Smart Cities have the potential to be social policy actors that embrace inclusivity at the foreground of its agenda. This changing in the way one conceptualizes Smart Cities will lead to two main consequences. First, a whole set of areas of action will be open for Smart Cities. In other words, changing how Smart Cities are conceptualized will enable us to ask different questions about what they can and should do. Second, changing conceptualizations will open a whole tool kit of concepts that have been developed in the social policy literature, which can be now served Smart City scholars.

Changing conceptualizations are often implicit in policy actors (Bacchi & Goodwin, 2016). These happen as practitioners realize via lived experience that the potential for a concept to evolve exists in practice. When it comes to conceptualizing Smart Cities as social policy actors, this can be noted in local authorities' work in various cities such as Vienna, Rio de Janeiro, Ljubljana, and London.

Over the past few decades, Vienna has integrated gender considerations into how they plan the development of the urban space. For example, through evaluating commuting patterns, it was made clear that women and girls use footways more than men, who tend to reduce more using vehicles. The city then used this knowledge to invest in public lightning in areas used predominantly by women and girls (Vienna, 2019). In the same line of investment, in Rio de Janeiro, local authorities have used technologies such as Safetipin to gather data on violence and harassment against women and girls. (Women, 2013). Women and girls are then able to record the areas of the city where they feel less safe. This has allowed local authorities to shape their urban development towards addressing these specific areas of the city.

The capital of Slovenia, Ljubljana, has implemented a solution for its citizens by providing electric vehicles that are available for everyone to request them by phone or online, to take them from home to the city center (Wedam, 2019).

Homelessness in London is a significant problem as the number of people living in the street has been rising for the past few years. To address this, the Mayor of London has put contactless points across the city to people donate money to various NGOs and created a GoFundMe page. Through this, they were able to raise more than £74.000 in less than two weeks (London, 2018).

The above can be seen as evidence for greater care from local authorities towards implementing various technologies to improve the inclusion of their cities. This is often not done as an explicit change in the way Smart Cities are understood but rather as an implicit change in goals. A policy change of this type is referred to in the literature as social learning (Bennett & Howlett, 1992). This can involve changes in "the social construction of policy problems, the scope of the policy, or policy goal" (May, 1992). What the examples above show is a shift in the policy goals of these cities. These cities are changing the purposes for which they use technologies towards the promotion of inclusion. In this way, we argue that even if implicitly, they are conceptualizing Smart Cities as social policy actors. This is, actors concerned with promoting inclusion and social wellbeing of their populations through the use of technologies.

How one conceptualizes policy issues and policy actors change the expectations and questions asked about them (Lancaster, Duke, & Ritter, 2015). In the early 20th century, changing conceptualizations about the role of the state led to changes in expectations towards (Castles, 2012). Foucault called bio-politics to the development of ways in which the state has become concerned with wellbeing and the life of its citizens (Nadesan, 2008). Conceptualizing Smart Cities as social policy actors can be seen as a parallel transformation to this. It means seeing the goal of Smart Cities not just in terms of technologies but also the inclusivity and well-being of its citizens. It means asking different questions about the role that the technologies developed can play. For example, besides questioning how they can impact effectiveness and costs, it means asking how they affect inclusivity.

7.5. Welfare regime Types and the "Smart city 3.0"

With a move towards a view of Smart Cities as social policy actors and an increasing attempt to include citizens and stakeholders at various levels, a whole literature from the discipline of social policy becomes relevant.

One of the pivots works in the field of social policy is that of (Esping-Andersen, 1990). Esping-Anderson (1990), divides high-income countries into three ideal types. These typical types, which he calls welfare regimes, correspond to different ways of combining the market, family, and the state in the provision of goods and services. The United Kingdom, for example, is considered as a liberal welfare regime (Wincott, 2006). Liberal welfare regimes are characterized by liberalized labor markets that lead to high levels of commodification. In other words, too high degrees of market influence on the provision of goods and services. The social democratic welfare regime is exemplified by countries such as Sweden. There are high decommodification levels and heavy reliance on the state for the provision of goods and services over the family and the market. Conservative welfare regimes type countries such as Germany and Italy are countries can be seen as in between liberal and welfare regime, with a higher reliance on family and social structures than any of the other two.

The relation between welfare regimes and specific policies is sometimes hard to discern. While some policies might follow the commodifying tendency of the welfare regime, other policies might act in a deco modifying way in order to counteract some of the undesirable trends of the welfare regime's general commodifying effect (Stephens & Fitzpatrick, 2007). Nevertheless, policy choices will always be influenced by the wider context in which they are inserted, one way or the other. When it comes to homelessness policy, Stephens and Fitzpatrick (2007) give the example of housing policy in which the UK's safety net for under risk homelessness people can be seen as having a deco modifying effect. This, in response to the undesirable effects of commodification in this field created by the UK's welfare regime types. However, other homelessness policies, such as the specific reliance on charities and volunteering organizations can be seen as following the welfare regime's commodifying tendency.

Any attempt to pursue more inclusive and stakeholder aware Smart Cities need to consider this wider context. If Smart Cities are to get out of their bubble, they must be mindful of what is out of it. More specifically, they must be mindful of the structures and relations between stakeholders who attempt to provide welfare to citizens and how these vary from country to country. The literature on welfare regimes can provide an entry point to this.

7.6. Non-tokenistic Participation and intersectionality

Various early attempts to promote gender equality suffered from the fact that they were based on tokenistic approaches (Cornwall, 2003). In other words, programs and policies were designed including specific women, assuming that they would represent the views of other women. However, it has been realized that there is a need not to assume that one individual just because they are members of a group, such as women, will automatically represent this group. Moreover, just because someone is present that does not mean that their interests will be represented. Cornwall reviews various attempts to promote gender equality in countries of the Global South. She outlines how many of these while they aim to include women, they do so in a tokenistic way. Individual women are present, but they are often either not given the opportunity to express their interests or do not represent the interests of women more broadly. Groups such as women are not homogeneous, the struggles they face are shaped by factors beyond gender, such as income and race.

If Smart Cities should aim to be inclusive, they need not start from zero. Insights from previous failed attempts to address issues of inclusivity should be taken into consideration.

7.7. Conclusion

In conclusion, digitalization inequalities will be growing in the future. Without considering inclusion, the barrier between those who can access the benefits of Smart Cities and those who are not will keep growing.

This article has argued that with the evolution of Smart Cities, one can start to conceptualize them as social policy actors who should care about its own inclusivity. Some of the consequences of conceptualizing Smart Cities in such a way have been discussed. It has been argued that literature from social policy becomes relevant once this conceptualization is accepted. Notions such as welfare regimes and intersectionality become suitable for scholars of Smart Cities. Smart Cities have the potential to become inclusive if they embrace citizens at all stages. Doing so will lead to better Smart Cities that genuinely fit with the needs of its people.

Aligned with the evolution of the Smart Cities concept, the methodology that a city must follow to become smart must acknowledge the role of the citizen over the several steps, and with the aim of promoting the inclusion of every citizen. There is still plenty of work to do in this field. There is more and more discussion about participatory approaches and what may be the designing tools citizens can help from. However, it is still missing KPIs focused on inclusion and a definition of an index capable of quantifying the inclusiveness in a city, guaranteeing that the promoted policies are aligned with inclusion goals.

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Chapter 8

The Inclusion of Citizens in Smart Cities Policymaking: The Potential Role of Development Studies' Participatory Methodologies

Reference

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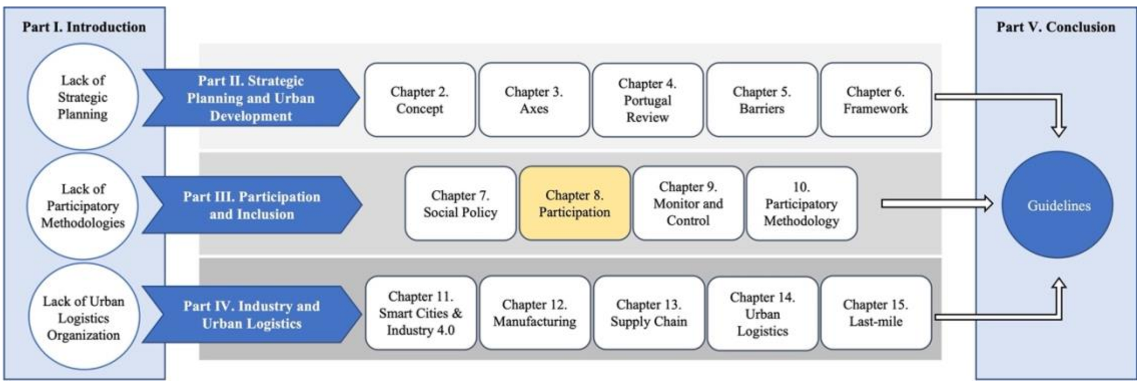

8. The inclusion of citizens in Smart Cities policymaking: the potential role of development studies' participatory methodologies

Abstract

Smart Cities emerged in the 90s. Since then the concept has passed from several phases from a purely techno-centric vision to see technology as a means and not an end in itself. Alongside this evolution, the role of citizens has been changing. Nowadays, citizens are seen as taking part in the co-design and co-creation of Smart Cities. However, standard participatory development methodologies are still lacking to guide policymakers.

This paper will critically evaluate the role of citizens in Smart Cities' governance. Smart City governance can be seen as a specific type of policymaking. Accordingly, knowledge from other disciplines that explore policymaking can be useful in highlighting flaws and future opportunities for Smart Cities governance. The present work explores this when it comes to the role of citizens in policymaking. It makes use of the knowledge from development geography, and reviews how citizens participation has been understood in Smart Cities governance. It does so by combining a review of the literature as well as interviews with Portuguese Smart Cities policymakers. This paper brings these insights together. The results show that while Smart City policymakers recognize the importance of including citizens in policymaking, the practical application of this is still very limited. This can be enhanced by using knowledge from development geographies approach to similar problems as well as via the development of tools and guidelines. Future research should explore both of these aspects.

Keywords: Citizen, Smart Cities, Development Studies, Participation, Inclusion and Co-creation.

8.1. Introduction

Smart city governance is a type of policymaking. It is distinct from other policymaking types as it focuses on local level changes that have a specific purpose, i.e. make cities smarter. Despite the definition of what can be considered a Smart City and therefore the object of Smart City policymaking is beyond this article's scope, this article addresses two key differences drawing on the above. First, Smart City policymaking, as compared to, for example, national-level policymaking in areas such as health and employment, involved markedly different actors such as local level policymakers and enterprises, which might create different policymaking dynamics. Second, this has led to Smart City policymaking being studied by a different academic community. While national-level policymaking is often studied in university departments of public and social policy, Smart City's governance is often studied in engineering departments. This leads to a creation of a diverse academic community which approaches policymaking in multiple ways.

There have been recently some works which have attempted to bridge knowledge from other academic communities into Smart Cities. In a previous paper, the authors attempted to show the importance of knowledge from social policy to Smart Cities' future (Correia & Feio, 2020). This paper follows this by bringing together the two issues outlined above. It explores the dynamics between actors relevant for Smart City policymaking. In specific, it explores the role of citizens in Smart Cities policymaking. Moreover, it does so by exploring debates on the inclusion of citizens in local policymaking, which have taken place in the discipline of development geography.

There is a great agreement in the literature about the importance of the citizen being included in the co-creation, however, there is little presence of information on what methods, tools, and timings there should be promoted their participation, and empirical examples of best practices that have revealed positive results.

When thinking about the citizens' role, it is useful to have a theoretical understanding of policymaking. There are various ways of understanding the several steps in policymaking and several theories about relevant factors for its development. One broad way of understanding policymaking is to see it as a cycle which starts with agenda setting (i.e. the recognition of a problem which needs to be tackled), followed by policy formulation (i.e. the development of a policy solution to the identified problem), legitimation (i.e. the recognition by relevant actors of the need to put forward the policy solution), implementation (i.e. the act of putting in place the policy solution), evaluation (i.e. the assessment of whether the policy solution has effectively addressed the identified problem), and finally the policy maintenance, succession or termination (i.e. a decision about how to change or not the policy in place which can then lead to a new agenda setting moment) (Head, 2008; Jasanoff et al., 1998).

Different stakeholders such as Non-governmental Organizations (NGOs), the general public and policymakers can play a role in different policy cycle parts. Moreover, their influence on policymaking will significantly depend on which elements of the cycle they are involved.

This understanding of the policy cycle should motivate scholars to understand not just whether certain actors are involved in policymaking but in which parts of it and in which ways (Leach, Scoones, & Wynne, 2005). This article aims to do so for one specific stakeholder, citizens, as well as for one specific type of policymaking, Smart Cities policymaking.

8.2. Theoretical Background

8.2.1. Learnings from Zero Carbon Cities and the importance of participation

When considering Smart Cities' future, it is useful to look back at previous disruptive conceptualizations and their consequences. One of the most predominant was the concept of Zero Carbon Cities.

Drastic cuts in emissions on 95% from all sources will be necessary in the developed world. Therefore, new urban developments are being announced, taking into account ambitious targets for carbon emissions and reducing energy consumption (Kennedy & Sgouridis, 2011), preserving sustainable urban development with the minimal ecological footprint.

Zero carbon cities (or carbon neutral) aim to become a city that does not emit carbon to the atmosphere. To achieve that goal, this term has been used to name the cities built from the scratch, with vast amounts of investment to fulfill that, and attract and nurture technology companies.

A diverse set of projects were being put in place to fulfill that ambition. Among them are Songdo in Korea, Masdar City in Abu Dhabi, UAE, and Dongtan in Shangai, China. In Songdo, South Korea, a city was built from scratch. This was a highly technologically advanced urban space, and its objective was to have 50% of green spaces with smart waste management between other Smart City technologies (Carvalho, 2015). A similar project was started in Masdar, Abu Dhabi, to make a zero waste and zero-emission city. The city is still under construction and aims to be a car-free city by favoring public transport and autonomous electric vehicles (Reiche, 2010). In Dongtan, Shanghai a similar project in an agricultural land located in the third biggest island of China, has a half a million target population. It has the goal of achieving 100% consumption of renewable energy by 2030 (Cheng & Hu, 2010).

These cities' projects, sometimes referred as "Smart Cities in box" (Calzada & Cobo, 2015), have been noticing several constraints and turned cities into ghost cities because people did not relate themselves with the built artificial environment and did not want to live there. In a nutshell, Ghost Cities were born from the concept of Zero Carbon Cities, megalomaniac projects in which cities were created entirely from scratch but whose occupation and habitability fell far short. These cities were thought with the first stage of Smart Cities in mind, having its development been largely pushed from corporations to residents.

This draws the attention to the growing importance of the theme of inclusion and participation. People have to be capable of using technology to benefit from it (Coe, Paquet, & Roy, 2001).

The inclusion of Citizens in the creation and design of Smart Cities comes to oppose the underlying assumptions of Zero Carbon Cities.

The adaptation of Smart Cities policies and ideologies towards the future rather than creating cities from zero seems to be the only way (Shelton, Zook, & Wiig, 2015). Thus, may not be the most technological or the most efficient but are intended to promote policies and solutions designed jointly with citizens to improve existing living conditions, understanding together which problems exist in cities and which solution best serves the purposes of citizens and with which they are identified more for their resolution. Moreover, if citizens are not consulted in any stage of the process, there is a risk that they will not adopt the proposed solution.

8.2.2. The role of citizens in Smart Cities

Smart Cities appeared in the 90s to face the challenges raised from urbanization and globalization witnessed by cities (Bastelaer, 1998; Gibson, D. V., Kozmetsky, G. and Smilor, 1992; Mahizhnan, 1999; Tan, 1999). The concept was primarily associated with technologies and had a techno-centric vision where Information and Communication Technologies (ICTs) would solve all the emerging problems (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017; Mora, Bolici, & Deakin, 2017). For some time, technological companies sold this vision and led cities' innovation. After Hollands (2008) criticized the direction things were going, the focus passed to promote sustainability and citizens' quality of life. ICTs were a means and not an end (Nam & Pardo, 2011). That was also fueled by the 2008 world's financial crisis and population acknowledgment of the global warming effects (Lom, Pribyl, & Miroslav Svitek, 2016).

Nowadays, cities have gone from being developed for citizens to being developed with citizens. The focus has changed from the technology diffusion to meet corporate and economic interests and citizens having a passive role to focus on people, governance, and policy where citizens act as co-creators and contributors for the city (Cohen, 2015). Cities are increasingly promoting a co-creative dynamic environment where the opportunity is given to citizens for co-creation in a technology-cities-people involvement.

Smart Cities public participation literature is centered in finding the best ways to engage citizens in urban designing using computing technologies, empowering them not just as data collectors but also as designers (Gooch et al., 2018).

Mueller, Lu, Chirkin, Klein and Schmitt (2018) created the concept of Citizen Design Science, as the new way to integrate citizens' ideas and wishes in the urban planning process combining crowdsourcing opinions through ICTs with design tools. Salim and Haque (2015) proposed a taxonomy of urban computing, addressing user interaction modes, provocations, and scale of participation, in mobile crowdsensing, urban probes, participatory urbanism, interactive public display, and also interactive urban intervention. Memarovic et al. (2012) defined three levels of engagement in public spaces: passive (people just observe), active (interact with the display) and discovery (learn and appreciate the contents stimulated). Through a workshop with various stakeholders, Forlano and Mathew (2014) set up a collaborative designing process from brainstorming to prototype a 25-30 years future city scenario. Marsal-Llacuna and López-Ibáñez (2014) developed a Smart Urban Planning Method based on reverse engineering principles. Through web-based surveys and data mining tools, citizens were asked about their urban activities in the previous 24 hours and their desired scenarios for urban activities to ultimately find the optimal land use.

City's sustainability and mostly social sustainability can only be achieved by the community's engagement, which can be enhanced through digital modes of participation rather than just the conventional (Bouzguenda, Alalouch, & Fava, 2019).

Simonofski, Asensio, De Smedt and Snoeck (2019) proposed the CitiVoice Framework where citizens participate in the three different phases: as democratic participants in decision making, co-creators of ideas and solutions, and users. It also defines the criteria as hierarchically organized into dimensions and sub-dimensions. Boukhris, Ayachi, Elouedi, Mellouli and Amor (2016) proposed a tool based on multicriteria decision making based on citizens' opinions. This hybrid model of weighting and options ranking is applied in deciding the allocation of the budget among several projects.

Because of the diminished noted existing research of citizen involvement in Smart Cities, Granier and Kudo (2016) studied several Japanese cities and communities through interviews and analysis of official documents and concluded that public participation is not at the city governance level, but instead as participants in the co-production of public services (e.g. energy production and distribution).

Webster and Leleux (2018) defined as mechanisms of Smart city participation and co-production: hackathons, living labs, fab labs and maker spaces, smart urban labs, citizens' dashboard, gamification, open datasets, and crowdsourcing. The survey of Szarek-Iwaniuk and Senetra (2020)'s case study made to Olsztyn's residents revealed that ICTs and mostly online surveys contribute and encourage the public to participate in decision-making. However, other options must not be forgotten to combat exclusion.

Although social media should not be considered as the primary tool for citizen participation, the Díaz-Díaz and Pérez-González (2016)'s case study of the Santander City Brain shows a collaborative tool designed to promote open innovation by the share of ideas, comment and vote, which proves that a social media adapted method can represent an effective way to set the political agenda and influence political discourse. Moreover, in the organization chart, it can be noted democratic and non-democratic parts in the process.

Citizens can increasingly play an active role not just in data collection but also in decision making. Furthermore, for this are necessary methodologies capable of extracting the maximum value of the citizen.

Although Smart Cities concept are new, we must not forget that politicians still run cities. Therefore, the Political Party in charge, the agenda, and the wills of city's policymakers shall be considered. The Smart City initiatives have to be aligned with the policy agenda, which has its cycle (Chen & Karwan, 2008). The governance of a city is made up of electoral cycles. What does not change is the people who inhabit it. In planning the strategy to be adopted by these ecosystems' decision-makers it is necessary to listen and brainstorm with the different "Stakeholders", never underrating in the final decision the importance of the "citizens voice".

8.2.3. The role of citizens in development initiatives

Scholars of Smart Cities are not the first to consider the role of citizens in policymaking. The discipline of development geography has been one of the first to address these and consider the citizens' role in development initiatives in the Global South. Therefore, in any debate about the involvement of citizens in policymaking, the literature from development geography to provide relevant insights to it.

The debates in this discipline can be subdivided into three main phases. Top-down interventions marked the first phase, which happened in the post- World War II (WWII) decades (Mathur, 1997). These were often defined and constructed by international organizations such as the International Monetary Fund and the World Bank with very little involvement of the people affected by reforms. These reforms often took the form of deregulation of the economy. They assumed that this was a solution that could be applied regardless of the local context. This phase is often referred to as the Washington Consensus (Gore, 2000). John Williamson (Williamson, 1997) defined in 1989 ten sets of specific recommendations related to this, which included free trade, floating exchange rates, free markets, and macroeconomic stability.

The second phase came to life as a critique to the Washington Consensus (Cornwall, 2003). It was recognized that there was a need to involve the people affected by policies in their development (Mosse, 1994). This appealed to both the new right and the left of the political spectrum to do development in the new millennium. Participatory development then emerged as the dominant paradigm. It was seen as a way of gathering the local knowledge of individuals to promote more efficient programs.

Moreover, it was also seen as a way to empower the poor and marginalized by giving them a voice and recognition in the development process (Mohan & Stokke, 2000). This led to the emergence of partnerships between international organisations and local NGOs. For example, NGOs like the Slum Dwellers International and organisations such as the UN have since then worked to promote informal settlers' involvement in the development of their own urban space.

A third phase came as a critique to this move towards participation. Authors such as Cooke and Kothari (Cooke & Kothari, 2001) argued that it was not enough to involve citizens in the policymaking process. It is essential to ask who is being involved and what way. They argued that most participatory development interventions did not empower individuals but rather use local people as tokens rather than provide any real change. This is not a critique to participation itself but rather to specific ways of involving citizens (Hickey & Mohan, 2004). What is needed is a complex understanding of the local context, which sees the power relations inherent to human relations and the struggles and conflicting interests between individual communities and intra-community groups.

This development of understanding first policymaking as a top-down process and then moving towards engaging with citizens to understand then and address the complexities of this engagement can be seen as three critical phases in the move towards more significant and more empowering citizens' involvement policymaking. Therefore, this paper will explore how policymakers in cities understand citizens' involvement in Smart Cities policymaking and attempt to place this understanding in one of these three phases to better grasp what still needs to be done in this field.

8.3. Methodology

8.3.1. Data collection, data analysis and sample

In terms of methodology, this research uses qualitative methods to explore citizens' role in Smart Cities. Specifically, how it is perceived, who are the actors that define the structure of these policy processes, and who is involved.

In terms of data collection, in-depth interviews were conducted with eight policymakers from different Portuguese cities. This covered a range of cities from different regions of the

Portuguese territory, with different characteristics, the smallest one with around 20 000 people and the largest one with around 240 000. The interviews were conducted via Zoom between January and February 2021. These were then transcribed. These interviews focused on understanding how policymakers think about and consider the role that citizens play in Smart Cities policymaking efforts.

In terms of data analysis, a thematic analysis was conducted. This followed an inductive approach. Accordingly, the transcriptions of the interviews were scanned, and emerging codes from the data were identified. The data was then coded according to these. The following sector presents them.

In terms of ethical considerations, this research's main ethical issue has to do with the anonymity of participants. This is especially the case due to the small number of interviews conducted. Interviews were therefore anonymized. For these purposes, no names of cities or policymakers will be referred. Interviewees (policymakers) will be numbered and only this information will be provided below in Table 8.1.

Table 8:1 Policymakers and cities sample data

Policymaker	City (Population)	City (Location)
1	45 000	South
2	20 000	Center
3	240 000	North
4	35 000	North
5	140 000	Center
6	40 000	North
7	210 000	South
8	190 000	North

8.4. Results

This section presents the results from the thematic analysis of the interviews. Data was aggregated to highlight the similarities between the interviewees' answers to the need, type and challenges of citizens involvement.

8.4.1. The need to involve citizens

All policymakers considered it is essential to involve citizens in the policymaking process. For example, Policymaker 1 considered it was essential to involve citizens through "initial opinion studies, which would increase commitment and gather contributions". Policymaker 5 considered that, despite their city does not actively involve citizens, "it is important to do so at an early stage to evaluated pros and cons and post-implementation to understand the satisfaction with a certain solution".

8.4.2. Types of citizens involvement

Another aspect that emerged from the interviews is the different ways of engaging with citizens. Following from the literature reviewed in previous sections, Table 8.2 outlines the different types of engagement across Policymakers. Two aspects become apparent. First, there is a wide range of citizens involvement across the various cities, from citizens not being involved at all to them taking part in the design and trial of solutions. This suggests that even within the same country, the local context is still determinant when it comes to citizens involvement. Second, besides variety, some cities already have a high level of involvement of citizens with focus groups, forum discussions and involvement in designing solutions.

Table 8:2 Types of involvement per Policymaker (PM) interviewed

Policymaker	Citizens are not involved	Passive Participation	Active Participation	Co-design of Solutions	Co-creation of Strategies
1		Questionnaires about policy options			
2	People are not motivated to get involved				
3				Design and trial of solutions	
4			Discussion Forums and Mobile Apps		
5	Participation is not promoted				
6	People are not motivated to get involved				
7			Focus Groups and Mobile APPs		
8		Requests for suggestions and feedback via email			

8.4.3. Problems associated with involvement of citizens

Citizens are not used to being involved. It was acknowledged that this is not a common practice and that "citizens are not used to be consulted" (Policymaker 2). One aspect which was mentioned across all interviews was that there was a cultural barrier to participation. It was argued that Portuguese citizens are not used to neither motivated for civic participation and strategic thinking necessary for Smart Cities policymaking. Citizens are involved in electoral campaigns but not in the policymaking processes that follow. Policymaker 6, for example, argues that after these campaigns, "there is no specific moment of discussion" for the involvement of citizens. Policymakers argued that citizens "do not give the information they are looking for" as often they focus a lot on their interests rather than on the city as a whole.

Citizens do not have the necessary information to be involved. It was also argued that citizens engagement is hampered by a lack of knowledge on their part. Citizens are argued not to have critical thinking regarding Smart Cities. Policymaker 6, for example, argued that in participatory budget exercise “none of the proposals related to Smart Cities” but rather to individuals’ interests. It was argued for the need to separate between what is qualified participation and what is not.

Often only the more radical voices are spoken. Various policymakers also mentioned that in different forms of engagement such as participatory budgets or via social media, it is often the most extreme vocal voices. This shapes the debate in a way that ignores the concerns of the majority of citizens.

Lack of human resources. Engaging with citizens is argued to require much commitment from policymakers. Most of them argue that this requires dedicated teams to inform citizens and sort out the information they provide. In often strained human resources, this is a problem outlined by many of the policymakers interviewed.

Lack of methodological standard approaches. Throughout the years the Government has promoted the enhancement of cities’ participatory budgets, however, these are unanimously seen by policymakers has a non-effective method. They refer that the logic of territorially distributing money across multiple projects is manipulated by the interests of some groups for local interventions rather than that the promotion of global well-being or a vision for the future. However, they also say that they lack other tools to involve citizens in a standard way.

8.5. Discussion

When analyzing the above responses, one is able to place how these Policymakers understand the involvement of citizens in relation to the literature of development geography reviewed in section 8.2.3. It is clear that all Policymakers recognize the importance of involving citizens in policymaking. This suggests that phase one is not a good description of the current state of play in Smart Cities policymaking. One can also note that while they recognize this importance, many Policymakers outline problems in involving citizens and various constraints associated with it. However, some Policymakers also recognize a highly developed understanding of power dynamics and how it is important to consider whose voice is being heard. This suggests that Smart Cities policymaking is currently in between the phase 2 and phase 3 of development geography understanding of the involvement of citizens in policymaking.

One should also pay attention not just to what is mentioned but also to what is not. When talking about the problems associated with citizens participation, most Policymakers put the onus on the citizens. It is the citizens who are not motivated and the citizens who are not well informed and that do not participate in the right way. However, one could easily turn the table around and say that it is the Policymakers who are not motivating the citizens enough, providing with the necessary information and explaining to them what type of insight they are looking for. Again, looking at the literature in development geography it becomes clear that it is possible to do high level engagement with citizens even if they lack knowledge and are not experienced in policymaking – a lot of development initiatives take place in countries of the Global South which have very low levels of education and in which citizens are often even further away from policy and politics than in countries of the Global North like Portugal. It is then clear that the problems outlined by Policymakers can be addressed by them and the responsibility for them should not necessarily be put on the citizens.

This research has two main limitations. First, only a small number of policymakers were interviewed which limits the generality of the findings. Second, the study only considers the perspective of policymakers. While this provides a good overview of the situation in this country it also limits the findings to the Smart Cities state of art in it.

In terms of future work, it becomes clear that at least in a Portuguese context there is a lack of knowledge about methodologies to involve citizens in Smart Cities policymaking. Most cities rely on participatory budgets while most Policymakers recognize that these are not adequate. Future research should explore the practical side of involving citizens, developing methodologies and guidelines for it. The goal to fully involve citizens will likely require involving them as early as possible. However, this is missing and requires guidance and research.

8.6. Conclusions

In conclusion, the need to include citizens in Smart Cities policymaking is unanimous. However, what is also unanimous is the many problems associated with this such as the inability of citizens to be able to have a holistic view and strategical thinking required to bring added value. This paper has argued that policymakers need to start viewing problems from their own perspective. It has placed the current thinking about citizens involvement within debates which took place in the discipline of development geography. This can allow for future research to explore insights from this discipline and use them in the development of citizens involvement in Smart Cities. Overall, by interviewing policymakers involved in Smart Cities it becomes clear that there is a need to develop practical tools to help them involve citizens in policymaking complemented with guidelines on how to deal with aspects such as inherent power relations within groups.

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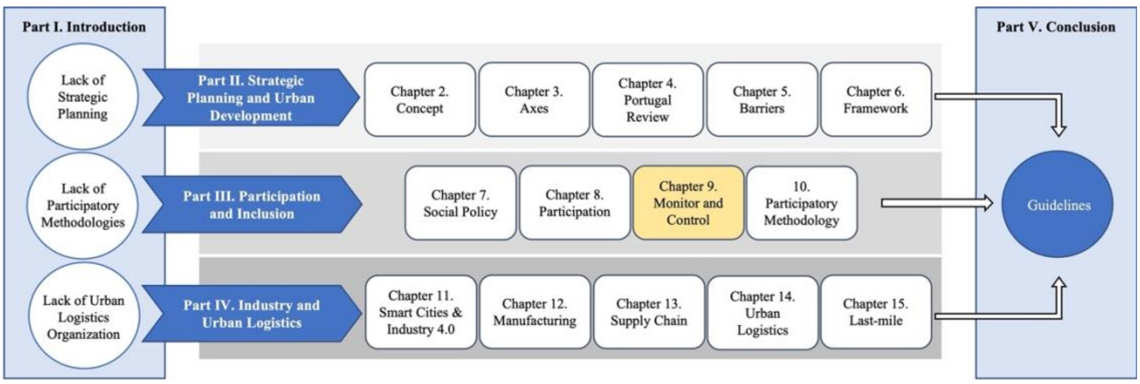
Chapter 9

City@PATH: A Collaborative Smart City Planning and Assessment tool

Reference

Correia, D., Marques, J. L., & Teixeira, L. (2022). City@PATH: A Collaborative Smart City Planning and Assessment tool. *Transport Development and Integration, WiT Press, 66–80*. https://doi.org/10.2495/TDI-V6-N1-66-80



9. City@PATH: A Collaborative Smart City Planning and Assessment tool

Abstract

The lack of strategic planning has increased urban pressure and accumulated traffic in cities. Smart Cities are replacing the short-time perspective with a long-term approach. The objectives align with city strategic goals, and citizens play an essential role in the decision-making process. High-level guidelines have emerged over the years to guide Smart Cities' vision and implementation. However, the lack of a tool that combines top-down and bottom-up approaches to help local policymakers plan and assess cities is still notorious. Moreover, this paper provides a methodology that allows the definition of structural priorities and contextual preferences while comparing policymakers' statements and citizens' opinions. Furthermore, this paper designs an approach to fill the existing gap and give policymakers a framework to monitor and measure their performance based on standard Key Performance Indicators and select relevant initiatives towards meeting the defined goals. This way, policymakers possess a tool that allows on the one hand, the standard comparison between cities and, on the other hand, the personalized comparison of their territory over time. Finally, a test case with the premise of improving city logistics is described to practically detail the guidelines of the proposed tool.

Keywords: Smart City; Transportation; Logistics; Participatory Development; Assessment.

9.1. Introduction

More than half of the World's population now lives in urban areas (Chourabi et al., 2012). By 2050, around 70% of the population will live in cities and neighboring regions (United Nations, 2015). The mass migration to the cities will increase the number of densely populated areas, further complicating urban mobility and logistics (OECD, 2012). Rapid urbanization also harms the environment. Although cities occupy 2% of the planet, they already account for 60% to 80% of energy consumption and 75% of carbon dioxide emissions. Increased traffic, pollution, waste, and energy costs continue to present a growing threat to human health and city's sustainability (Neirotti, Marco, Cagliano, Mangano, & Scorrano, 2014).

Urban planning defines the rules of land usage to maximize economic development, with concerns to a high quality of life, wise management of natural resources, and efficient operation of infrastructures (Anthopoulos & Vakali, 2012; Bibri & Krogstie, 2017). Smart Cities are an innovative view of urban development (Meijer & Bolívar, 2016; Nam & Pardo, 2011). The concept from its origin advocated new policies for urban planning (Colin Harrison & Donnelly, 2017). Nevertheless, urban planning has neglected social and sustainable practices by promoting private car usage (Newman, Beatley, & Boyer, 2017). Nowadays, policymakers' tendency to return city centers to citizens can be explained by the cultural misrepresentation noticed mainly because of tourism and associated economic activities. These increased inequality and housing unaffordability to inhabitants. Several authors refer to the need to restudy the concept of modern urban planning since it led to unsustainable urban trends (Adkins, Cooper, & Konings, 2019; Gurstein & Hutton, 2019).

In addition, Covid-19 pandemics accelerated the necessity to re-think cities. Moreno et al. (2021) noted the need to assist citizens with closer public services, who proposed a "15-Minute city" conceptual approach to help policymakers to reflect on the strategic vision for their cities. In a nutshell, the four-dimensions concept (density, diversity, digitalization, and proximity) aimed to help plan cities towards the availability of essentials to inhabitants, by foot or bicycle, promoting citizens' quality of life and combat the need of car usage. The application of this concept allows access to services in an outbound way, considering the citizens' movement from their homes. However, the same can be considered for the inbound transport of goods to the citizen, using transport modes such as scooters, bikes, and cargo bikes (Arnold, Cardenas, Sörensen, & Dewulf, 2018).

The new paradigm of fulfilling citizens' real-time needs will represent a significant effort of urban planners and policymakers. Thus, it will require closer collaboration with citizens and the remaining stakeholders to plan the city accordingly. Traditional decision-making models do not allow the implementation of co-creation processes. Existing participation can sometimes have an opposite effect, as they do not mirror the majority's will because of the poor representativeness of the sample.

Smart Cities are replacing the short-term perspective to a more sustainable and long-term sustainable approach where objectives are aligned with the city's strategic goals. Municipalities are increasingly adopting open governance and promoting citizens' interaction by creating programs for a more efficient, transparent, and collaborative environment (Carter & Bélanger, 2005), aligned with the noticed evolution of the Smart City concept.

Nevertheless, Smart city scholars are not the first to consider the role of citizens in policymaking. The discipline of development geography has been the first to address these and consider the citizens' role in development initiatives in the Global South (Correia, Feio, Teixeira, & Marques, 2021).

The debates in this discipline can be subdivided into three main phases. Top-down interventions with very little involvement of the people marked the first phase, which happened in the post-World War II (WWII) decades (Mathur, 1997). This phase is often referred to as the Washington Consensus (Gore, 2000). In the second phase, there was a need to involve the people affected by policies in their development (Mosse, 1994). It was also seen as a way to empower the poor and marginalized by giving them a voice and recognition in the development process (Mohan & Stokke, 2000). This led to the emergence of partnerships between international organizations and local non-governmental organizations (NGOs). A third phase came as a critique of this move towards participation. Authors such as Cooke and Kothari (Cooke & Kothari, 2001) argued that it was not enough to involve citizens in the policymaking process. It was essential to ask who is being involved and in what way. This was not a critique of participation itself but rather specific ways of involving citizens (Hickey & Mohan, 2004). Furthermore, a complex understanding of the local context is needed, which sees the power of human relations and the struggles and conflicting interests between individual communities and intra-community groups (Correia et al., 2021).

Moreover, although high-level guidelines have emerged to guide Smart Cities' vision and implementation, policymakers still stress to comprehend and translate them to a practical tool that helps them define the priorities and monitor their actions according to their local environment. Furthermore, it lacks a comprehensive methodology to help plan and assess cities. Frameworks that assist decision-makers in conceptualizing strategies and implementing solutions towards defined goals by bringing together the various stakeholders, provide greater collaboration represent excellent tools (Oliveira & Margarida Campolargo, 2015; Shelton, Zook, & Wiig, 2015).

Thus, this paper aims, on the one hand, to provide a tool for the comparison among cities of their Smart City performance and, on the other hand, the regular cites' assessment to select and define an operational action plan to achieve their goals.

Therefore, after reviewing the literature on the transportation issues within cities and presenting the background on Smart Cities evolution and existing frameworks, this paper details a methodological planning and assessment approach rooted in the findings of previous studies. Ultimately, a test case on city logistics is addresses to allow a practical understanding of how the proposed methodology can be applied.

9.2. Transportation Issues within cities

The urban population growth caused an increase of goods transportation in the city center, impacting traffic congestion, the environment, and energy consumption. Urban freight transport is influenced by lands usage distribution within cities. Warehouses throughout the years moved from the city centers to metropolitan areas due to the land costs and availability, meaning more considerable traveled distances and increasing number of vehicles (Dablanc, 2014). Moreover, urban logistics is one of the most resource consumer and greenhouse gas emission existing activities, challenging cities' sustainability (Bibri & Krogstie, 2017). It is a primary cause of congestion in cities representing between 8% and 18% of urban traffic, at the same time that road capacity is decreased by 30% because of pick-up and delivery services (Nocerino, Colorni, Lia, & Luè, 2016). Although goods transport is responsible for 14% of the vehicle kilometers, 19% of energy use, and 21% of CO_2 emissions in urban areas, city logistics needs are often neglected in urban planning (Francesco Russo, Rindone, & Panuccio, 2016)

E-commerce, especially in the case of business-to-consumer (B2C), represents a significant challenge in urban logistics (Eiichi & Yasushi, 2004; Gatta, Marcucci, Nigro, Patella, & Serafini, 2018; Van Duin, De Goffau, Wiegmans, Tavasszy, & Saes, 2016; Visser, Nemoto, & Browne, 2014), increasing the difficulties of product distribution with direct impact on traffic congestion and accessibility (Morganti, Dablanc, & Fortin, 2014) as well as environmental pollution and global warming (Ducret, 2014). Online sales are expected to increase to 5 US $ trillion by the end of 2021 (eMarketer, 2019). Moreover, parcel and express transports can be expected to grow exponentially, which will cause increased congestion and inflict the environment (Taniguchi, Thompson, & Yamada, 2016). Several authors refer to the advantages of simultaneous and integrated proximity approaches between home delivery and client's pick-up (Zhou, Baldacci, Vigo, & Wang, 2018; Zhou, Wang, Ni, & Lin, 2016). Furthermore, consumers' orders have an impact on logistics activities which interferes with the dynamics of cities. Wasteful travel time due to the significant variation of today's demand, the complexity of transportation networks, and increasing vehicle fleets are some of today's problems cities face (Lee, Kang, & Prabhu, 2016). Moreover, the mobility of people and transportation of goods neglected by urban planning are critical challenges for the future.

The above problems require newfangled urban thinking grounded in a holistic approach and long–term perspective. Urban sustainability's desire to balance environmental protection, economic development, and social equality can only be achieved with the proper use and development of the land, environment, infrastructure, related ecosystem, and human services.

The United Nations sustainable development objectives (UN, 2018) led cities to consider decarbonization goals, adopting green and sharing policies with an additional focus on improving quality of life. On behalf of the Green Deal, the European Commission hopes to achieve carbon neutrality in the European Union by 2050. Sustainable Industry and Sustainable Mobility are among Green Deal policy areas (EC, 2019). Moreover, two goals are striving towards sustainable and smart mobility and mobilizing the industry to a clean and circular economy (European Commission, 2019).

Nevertheless, strategic planning is still an abstract and unexplored idea in terms of design and operationalization (Angelidou, 2014). Therefore, there is a need to create tools capable of supporting urban development decision-making (Zygiaris, 2013) and assessing cities' progress towards specific goals (Mohanty, Choppali, & Kougianos, 2016).

9.3. Smart Cities Planning and Assessment

Smart Cities emerged in the 1990s to answer the challenges of urbanization and globalization and have evolved ever since. From the first technical perspective (Mora, Bolici, & Deakin, 2017) to the understanding of technology as a means to achieve city's sustainability and improve the quality of life of their citizens (Angelidou, 2015; Tan, 1999). Nowadays, a new paradigm is emerging. The focus is on the inclusion of citizens in the co-creation and co-design of cities' processes and strategies (Mainka et al., 2016) to improve the policies' chances of success (Al-Nasrawi, El-Zaart, & Adams, 2017). Table 9.1 summarizes the evolution of the Smart City concept.

Furthermore, Smart Cities have the responsibility to overcome inequality and social polarization (Hollands, 2008). In these matters, inclusiveness shall have a significant role in a Smart City's design thinking (Correia & Feio, 2020). The decision-making process must promote inclusion and reduce social barriers (Silva, Khan, & Han, 2018). The bottom-up participatory approaches play an essential role in assessing and developing Smart Cities (Hemment, Woods, Appadoo, & Bui, 2016).

Table 9:1 The three Smart City stages

Stage	Concept	Sources
Smart City 1.0	A city that uses ICTs to collect data to improve its critical infrastructures and services' efficiency.	(Hall, Bowerman, Braverman, Taylor, & Todosow, 2000; C. Harrison et al., 2010)
Smart City 2.0	A city that starts with the human capital, motivating citizens to create and flourish their lives, using ICT to increase the quality of life and the city's social, economic, and environmental sustainability.	(Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017; Angelidou, 2014; Barrionuevo, Berrone, & Ricart Costa, 2012; Caragliu, del Bo, & Nijkamp, 2009; Chen, 2010; Hollands, 2008; Mohanty et al., 2016; Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014; Rios, 2008)
Smart City 3.0	A city that uses ICT to promote citizen engagement and active participation allows continuous interactions. The strategy is collaboratively created with citizens and relevant stakeholders.	(Albino, Berardi, & Dangelico, 2015; Trivellato, 2017; Van der Graaf & Veeckman, 2014)

Russo et al. (2014) recall the Smart City definition and guidelines evolution at an EU level. The European Parliament synthesizes international debate over Smart City concept by stating that including the participation of citizens and relevant stakeholders is a critical success factor. The Europe 2020 strategy was focused on three priorities (European Commission, 2010): Sustainable growth (low-carbon economy), smart growth (education, research, and innovation), and inclusive growth (jobs and wealth). These are reflected on the three axes (Sustainability, Innovation, and Quality of Life) of the Triangular Pyramid Trunk proposed by Correia et al. (2020). Nevertheless, the vertical of Smart Cities is considered under the umbrella of "Smart Growth", leaving Sustainability and Inclusiveness aside (F. Russo et al., 2014).

Of the Smart Growth priority, two stakeholder advisory platforms emerged: ETPs (European Technology Platforms) and EIPs (European Innovation Platforms). The last aimed to bring public and private stakeholders together to accelerate research and innovation. Moreover, through EIP-SCC (EIP for Smart Cities and Communities), the Smart City assumed a relevant role (Francesco Russo et al., 2016). The two governance bodies of EIP-SCC, High-Level Group (HLG) and Smart Cities Stakeholder Platform (SCSP), were responsible for defining rules and guidelines for the development of Smart Cities. The first joined high-level representatives from industry, academia, and city administrations; the second aimed to be a collaborative tool for sharing knowledge and best practices. These can be found in the Strategic Implementation Plan (SIP) (European Commission, 2013), and the Operational Implementation Plan (OIP) (European Commission, 2014).

The guidelines cross i) three specific vertical areas: sustainable urban mobility, sustainable districts and built environment, integrated infrastructures and processes across energy, ICT, and transport, with ii) eight horizontal themes aggregated into three classes: Decisions (citizen focus, policy and regulation, and integrated planning and management), Insight (knowledge sharing, metrics, and indicators, open data and standards) and Funds (business models, procurement and funding). The intersection of vertical areas and horizontal themes constitutes 24 focus areas (Francesco Russo et al., 2016).

Strategic planning raises the challenge of integrating the needs for smarter urban environments with the policy strategies followed by local decision-makers in response to the existing weaknesses of the urban system. This raises the question of whether the produced decisions express citizens' preferences, and if the answer is positive, how (Wolf, Borges, Marques, & Castro, 2019).

Thus, in the breakdown of strategic plans, local decision-makers are challenged to adopt new approaches and instruments to answer complex, territorialized socioeconomic needs. The challenge is to transfer macro guideline scales to micro reality.

In addition, from the European Smart Cities Ranking (Giffinger, 2007) to other assessment indexes present in the literature, there is a lack of medium and long-term goals consideration (Osella, Ferro, & Pautasso, 2016). Therefore, there is not a standard tool used by cities to monitor themselves continuously. International Organization for Standardization (ISO) and International Telecommunication Union (ITU) have played a leading role in defining standards for these matters. However, there is no tool capable of monitoring and assessing the city's performance towards specific objectives (ISO, 2014) nor contemplating citizens' points of view.

In terms of city assessment, the existing frameworks have been mostly used to rank the cities, mixing up different concepts, and not consider the evolution noticed in the Smart City concept. However, they present significant insights (see more at (Correia et al., 2020)). For example, Sharifi (2019) concluded that assessment tools do not consider indicators' interlinkages and correlations as well as local needs and participatory approaches; Ahyenniemi et al. (2017) demonstrated that Smart City assessment tools are focused on social aspects and the Sustainable Cities' on the environment; Huovila et al. (2019) concluded that 90% of the KPIs from ISO 37120 were focused on Sustainability and the ITU 4902 had a purely ICT-enabled indicator orientation. In contrast, the remaining have an inadequate presence of these indicators (Stratigea, Leka, & Panagiotopoulou, 2017). Thus, it reinforces the relevance and the role of the citizens. Moreover, the objective approach shall be combined with a subjective perspective.

The following section considers the literature findings to provide a tool to assess and monitor Smart Cities' performance and help policymakers select and define relevant initiatives to answer urban challenges.

9.4. Proposed Smart City Assessment and Planning Approach

Section 9.2 identified the existing transportation challenges caused by globalization and urbanization, where the environment will be impacted by the evolution of transportation (of passengers and goods) considering the decisions of policymakers and urban planners.

Therefore, collaborative strategic planning is crucial to achieve sustainability and promote citizens' well-being. Nevertheless, Smart Cities' literature pinpoints the need for a methodology to help local policymakers realize the city's current state and define an action plan towards their goals.

Therefore, the following methodology is designed to contemplate the macro (structural) and micro (contextual) dimensions, to provide the chance of evaluating the territory, while enabling the development of different initiatives based on local priorities and preferences. Based on the previously mentioned studies' conclusions, three axes were defined, considering the evolution of the Smart City concept (Barrionuevo et al., 2012; Etezadzadeh, 2016; Venkat Reddy, Siva Krishna, & Ravi Kumar, 2017) also mirrored in the priorities of Europe 2020 strategy (European Commission, 2010).

Cities have the need to acknowledge their services, processes, and systems and realize what can be optimized (where the resources are being misused). Thus, perform a self-assessment to build a strategic plan based on the solutions that can significantly impact the territory towards the defined strategic goals. To adequately address a Smart City strategy, it is necessary to measure city's performance overtimes. Therefore, in policymaking, three different assessment moments are vital (HM Treasury, 2020), as shown in Figure 9.1:

I. Before starting the process (Ex Ante) – calculating the values for the KPIs to define the strategic goals and define the relevant initiatives;

II. Ongoing assessment (Monitoring) - current assessment of the implemented solutions and their impact on the defined targets;

III. After the conclusion of a specific initiative (Ex Post) – a comparison if the implementation met the expected results towards the city strategic goals.

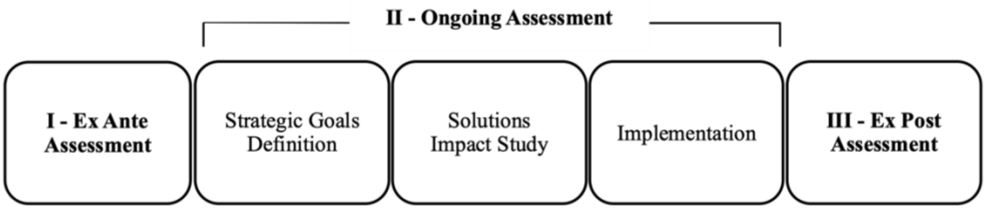


Figure 9:1 Assessment Overview

Following Correia, Teixeira, and Marques (2020), the primary Key Performance Indicators (KPIs) will be collected from ISO 37120, ITU 4901, and Mercer's annual quality of life survey.

Two axes shall be considered with two different approaches each:

- The vertical is divided in i) top-down approach – objective statistical analysis. Consideration of political guidelines explained in strategic planning documents, and public policy programs; ii) bottom-up approach – which gives particular emphasis to the citizen, on the development of composite indicators and in the definition of initiatives towards the improvement of people's living conditions.
- The horizontal axis combines the i) structural approach (classical) - measurement of the standard Smart City performance through a set of indicators, comparable between cities; and ii) the contextual (operational) approach – contemplates each territory's priorities to personalize the understanding of the Smart City action plan in each context, comparable in different moments.

Moreover, the axes can be summarized and organized into four quadrants as they are represented in Figure 9.2.

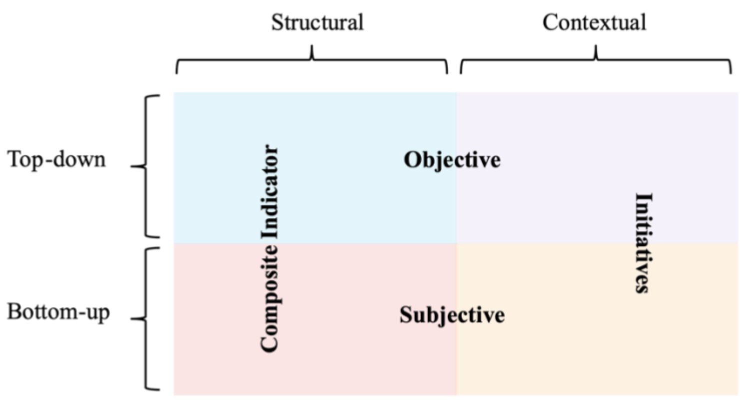


Figure 9:2 The Quadrants of the Smart City Assessment Tool

The horizontal and vertical axes have the objective of combining bottom-up and top-down approaches to:

1) Monitor and measure the performance – To reduce the number of KPIs, there must be analyzed existing relationships. The focus shall be given to the variables that significantly influence the overall statistical representativeness, avoiding redundancies. Thus, through factor analysis, the fundamental dimensions and KPIs of each axis should be returned. Factor analysis can be complemented with the creation of a composite indicator by aggregating the independent factors. Moreover, on the one hand, a top-down composite indicator can be obtained based on objective statements – aggregated by assigning a weight to each factor according to the proportion of the explained variance in the data set – and, on the other hand, a subjective composite indicator – through the factors' level of importance given by citizens.

2) Select and define relevant initiatives - Existing priorities are crucial to select the initiatives that help the city achieve the established goals. The reasoning starts from the same primary KPIs or those from the Factor Analysis (green color connection in Figure 9.3). As mentioned before, the participation of citizens is vital to Smart Cities. The inclusion of the citizens will also be done on behalf of the priorities' definition. In the top-down approach, political statements and directory plans will base the priorities of policymakers. At the same time, subjective data will be gathered from citizens to define the priority (weight) for each KPI. This way, it is preserved that citizens are different among cities and, therefore, have different priorities. The priorities of citizens (bottom-up) can be evaluated through a Likert scale or peer-to-peer pairwise comparison. Only the variables mirrored in the composite index and their grounded factors are contemplated for evaluation.

First, the confrontation of the KPIs' results with the study and comparison of their importance to the local community, and second, the priorities for the territory will give policymakers the knowledge of the city goals, how far they are from reaching them, and the KPIs that will deserve the attention of the action plan. Thus, the difference between the evaluation of citizens (bottom-up) and policymakers (top-down) can be understood as the fulfillment deviation. This should enhance the definition of an action plan with clear goals to overcome this difference.

Ultimately, the definition of the implementing policies can be carried out contemplating the Multi-Criteria Decision Analysis (MCDS) (Huang, Keisler, & Linkov, 2011) - definition of criteria to achieve the intended goals - or the Data Envelopment Analysis (DEA) (Cooper, Seiford, & Tone, 2007) - input management to maximize the efficiency of outputs.

Regardless of the chosen method, the difference between the current KPIs results and their goals shall be the starting point for procurement solutions that can improve their current values. A single digital marketplace can be set up where the entities shall promote their solutions and case studies. Cities shall study each option to improve the KPIs value and the expected return on the investment. Moreover, third parties' developments can also answer the existing challenges through partnerships, where local governments do not act in isolation but in collaboration with the stakeholders.

Furthermore, a solution's impact must be calculated with the expected KPI improvement towards the defined goals. Therefore, a reverse engineering process must be carried out to understand which solutions should be implemented. Additionally, the target audience of a specific policy or initiative must be measured and compared. Each city shall assess the representativeness (percentage of people) of each social group (or just the minorities' inclusion) reached with that initiative. It will allow understanding the population's number and the social groups that are not being considered.

The assessment cycle ends with the measurement of the policy's impact based on the new KPI value. The policy's impact evaluation shall be calculated according to the measurable outcomes, their contribution for the final result, which groups were affected, the influence of the context, and reproduction (HM Treasury, 2020).

In summary, the methodology that will guide, on the one hand, the comparison among cities and, on the other hand, cities' assessment to select and define an operational action plan is detailed in Figure 9.3.

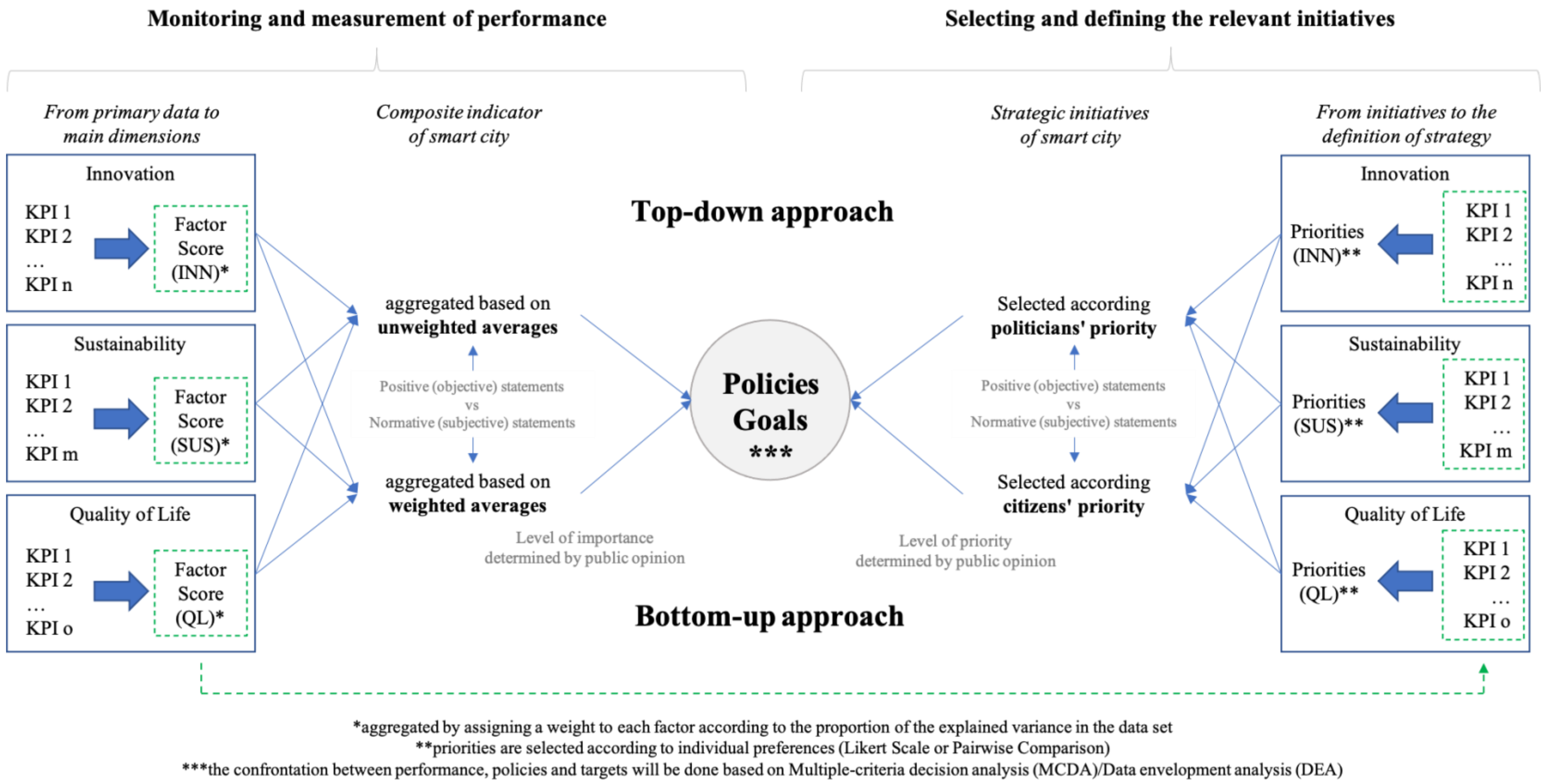


Figure 9:3 City@PATH

9.5. City logistics Test Case

Test cases are usually executed to test every requirement on the level of software units, software integration, and system tests (Schuldt, Reschka, & Maurer, 2018). Thus, this work conceptualizes the initial guidelines to build a dedicated software. Moreover, as it was intended to conceptualize a generic tool, this section describes the needed steps to adapt it to any use case.

The goal of the proposed methodology (Figure 9.3) is to monitor the city's current state while planning the actions towards the priorities defined by citizens and policymakers.

Among the 24 cross working areas of the European guidelines identified above, the city logistics case derives from the intersection between sustainable urban mobility (vertical area) and integrated planning and management (horizontal theme) (Francesco Russo et al., 2016). Furthermore, as stated before, mobility and goods transportation have a significant impact on city dynamics. Thus, this test case has the premise of a city that needs and wants to prioritize the actions that improve the transportation network and avoid using the private car (assuming that the KPIs results are poor, and it is a citizens' priority). At the same time, optimize and promote proximity last-mile solutions to reduce the number of vehicles circulating.

Therefore, the methodological procedure must be considered as follows. The first steps define the importance of each KPI for the city strategy, which is directly associated with the local understanding of what a Smart City shall be (macro-level). From step 4 onwards, are mirrored the local priorities (micro-level), which will be the mobility and city logistics in this test case. Therefore, the first steps are standard. The step 4 is where the priorities are defined. This test case will be based on the related KPIs to city logistics and urban transportation.

Step 0: Identification of a territory and calculation of the KPIs of each axis.

Step 1: Principal Component Analysis (Factor score) on the KPIs for each axis. Consider only components with greater representativity (significant).

Step 2 [Top-down structural]: The objective Composite Indicator of Smart Cities is the result of the disaggregated average of the three axes results.

Step 3 [Bottom-up structural]: The subjective Composite Indicator of Smart Cities is the result of the aggregated average based on weights average. Weighting is carried out to each axis by citizens. This importance level can also be given to each of the KPIs.

There is no direct aggregation between bottom-up and top-down evaluations. The top-down allows the possibility of making standard comparisons between cities and within the same city at different times since there is no allocation of weights. The bottom-up evaluation has an associated subjective component depending on the given weights by citizens, thus making each city unique. The comparison between objective and subjective results will allow assessing the relationship between policymakers and the opinion of citizens. Thus, it allows the understanding of whether citizens value the variables with higher performance (best results). On the other hand, the city's strategy is inaccurate because the objective composite value is higher than the subjectively weighted average. The analysis of both perspectives will allow the definition of the city's strategic goals, since the aim will be to understand the disparity of top-down approach regarding the bottom-up to define an action plan with clear objectives towards improving the variables that have poor results or are prioritized by citizens.

Step 4 [Top-down contextual]: Study of the priorities. These can be obtained according to the worst KPIs results or by political orientations.

Step 5 [Bottom-up contextual]: For each axis is asked the opinion of citizens about the priority of their KPIs. Citizens allocate the weights through the Likert Scale or Pairwise Comparison.

Because this test case has the premise of a city whose priority is to improve urban logistics (KPIs with the worst results or valued the most by citizens), the focus would be on the following KPIs:

- *Kilometres of public transport system per 100 000 population*
- *Annual number of public transport trips per capita*
- *Percentage of commuters using a travel mode to work other than a personal vehicle*
- *Kilometres of bicycle paths and lanes per 100 000 population*
- *Greenhouse gas emissions measured in tonnes per capita*
- *…*

Step 6: Once the KPIs are identified, a search for solutions (possibly with scientific evidence) about the hypothesis that can positively impact the KPIs towards the defined goals should be carried out. These solutions can also emerge from the discussion with the community. The definition of the action plan will be based on the confrontation between the goals and the impact of solutions based on Multi-criteria decision analysis (MCDA) or Data envelopment analysis (DEA).

The possibility that citizens can view the top-down information while giving their opinion or, at least at a final stage, may allow a better perception and knowledge of the matter, which will contribute to the community's discussion and engagement.

9.6. Conclusions, Limitations and Future Work

Urbanization and globalization have increased urban pressure, which affected urban mobility and the environment. These problems arose from the disregard of strategic planning. Concepts as the “15-minute city” have emerged to highlight the importance of urban planning, contemplating the disposal of essential services close to the citizens to combat the need to use the private car.

This paper crossed the literature of development geography and Smart Cities to clarify the existing gap on participation schemes, which is mainly because high-level guidelines cannot be translated into practical steps that consider local contexts. That can be acknowledged on European Commission guidelines and the strategic and operational plans promoted by the EIP-SCC. It lacks the ability to policymakers adjust the framework to their community needs and monitor their strategy towards co-defined priorities.

Moreover, this paper proposed combining top-down and bottom-up approaches based on the collaboration between decision-makers and citizens to providing a framework capable of monitoring Smart Cities and support decision-making by addressing specific priorities. The tool allows the overview of city's current state and the understanding of the most critical KPIs to establish strategic goals and look for solutions to improve their results.

Besides stating the city’s current state concerning the Smart City concept phase, the objective was to allow policymakers realize how far they are from achieving the goals and satisfy citizens' wishes. With this tool, policymakers can understand their citizens' preferences profile, allowing better planning, investment, and resource allocation. The continuous performance assessment is crucial to guarantee that cities are going towards the defined goals.

The city logistics test case explained how the framework could be applied to any use case (priority). The methodology helps structure cities’ design thinking and strategy definition through continuous evaluation, comparison between territories, and contemplation of citizens' opinions. Moreover, depending on current opportunities, (mainly at the financial support level) priorities can be changed. Therefore, the exercise should be reviewed in a defined time-space to align expectations with the reliability of outputs.

As a limitation, the framework rationale starts from the understanding of 3 distinct axes – Sustainability, Innovation, and Quality of Life – based on a previous study that is not yet widely adopted in academia. Nevertheless, the methodology can consider other axes and associated KPIs. The paper's contribution is on the definition of the path to evolve citizens and policymakers in decision-making and allow the creation of a tool that considers their opinions as equal for the understanding of what a Smart City is and the priorities of the territory. The importance of the KPIs themselves can also be studied. Weights should be reviewed periodically because the assigned importance may change over time. Considering the city's evolution, the circumstances of the moment, and the context in which the changes were advocated may be essential to understand the reasons behind.

As future work, it is vital to study citizen's participatory development and engagement methods of specific groups in practice. Dashboards and software solutions can be created with the present research to provide user-friendly interfaces to plan and assess cities.

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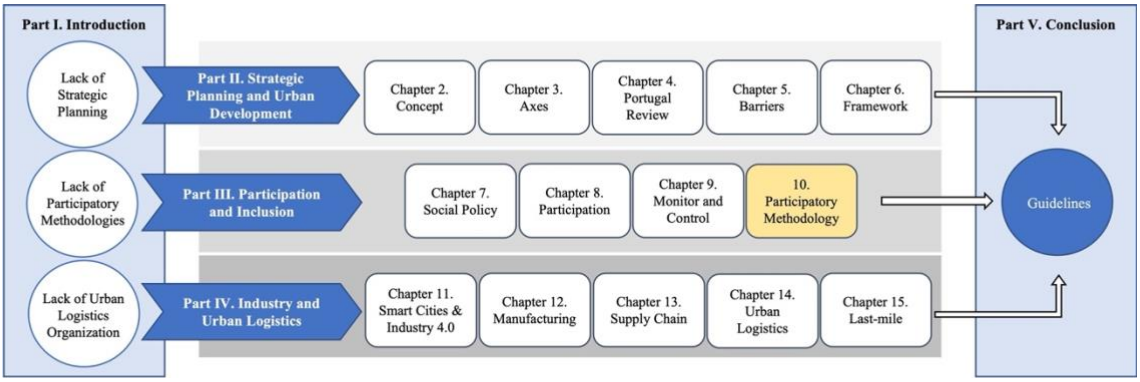
Chapter 10

Participatory methodology guidelines to promote citizens participation in decision-making: evidence based on a Portuguese case study

Reference

Correia, D., Feio, J. Marques, J. & L., Teixeira, L. (2022). Participatory methodology guidelines to promote citizens participation in decision-making: evidence based on a Portuguese case study. *Cities*.



10. Participatory methodology guidelines to promote citizens participation in decision-making: evidence based on a Portuguese case study

Abstract

Citizens' role evolved to become active agents in decision-making. However, existing policy definition procedures are still not tailored to engage citizens and the participation of specific groups. Moreover, it is vital to understand citizens' interests and motivations to set the methods and build democratic methodologies that make them feel comfortable and willing to participate. In this context, this paper explores how policymakers view the role of citizens in policymaking. Specifically, it looks at the obstacles outlined by policymakers to the involvement of citizens in the policy definition. Second, it explores how citizens view their participation and the respective challenges. This study was conducted within the Portuguese context, following a methodology supported by mixed methods research, which combined interviews with policymakers and questionnaires applied to citizens. Furthermore, this research shows detailed data about how the Portuguese population and how particular groups wish to engage in decision-making. Guidelines are presented in the following areas: willingness to be identified, subjects, topics, methods, and channels to participate. The findings suggest there is significant heterogeneity on the engagement modes. Therefore, to promote the inclusion of different groups of citizens, policymakers should tailor participatory methodologies to these, in line with the guidelines of this paper.

Keywords: Urban Planning, Smart City, Citizens, Participation, Guidelines, and Heterogeneity.

10.1. Introduction

There is a wide consensus in the literature about the importance of involving citizens in policymaking (Oliveira & Margarida Campolargo, 2015; Sadoway & Univerisity, 2018; Trencher, 2019). Citizens' participation can bring many benefits: on the one hand, it allows policymakers to find answers to the real needs and expectations of a community, and on the other hand, it helps to legitimize decision-making procedures by making sure that the people affected by policies have a say in them. However, there is little information about the personalization of methods, tools, and timings that should be used to promote their participation. The communication and forms of engagement shall be different depending on the target audience (Ashley & Tuten, 2015). Between other aspects, it is vital to develop practices that remind citizens of their citizenship role (Carreira, Machado, & Vasconcelos, 2016).

Although high-level frameworks have emerged to guide smart cities' vision, policymakers struggle to translate them into practice and promote the engagement of the population (Correia, Marques, & Teixeira, 2022; Correia, Teixeira, & Marques, 2020). The concept of participation in urban governance evolved to the co-creation and co-production with the active help of citizens and partner organizations. This has resulted in a change in how citizens' roles are understood from passive subjects to active actors who influence decisions and demand, between other aspects, more participatory, transparent, and accountable processes (Bonsón, Torres, Royo, & Flores-Munoz, 2012; Stoker, 2006). However, one major challenge lies in promoting their involvement in the democratic process of public decisions (Boukhris, Ayachi, Elouedi, Mellouli, & Amor, 2016; Hemment&Townsend, 2013). Cortés-Cediel, Cantador and Bolívar (2021) reviewed the literature and the initiatives of EUROCITIES network and noted an increasing interest for smart city projects involving citizen participation, mostly on the governance side. Nevertheless, while some work has been done on this topic, research exploring methodologies in smart cities' decision-making is still lacking. Some authors such as Szarek-Iwaniuk and Senetra (2020) and Díaz-Díaz and Pérez-González (2016) focus on case-studies analysis and the pros or cons of a particular way of engaging citizens. Other authors, such as Mueller, Lu, Chirkin, Klein, and Schmitt (2018), Salim and Haque (2015) focus on theoretically understanding participation, and Boukhris, Ayachi, Elouedi, Mellouli and Amor (2016) on developing tools to help decision-making. In summary, very little research has been done on the methods used to promote participatory methods' democratic role and the respective barriers that exist to citizens' participation (Wolf, Borges, Marques, & Castro, 2019). Moreover, when authors explore these topics, they either focus on a single case study, on a single tool, or on a single stakeholder.

Enhancing the participation of citizens in decision-making and responding accordingly to the challenges of social sustainability could be done, for example, by reaching a greater number of citizens and diverse groups of people (Bouzguenda, Alalouch, & Fava, 2019). Various early attempts to promote gender equality suffered from the fact that they were based on tokenistic approaches (Cornwall, 2003). In other words, programs and policies were designed including specific women, assuming that they would represent the views of other women. To guarantee the representativeness of different groups and combat discrimination there must be accounted relevant characteristics (such as gender, age, and educational attainment) (Correia & Feio, 2020). Communities differ from each other, not only at the level of their needs but also at their expectations towards local and national government. These are instinctively related to their socio-economic attributes. Thus, between but also within communities, these varying needs and expectations must be considered and there is a need to adjust participatory approaches to these local and socio-economic idiosyncrasies in order to promote the greatest level of participation from citizens. Overall, it is essential to understand the aspects that drive citizens to participate and put in place tools that encourage them to engage in the decision-making process.

Therefore, this paper aims to fill this gap by proposing guidelines to help decision-makers design methodologies to involve citizens in decision-making. Furthermore, its practical output is built upon the realization of existing participation and current challenges. Thus, the present research complements the insights of policymakers with the citizens' views focusing on two main aspects. First, it explores whether citizens share the policymakers' views on the obstacles to participation. Second, it presents guidelines for policymakers to allow them to develop their participatory processes.

The methodology used follows a mixed-method research approach, with two different and complementary data collection methods. First, interviews were conducted with Portuguese policymakers to understand their perception of citizens' involvement. Second, a questionnaire to citizens to ascertain whether there is evidence to support some of the assumptions made by policymakers. This allows for an analysis of whether barriers outlined by policymakers are actual obstacles or wrong perceptions they have about citizens and their participation.

The guidelines on participation might change depending on the specific characteristics of individuals, which influence the way citizens prefer to engage in participatory efforts. Therefore, variables such as the gender, age, and educational attainment of respondents were taken into consideration in the analysis of results. The findings related to these variables will be used to develop the guidelines that policymakers should consider when designing participatory methodologies for each specific group.

Thus, the paper is organized into five sections. Section 10.2 presents a literature review of the smart city concept and citizens' involvement, the methods of participation on urban planning and provides an overview of the Portuguese context. Section 10.3 details the methodology used in this research, which comprises of a mixed approach; on the one hand, a qualitative analysis through interviews to policymakers, and on the other hand, a quantitative analysis, applying inferential statistics to a questionnaire answered by citizens. Section 10.4 gathers the results, that is, the perceptions of decision-makers and citizens, regarding the challenges of participation as well as their relevance to design and implement a smart city strategy, in line with the real need of the community. In addition, results on the perceptions of different socio-economic groups, based on age, gender, and educational level, will be presented. Finally, section 10.5 concludes, presenting the research challenges and summarizing the guidelines that policymakers shall contemplate to promote the participation of citizens.

10.2. Theoretical framework

This section first reviews the smart cities concept evolution towards citizen involvement; second, it gives an overview on recent methods of engagement in urban planning; finally, it provides and overview on the current state of smart cities in Portugal and existing public participation.

10.2.1. Smart Cities and Citizen Involvement

The smart city concept emerged in the 1990s and has passed through three different stages (Cohen, 2015; Trencher, 2019). At the first stage of the concept, ICTs were seen as the end and not a mean (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017). Smart city initiatives were for many years associated with technological implementations. Real-time monitoring of parking spaces or the checking status of wastebins using filling level sensors were some of the examples (Lin, Rivano, & Le Mouel, 2017; Shyam, Manvi, & Bharti, 2017). The lack of consideration of the territories' context in terms of their social and cultural dynamics as well as the centralization of decision-making in policymakers created a dependency on technological companies (Neirotti, De Marco, Cagliano, Mangano, & Scorrano, 2014). After Hollands (2008) criticized the lack of foundations grounding the implemented smart city initiatives, the concept strived for more human and social capital. The "What" was replaced by the "Why" and the emphasis then shifted towards how ICTs could improve citizens' quality of life and city's sustainability (Caragliu, del Bo, & Nijkamp, 2009). Afterwards, the participation of citizens and relevant stakeholders began to be seen as a critical success factor for smart cities (Russo, Rindone, & Panuccio, 2016). Moreover, smart city literature started to promote citizens' engagement and active participation (Albino, Berardi, & Dangelico, 2015; Cardullo & Kitchin, 2019; Correia & Feio, 2020; Goel, Yadav, & Vishnoi, 2021). Recently, Lim, Edelenbos, and Gianoli (2019) reviewed the development of the concept and exposed more than fifty definitions in the literature. The study's findings suggest that although the role of human, social, and institutional capital is recognized, the primary emphasis of the concept is on technology. Thus, there is a growing effort to include citizens in policy definitions, which may be accomplish by the consideration of technological methods.

10.2.2. Public Participation in Policymaking and Smart Cities' Co-design

Public participation is generally perceived as the involvement in policymaking of those who normally are excluded from the process, with the purpose of influencing decisions (Arnstein, 1969). Public participation is crucial to democracy, and it inevitably influences the goals of public policy. Citizens can usually be classified into three categories: active, standby/monitors, or passive (Carreira et al., 2016). The empowerment of local communities can provide a wide range of possible solutions, avoid future conflicts, and create a sense of ownership (O'Faircheallaigh, 2010; Reed, 2008; Renn, 2006). Socio-cognitive theories have been introduced as analytical tools to explain individual and collective behaviors, decision rules, and cognitive mechanisms (Borges, Marques, & Castro, 2021). Revealed preferences approaches have been emerging based on the embeddedness of these socio-cognitive dimensions on the design of research methods (Batista, Marques, & Borges, 2020; Correia, Marques, et al., 2022; Correia et al., 2020).

Smart Cities public participation literature is centered in finding the best ways to engage citizens in urban designing using computing technologies, empowering them not just as data collectors but also as designers (Gooch et al., 2018). Through a workshop with various stakeholders, Forlano and Mathew (2014) set up a collaborative designing process from brainstorming to prototype a 25-30 years future city scenario. Marsal-Llacuna and López-Ibáñez (2014) developed a Smart Urban Planning Method based on reverse engineering principles. Through web-based surveys and data mining tools, citizens were asked about their urban activities in the previous 24 hours and their desired scenarios for urban activities to ultimately find the optimal land use. Webster and Leleux (2018) defined as mechanisms of smart city participation and co-production: hackathons, living labs, fab labs and maker spaces, smart urban labs, citizens' dashboard, gamification, open datasets, and crowdsourcing. Mueller, Lu, Chirkin, Klein and Schmitt (2018) created the concept of Citizen Design Science, as the new way to integrate citizens' ideas in the urban planning process combining crowdsourcing opinions through ICTs with design tools. City's sustainability and mostly social sustainability can only be achieved by the community's engagement, which can be enhanced through digital modes of participation rather than just the conventional offline ones (Bouzguenda et al., 2019). The survey of Szarek-Iwaniuk and Senetra (2020)'s case study made to Olsztyn's residents revealed that ICTs and mostly online surveys contribute and encourage the public to participate in decision-making.

However, they pointed out that other options should not be forgotten to tackle exclusion of certain groups.

Thus, a significant discussion is still in place about the role of citizens’ and their stage of involvement in policymaking. For example, because of the noted diminished research on citizen involvement in Smart Cities, Granier and Kudo (2016) studied several Japanese cities and communities through interviews and analysis of official documents and concluded that public participation is not often done at the city governance level, but instead in the co-production of public services (e.g. energy production and distribution). On the other hand, Simonofski, Asensio, De Smedt and Snoeck (2019) proposed the CitiVoice Framework where citizens participate in the three different phases: as democratic participants in decision making, co-creators of ideas and solutions, and users. In the same line, Díaz-Díaz and Pérez-González (2016)‘s case study of the Santander City Brain shows a collaborative tool designed to promote open innovation by the share of ideas, comment and vote, which proves that a social media adapted method (with democratic and non-democratic parts) can represent an effective way to set the political agenda and influence political discourse.

Current participatory methods tend to focus on the technological design of cities and aim to get more accurate responses of citizens wishes. However, there is still a long way to go on the pre-democratic step. In other words, before engaging citizens in the cities’ design, there is still the need to get their voices to choose, through democratic procedures, daily policymaking decisions.

Moreover, the literature lacks a broader contextual understanding when it comes to the state of the art regarding citizens' involvement and how citizens' participation must be performed depending on their situation, for example, in terms of their socio-economic characteristics.

10.2.3. Public Participation in the Portuguese Context

The three phases of the Smart City concept are perceived in slightly different ways in Portugal. Although in the literature the third phase corresponds to the collaboration and co-creation of strategies, few cities are already there. Thus, most cities are focused on changing cultural behaviors and combating the inactivity of citizens (Correia, Teixeira, & Marques, 2022). Correia et al. (2021) performed a case study analysis to understand citizens’ engagement in Portugal. The results suggest that cities with fewer inhabitants tend to not involve citizens in decision-making. Furthermore, their role as co-creators is still scarce in the country. Although this could be citizens’ fault, the authors compared it with the development geography literature and concluded that it is possible to have high levels of engagement even if citizens lack knowledge and are not experienced in policymaking - as many development initiatives in the Global South case have shown.

Several case studies in Portugal can be found in the literature. Videira et. al (2003) developed a participatory modelling design with selected participants composed by four workshops to define a management plan for a Portuguese natural park. Gil, Calado and Bentz (2011) putted together relevant public and private stakeholders impacted directly or indirectly by urban mobility to define a sustainable mobility plan. A similar approach was used by Fonseca et al. (2011) for the conservation of small islands. Ferreira, Seixas and Marques (2015) assessed the success of the management action to a costal marine protected area, based on the public participation of the fishing community, visual census and interviews with different visitors. Rodrigues and Loures (2017) redesigned a public space using a participation methodology, where methods of behavior mapping, interviews and focus group were implemented. The city of Guimarães aimed to implement an intervention on their main lake to enhance the water value and the overall sensory experience provided by the water features in the park as a place people can use to contact with nature, leisure and recreation, resulting from a co-design process with public and private stakeholders (Külvik et al., 2021).

Nevertheless, the participation culture and policy definitions are still scarce. Matos and Serapioni (2017) analyzed existing mechanisms for public participation in health systems in the countries of Southern Europe (including Portugal) and found that it is still limited to legislation, with little expression in actual practices. Carvalho, Pinto-Coelho and Seixas (2019) proposed an analytical framework to analyze discursive practices involved in public consultation processes, and studied citizens influence in the 'public notice and comment'. The findings suggested that official authorities enacted citizens power and opinion. Citizen participation was, however, constricted in terms of access, standing and influence. In a survey to Portuguese individuals, Carreira et al. (2016) noted that most of the respondents have the idea that the government does not listen to people's opinions. Thus, they desire to see their opinion taken into consideration, a key request which relates directly their participation in decision-making.

In Portugal, citizen engagement is mostly focused on gathering citizens' views on policy proposals or by the choice (or weighing) between alternatives or policy options, including the right to veto through an open and fair process (Pepermans & Loots, 2013). For example, after the identification of the main goals and the strategic projects from decision-makers, Wolf et. al (2019) established a voting exercise was organized in each of the strategic plans, allowing the participants to establish the territories' planning priorities establish and rank the key projects for the medium term.

Overall, what we can say is that the specificities of the Portuguese context warrant a specific analysis of it, rather than a transfer of knowledge created in other countries. This is especial the case as the development of the various phases of the Smart City concept, which has been extensively analyzed in the literature, cannot be appropriately translated into the Portuguese context, which still lacks behind.

For the public to engage in the process it is necessary to focus on those who will look at the consultation process in an interested manner. Only this way will the process be granted civic legitimacy. Thus, it is necessary to find the relevant audience using different methods to guarantee their participation and constructed views.

Already two decades ago, authors such as Cooke and Kothari (2001) argued that it was not enough to involve citizens in the policymaking process. It is essential to ask who is being involved and in what way. They argued that most participatory development interventions did not empower individuals but rather use local people as tokens rather than provide any real change. This is not a critique to participation itself but rather to specific ways of involving citizens (Hickey & Mohan, 2004).

This discrepancy might be caused by a selection bias in the citizens that currently participate in participatory methodologies. The majority of citizens outline having never been asked to participate or give their opinion on the cities' problems. Therefore, this suggests that the focus should be on improving the understanding on methodologies used to engage with citizens. This is the aim of this paper.

10.3. Methodology

Based on the gap mentioned above, this study intends to use the Portuguese context to understand current participation in decision-making based on interviews with policymakers. It aims to find ways the best methods to engage with the community and related them with their citizen profile.

10.3.1. Method Design

Mixed-method research has been used in this paper, with two different data collection methods. First, interviews were conducted with Portuguese policymakers, with the aim of understanding how they perceive the participation of citizens in smart cities as well as the existing challenges. It should be noted, however, that the findings of this approach outline the policymakers' perspective. Many of the arguments they outline are opinions on how citizens relate to smart cities and their decision-making. It could be the case that these are biased and, rather than actual, are perceived challenges. This could be because of particular bias or faulty methodologies from their part. For example, policymakers might only have contact with certain groups that are not representative of the whole population or have biased views based on previous experiences and ideological commitments.

A second data collection was performed to ascertain whether there is evidence to support some of the assumptions made by policymakers. Based on an inductive analysis performed to the interviews' data, a questionnaire was developed and conducted with citizens to check some of the policymakers' views and ascertain how policymakers might engage in a participatory methodology, from a citizens' perspective. The questionnaire method was developed in a way to give a heterogeneous representation of society. Thus, a general and abroad audience was targeted. Figure 10.1, describes the several stages of the methodology, highlighting the people involved, the techniques used, and the expected results.

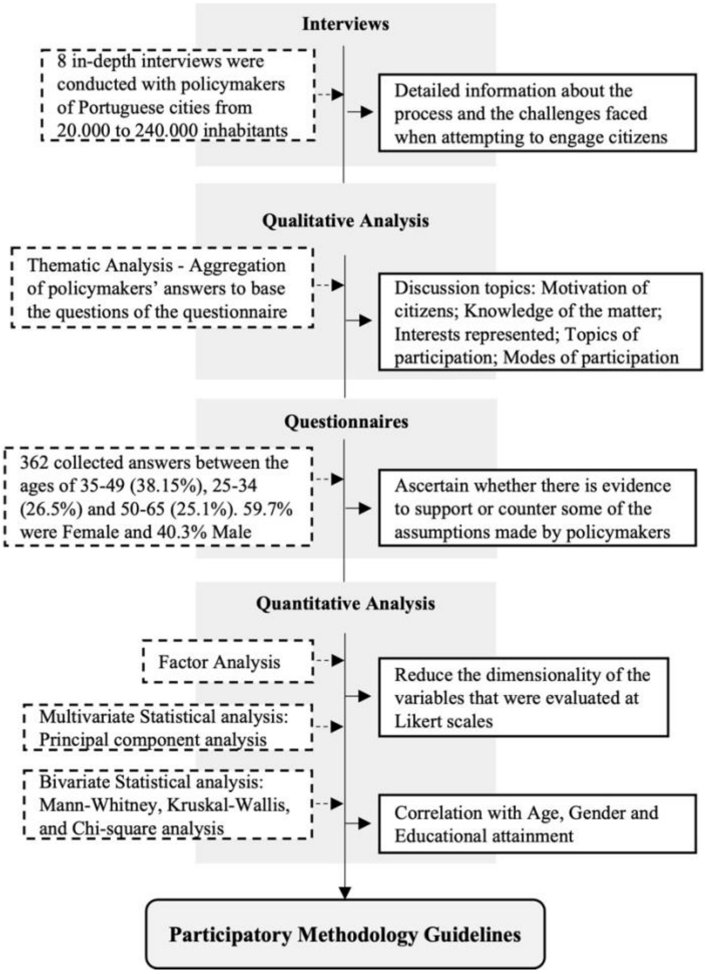


Figure 10:1 The framework of the research method

10.3.2. Data collection methods

The interviews were performed to get detailed information about the process and the challenges faced when engaging citizens. Moreover, the structure was divided into two parts. First, the aim was to understand policymakers' approach to the smart city concept, and second to perceive the involvement of citizens. Eight interviews were conducted in Portuguese via Zoom between January and February 2021. The data was collected through semi-structured interviews with Portuguese policymakers, in which the following primary research questions supported them to understand if they are considering citizens in policymaking and what are their views on it: *"How was defined your smart city strategy"; "Did you involve the citizens?"; "What are the challenges and principles that should guide citizens participation?"* (see in more detail, Appendix 10.1 the central questions of the interview).

Regarding the perspective of citizens, the data was collected based on a questionnaire. The questionnaire with closed questions was developed using Google Forms and spread through social media and other means between the 15th and 21st of July of 2021. Although the channel was social media, there was a careful control about the dispersion and randomness of the sample, which can be noted in the sample characterization. In total, there were 362 answers. The questionnaire questions were based on the inductive thematic analysis performed to the content of the interviews, using NVIVO software for codification. Thus, based on the findings of the interviews, the questionnaire aimed to get the citizens' opinions to corroborate or contradict policymakers' assumptions. Thus, based on citizens' perceptions, the questionnaire aimed to understand if policymakers usually involve citizens and if citizens are willing to participate, as well as to perceive in which ways and through which channels citizens would like to be involved in voicing their opinions (see, in more detail, Appendix 10.1 the questions of the questionnaire). The way questions were asked came mainly from existing conventional methods complemented by the digital communication channels used by citizens on their everyday lives.

In terms of ethics, all the data was anonymized. Participants were made aware of the purpose of data collection. All the necessary steps were taken following General Data Protection Regulation (GDPR). Therefore, no major ethical concerns are expected from this research.

10.3.3. Data Analysis

The interviews focused on an in-depth understanding of how policymakers consider citizens' role in smart cities' policymaking efforts. Moreover, the interviews were tape-recorded with policymakers' permission and transcribed. The resulting data was then thematically analyzed following an inductive approach. Accordingly, emerging topics (themes) were drawn, which formed the basis for the analysis. These topics also served as the basis for the questions addressed in the questionnaire, and the results were compared. The data analysis was inductive as the objective was to analyze the answers without bias from the literature and confront them with the following questionnaire. Therefore, it is not possible to draw hypothetical categories that could be used to guide the analysis. Moreover, in the context in which this research was developed, Portugal has even less research on this topic (as noted in the previous section). Therefore, it justifies using an inductive approach to avoid ignoring contextual differences.

As for the questionnaire data, a quantitative analysis was performed. Three dimensions were analyzed to ascertain if based on gender (two classes - nominal variable), age (five levels - ordinal variable), and educational attainment (five levels - ordinal variable) there were significant differences between respondents. Therefore, to analyze whether there were differences in the responses according to socio-economic characteristics, two types of analysis were performed: (i) first, a principal component analysis (PCA) to reduce the dimensionality of the numerical variables; (ii) second, bivariate non-parametric analysis (Mann-Whitney, Kruskal-Wallis and Chi-square). The last aimed to test the significance level between, on the one hand, the socio-economic conditions of the respondents (by gender, by age, and by educational level), and, on the other hand, the results from the PCA and the other categorical variables included in the questionnaire.

10.3.4. Sample Characterization

Concerning the qualitative approach, eight in-depth interviews were conducted with policymakers from different Portuguese cities. The Interviewees selection aimed to count with decision-makers of urban and rural areas with distinct backgrounds, roles, and expertise. This covered a range of cities from all the major regions of the Portuguese territory, with different characteristics; the smallest one with around 20 000 people and the largest one with around 240 000. After identifying the city, was contacted the most representative policymaker for the Smart Cities topic. Within the sample, there was not represented any Mayor, and only one female. Nevertheless, the roles of the Interviewees rotate from Vice-Mayor and Alderman. Thus, the characterization of the policymakers interviewed is stated in Table 10.1.

Table 10:1   Identification of the policymakers

Interviewee	Role	Gender	Area	Population	Location
1	Vice-Mayor	Male	Environment, Mobility and Tourism	45 000	South
2	Alderman	Male	Social Policy, Innovation and Tourism	20 000	Center
3	Vice-Mayor	Male	Innovation, Environment and Energy	240 000	North
4	Vice-Mayor	Female	Environment, Social and Energy	35 000	North
5	Alderman	Male	Mobility and Urban Planning	140 000	Center
6	Vice-Mayor	Male	Urban Plannning and Mobility	40 000	North
7	Vice-Mayor	Male	Urban Plannning, Innovation and Mobility	210 000	South
8	Alderman	Male	Mobility and Urban Planning	190 000	North

Regarding the quantitative approach, most answers came from people between the ages of 35-49 (38.15%), followed by 25-34 (26.5%) and 50-65 (25.1%). The age groups between 18 and 24 and 65+ composed less than 6% of responders each. The female gender represented

59.7% of the answers and the male gender with 40.3%. The distribution of responses as well as the gender of respondents can be seen in Figure 10.2. Out of 308 municipalities in Portugal, data was collected from residents of 84 of them. In addition, 42.3% of the respondents have a bachelorette, 25.1% a 12th grade, and 20.4% have a master's degree.

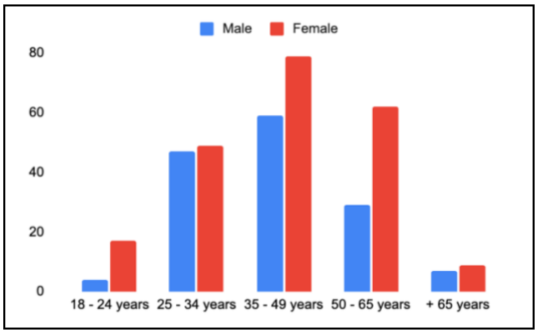


Figure 10:2 Number of questionnaire respondents per age group and gender

10.4. Results and Discussion

Inductive thematic analysis was performed on the transcribed data from policymakers' interviews. Based on the questions and context of the interviews it was possible to find patterns within the responses and acknowledge the existing challenges of citizens' participation, understand if for policymakers it is important to include them, if they have been including them and how.

Thus, the results, and consequently the discussion, were aggregated on the following five major challenges for public participation: i) motivation of citizens, ii) knowledge of the matter, iii) interests represented, iv) topics of participation and v) modes of participation. These specific topics are discussed in this section. For each theme, the vision of the decision-makers (collected through the interviews) and the vision of the citizens (collected through the questionnaires) is compared. For the questionnaire, only significant statistics were embedded within the text to help to explain the results. Moreover, the information about their significance level is present in Appendix 10.3.

10.4.1. Motivation of citizens

Interviewees mentioned that the first challenge to participation was the lack of motivation of citizens. In all interviews, it was mentioned that Portuguese citizens are not used to participating in the design and implementation of policies, reinforcing the lack of a culture of participation argument. It was argued that citizens are not motivated to participate, as they only get involved in electoral campaigns (and even on these, the abstention level is high).

After that, there is very little, if any, engagement (Interviewee 6). Additionally, it is challenging to mobilize the population (Interviewee 1) due to a fear of being judged for what they are saying (Interviewee 7).

Some Interviewees mentioned that there is some participation, but only when it comes to election campaigns and participatory budgets. However, these are a type of reactive participation, in other words, that does not result from citizens' motivation but rather from external pressure to participate.

It was broadly agreed by all Interviewees that there would be benefits to involve more citizens. Interviewee 1 said, for example, that it is essential that "opinion studies are made to increase commitment and collect citizen's contributions".

The evidence from the questionnaire does not support this perceived challenge from policymakers. First, it should be noted that 90.1% of respondents said that they had never been contacted by local authorities to give their opinion on problems in their city. In addition, the ones that responded they had been contacted were mainly for ad hoc matters related to local street works and waste collection. Nevertheless, it was noted that the higher the educational attainment, the higher the number of times a respondent has participated in the process of defining a public policy (Appendix 10.3). Furthermore, no significant difference was found in terms of the availability of respondents or their preference to participate monthly based on gender, age, or educational attainment. They all showed willingness to participate. In addition, the principal component analysis (PCA) aggregated in one component the citizens, the companies, the knowledge centers, the executives, and the city hall's employees, leaving out in another component the political parties (see more in Appendix 10.2 - A). Thus, from a citizens' perspective, political parties should not be involved in city public policies, probably because they are biased by their political interests and support a rigid perspective that is not aligned with the local context needs.

Furthermore, when asked whether they would like to participate in the decision-making process of their city to help solve problems it faced, 34.8% gave the highest value of motivation to participate (5 out of 5). Another 32.5% gave the second-highest value (4 out of 5). Nevertheless, youngers of 18 to 24 years old lacked the motivation to participate in the definition of a city's public policy (as presented in Appendix 10.2).

When asked about the reasons for their lack of involvement, 61.8% said that they had never been asked to participate. A further 25.1% said their opinion was not significant, and 15.9% said they lacked the time and motivation to participate. Other less common options included lack of appropriate and user-friendly channels to participate; not believing in the political system; not knowing how to participate; having already written to the city hall and receiving no feedback; lack of interest from the city hall on the opinion of citizens; and not having the knowledge to contribute.

10.4.2. Knowledge of the matter

The Interviewees mentioned the lack of knowledge from citizens as a challenge to participation, stating that when it comes to digitalization, citizens misunderstand it as the city's presence on the web and social media (Interviewee 6). They also state they have not received proposals that target digitalization and smart city-related initiatives in their participatory budget processes. Moreover, they stress that it is challenging to get constructive feedback and knowledge to design a long-term strategy for the city (Interviewee 2).

Some Interviewees, therefore, mention the need to promote qualified participation. They contrast this with what often happens in social media, where too much noise does not allow a constructive use of citizens' opinions (Interviewee 8).

The evidence from the questionnaire somewhat supports these arguments. When asked whether they are familiar with the term "smart city", only 15.9% said they knew what it was, 44.3% said that they thought what it meant. A further 17.8% and 22.0% said that they had heard it but did not know what it meant or that they had not heard it and did not know what it meant. Furthermore, 15.0% said that they did not think they knew enough to give their opinion on smart cities, and 61.8% said that they would need a short talk to give their opinion. Only 23.1% said that they already had the necessary information to give their opinion on smart cities. As per as the familiarity with the concept and willingness to express their opinion regarding smart cities, it decreases with the decrease of educational attainment (see Appendix 10.3). In addition, men are more assertive and confident about their knowledge of the topic.

Furthermore, the PCA intended to study the respondents' understanding of a smart city (see more information in Appendix 10.2 - B). The four answers (technology, sustainability, quality of life, and citizens participation) are represented by the same component, which means that respondents associated smart cities with all these dimensions. This can be explained by the fact that most respondents are not familiarized with the concept of smart cities (and their respective stages) since 68.0% never heard the term associated with their city.

Nevertheless, the most highly associated terms with smart cities were *sustainability* and *technology* followed by *quality of life* and, to a lesser extent, *citizens' involvement*. Thus, it suggests that Portuguese cities, from citizens' perspective, are not in the third phase of the smart city concept.

10.4.3. Interests represented

Another significant challenge for citizens' involvement is the interests they see themselves as representing. Various Interviewees mentioned that when citizens are involved in decision-making, they tend to give opinions based on individual interests rather than for a broader common good.

Moreover, people are not used to being asked for their opinion so that, when they are, their concern is their interest (Interviewee 2). It is argued that citizens have a very individual perspective and do not think about broader goals, misunderstanding personal interests for them (Interviewees 3 and 5).

Thus, a further challenge outlined was the fact that citizens primarily represent their individual interests. Regarding the citizen's perspective, when asked, 90.0% said they would like to give their opinion on how the city could be improved for all the population. Around 32.0% said they would like to give their opinion on how the city could be improved for their family, 22.0% for their professional group and only 23.7% for themselves. Youngers from 18 to 24 years old are neutral about giving their professional group opinions (see Appendix 10.3). This willingness increases with age and literacy.

On the other hand, citizens were asked if the elected mayors represented their interests. 74.3% of the respondents usually voted on the city council elections. The majority was neutral about the fact that policymakers sought to solve the problems they cared.

10.4.4. Topics of participation

Interviewees stressed another challenge to participation that had to do with the topics that citizens engage. The involvement is mainly from young people concerned about climate change, and landowners worried about land management policies (Interviewee 6). In addition, it was said that thinking over the city's future is not a necessity for citizens. Therefore, they do not get deeply involved.

According to the citizens' view, collected by questionnaire, the results do not support the findings of the interviews. Moreover, 62.7% of responders said they would want to give their opinion on next months' projects, 42.6% on day-to-day problems of the city, and 58.5% would like to contribute to long-term strategies. Younger people tend to prefer giving their opinion about projects that will take place in the next few months, a tendency that decreases with age (see Appendix 10.3). In contrast, the higher the literacy, the higher the preference for giving their opinion about any strategic vision, which men also prefer.

Regarding the topics that citizens would like to give their opinions on, there is great variety: mobility and transports, 65.7%; environment, 65.5%; infrastructures and housing, 60.4%; health, 56.8%; education, 56.8%; between others. This is also corroborated by the data present in Appendix 10.3.

10.4.5. Modes of participation

A final challenge to participation mentioned by Interviewees has to do with the modes of participation. The Interviewees mention that the way they have attempted to engage citizens is not suitable.

The primary mode of participation for those that engage in such efforts is participatory budget programs. In these, citizens put forward ideas that they think should receive funding from the local authority. Unfortunately, this mode of participation is manipulated by the interests of specific groups for local infrastructures instead of something that would address the common good or a strategic vision for the future (Interviewee 2). In addition, the information collected from these efforts often has very little use (Interviewee 4).

Other modes of participation are used, such as public debates, questionnaires, email suggestions, phone apps, though to a lesser extent. Interviewees admit the need to include citizens in an earlier decision-making stage, to analyze advantages and disadvantages, and post-implementation to analyze their satisfaction with the solutions implemented (Interviewee 5).

The outputs of the PCA allowed to aggregate in three groups the methods (as presented in Appendix 10.2 - C): via phone (phone call, voice message, phone interview, text message), personal contact (focus group, auditorium discussion, and face to face interview), or online interaction (online questionnaire, interview). Women, on average, have a lower preference for personal contact methods than men, as the online methods.

Furthermore, in terms of the mode of participation, only 39.3% would like to anonymize their opinions. The remaining wanted to give their identification. In the case of people in the retirement age (over 65 years old), they prefer to be identified at a much higher rate than those between 25 and 34 years old (see Appendix 10.3). In addition, most men prefer to be identified (70.5%), while only half of the women (54.6%).

Concerning the favorite channel, Cortés-Cediel, Cantador and Bolívar (2021) found that ad hoc e-participation platforms are the generically the most preferred tools. Within the personalization approach aimed by this research, two components emerged (see Appendix 10.2 - D): through a platform of the municipality (from on the municipality's website, chat on the municipality website and municipality mobile application) or through a personal channel (WhatsApp, Messenger, or phone). Furthermore, the most preferred ways to give their opinions are email and online questionnaires. On the contrary, the least preferred are voice and text messages, phone calls, and questionnaires done at their door. Older people tend to prefer fewer personal channels. In contrast, are young people between the ages of 25 and 34. In addition, women prefer municipality channels (see Appendix 10.3).

Also, 67.1% of the respondents would like to give their opinion once a month. On the other hand, 18.7% would like to do it once a week, the remaining either once a year or never.

When asked about the information flow, there is no clear answer. It is almost equally divided between the three hypotheses. Around a third said citizens should give their opinions directly; another third said they should be channeled through associations that defend collective interests. The last third said that it should be the elected representatives of the citizens that should represent their interests. The heterogeneity of responses is also noted in Appendix 10.3.

Furthermore, in terms of transmission of opinion, the 9th graders prefer a representative who communicates the opinion of citizens. Higher levels of educational attainment are associated with a neutral position with a tendency for citizens. Finally, doctorates prefer that opinions are communicated via organizations and dedicated movements.

10.4.6. Research Findings and Final remarks

In summary, five main challenges have been identified, considering the main results that emerged from the data collected, where the perspectives of decision-makers and citizens are confronted and compared:

1. Policymakers pointed out citizens' lack of motivation to participate, which was not corroborated by citizens.
2. A lack of knowledge on the part of citizens to actively participate in smart city strategies was outlined by policymakers, and citizens also corroborated this.
3. Policymakers point out that when citizens participate, they often represent their interests rather than the collective interest. On this matter, citizens' opinions contradict policymakers' views.
4. Policymakers stated that citizens focus only on a few topics and neglect the holistic vision of smart cities. The variety of subjects and the will to participate in short and medium-term goals outlined by citizens does not support this.
5. The Interviewees stressed that the current modes of participation are not adequate, which citizens disagreed.

Table 10.2 summarizes the results. The findings serve as the base for the further discussion of the following section about the methodology aspects that may be considered for each specific group based on the significance of the variables.

Table 10:2 Research findings from the comparison of Citizens and Policymakers' views

Topic	Policymakers	Citizens	Findings
Motivation of citizens	- Citizens are not used or motivated to participate in the design of policies. - Lacks a participation culture.	- 90.1% of respondents said that they had never been contacted by local authorities to give their opinion. - 34.8% gave the highest value of motivation to participate, and another 32.5% gave the second-highest value. - 61.8% referred to their lack of involvement because they were never asked to participate	Citizens do not support Policymakers' argument
Knowledge of the matter	- Citizens misunderstand digitalization and have no opinion about smart cities. - Lack of qualified participation. - Lack of proposals on the subject and constructive participation for long-term strategies.	- Only 15.9% said that they precisely knew the meaning of the "smart city" concept. - Only 23.1% said they already have the necessary information to give their opinion on smart cities. - 68.0% of the respondents never heard the smart city term associated with their city.	Citizens support Policymakers' argument
Interests represented	- Citizens tend to give opinions based on their interests rather than on a common good (broader goals).	- 90.0% said that they would like to give their opinion on how the city could be improved for all the population.	Citizens do not support Policymakers' argument
Topics of Participation	- City's future is not a concern for citizens. - Only young people care about climate change and landowners about land management policies.	- 62.7% would want to give their opinion on projects that the city could develop in the next few months. - There is a great variety of topics that citizens would like to give their opinions (65.7%; environment, 65.5%; infrastructures and housing, 60.4%; health, 56.8%; education, 56.8%; between others).	Citizens do not support Policymakers' argument
Modes of participation	- Attempts to engage citizens did not work. - Participatory budget programs do not work. - Participatory processes are manipulated by the interests of certain groups. - Public debates, questionnaires, email suggestions, phone apps are also used to a lesser extent.	- Only 39.3% of the respondents would like to give their opinion anonymously. - The most preferred ways to give their opinions are email and online questionnaires. - 67.1% would like to give their opinion once a month.	Citizens do not support Policymakers' argument

These findings outline assumptions that policymakers can rely on to set their future work agenda. First, citizens have been misled by policymakers since they are willing to participate. Policymakers may work on the ways to involve and try to get the most of every one's voices. Since both agree on the existing lack of knowledge and context about Smart Cities and long-term strategies, it is necessary to define actions to increase their awareness about existing solutions and projects, and the vision of the municipality to the territory for greater involvement and scrutiny of the population. The qualification of participation is ultimately connected with education, training, and sharing of information to the community, which is usually the responsibility of city governments. In terms of the topics to participate, although the feeling of policymakers is that only specific groups of citizens are concerned about specific subjects, it is necessary to understand the reasons behind this fact. Based on the citizens results for this matter, policymakers should understand the level of citizens' confidence to give their opinion about specific subjects and ask is only based on this citizen profile and for concrete questions. The quality of data collections and structure will certainly improve the output, increase the interest of the population to participate since they may recognize that their opinion counts. Regarding the modes of participation, Interviewees admitted including citizens in the early stage of decision-making process. Thus, although they have not succeeded in collecting and implementing citizens' feedback, the questionnaire results helped to identify the preferred ways (of general and existing methods) and timings to ask their opinions, which is dependent on specific citizens' groups.

10.5. Guidelines and Final Remarks

Different strategies and methodologies can be applied by policymakers to increase the level of citizens' participation. Of the various findings based on different socio-economic caracteristics of individuals (whose significance is reflected in Appendix 10.3), from the quantitative data analysis, the following aspects should be considered by policymakers.

When it comes to gender, women tend to outline less knowledge of what a smart city is and lack more information to give their opinion. Moreover, women are less likely than men to want to be identified when giving their opinion. They also outline a greater preference than men for online methods of participation and channels through the municipality. Men prefer face-to-face methods and personal channels of communication. The topics in which respondents want to contribute also varies across gender, with women preferring, for example, health and men, infrastructure, and housing.

When it comes to age, people generally tend to prefer being identified, nevertheless, those between 25-34 prefer anonymity. Older people tend to prefer fewer personal channels; the opposite is the case for young people. Young people tend to prefer giving their opinion about strategic vision and projects that will take place in the next few months, something that decreases with age. The topics that people would like to give their opinion on also vary across age.

The higher the educational attainment, the higher the familiarity with the term smart cities and the feeling that they have the necessary knowledge to contribute. The higher the literacy, the higher the preference to give opinions about a long-term strategic vision for the city and the lower their preference for personal channels of engagement. Preferences for specific topics also change based on education. For example, people with 12th grade, bachelorette, or a master's degree prefer to give their opinion about the environment. Regardless the literacy, no group wants to give their opinion about digitization/technology or energy.

Finally, the higher the educational attainment, the more times a respondent has participated in defining a public policy.

Table 10.3 summarizes the information of the significant results (only) of the different groups in terms of the engagement findings.

Table 10:3 Summary of the research findings of the quantitative analysis in terms of engagement

Group	Identification	Subjects	Topics	Methods	Channels
Male	Yes	Long-term objectives (5 or more years)	Infrastructure and Housing; No Culture	Online	Municipality
Female	-	-	Health; No Energy, No Digitization/Technology	Face-to-Face	Personal
18 – 24 years	Yes	Projects for next months and Long-term objectives (5 or more years)	-	-	Personal
25 – 34 years	No	Projects for next months and Long-term objectives (5 or more years)	-	-	Personal
35 – 49 years	Yes	Next months projects	No Technology and Digitization; No Economy/Commerce	-	Personal
50 – 65 years	Yes	Next months projects	No Technology and Digitization; No Economy/Commerce; No Education	-	Municipality
+ 65 years	Yes	No projects for the next months	No Technology and Digitization; No Economy/Commerce	-	Municipality
9th grade	-	No projects for the next months and long-term objectives	No community; No education; No Technology and Digitization; No energy	-	Personal
12th grade	-	No long-term objectives	Environment; Mobility; No Technology and Digitization; No energy	-	Municipality
Bachelorette	-	Projects for next months and Long-term objectives (5 or more years)	Environment, Mobility; Community; Education; No Technology and Digitization; No energy	Online	Municipality
Masters	-	Projects for next months and Long-term objectives (5 or more years)	Environment; Mobility; Education; No Technology and Digitization; No energy	Online	Municipality
PhD	-	Projects for next months and Long-term objectives (5 or more years)	Mobility; Education; No Technology and Digitization; No energy	Online	Municipality

Table 10.3 gives (Portuguese) policymakers significant data about their population and the preferred ways the specific groups would like to be engaged considering their i) identification, ii) subjects, iii) topics, iv) methods and v) channels.

Previous research stated the lack of existence of legislation and seriousness on the consideration of citizens' opinion. Thus, it is important for policymakers to define processes based on what they want to obtain from citizens. Furthermore, it is vital to make sure they have the knowledge to participate in the consultation process, for example, by taking part on a brief questionnaire to ensure that they are aware of its content and therefore, their vote or opinion is substantiated.

In summary, the findings suggest that policymakers need to have open methodologies in the sense that they allow for participation in different ways. The engagement will increase when there are an omnichannel, where citizens regardless of their socioeconomics have a comfortable way to participate and, in the end, their opinions are integrated and analyzed. Otherwise, they risk leaving out certain groups of the population and biasing their data. If this is not possible, careful attention should be paid to the groups with lower preferences for the deployed methods to ensure their appropriate participation.

10.6. Conclusions, implications, and future work

This paper has explored two main aspects. First, whether the barriers outlined by policymakers in terms of citizens' involvement in smart cities policymaking are perceived or actual existing barriers; second, it explored how policymakers can engage in these efforts.

In conclusion, the citizens responses suggest that the barriers outlined by policymakers' interviews are either not supported by evidence, or there are ways of addressing them that do not impede citizens participation in smart cities' policymaking (e.g., via short talks to citizens before they give their views). This discrepancy might be caused by a selection bias in the citizens that currently participate in participatory methodologies. The majority of citizens outline having never been asked to participate or give their opinion on the cities' problems. In addition, they point out that their opinions do not count for policymakers. These results corroborate previous literature findings. Therefore, this suggests that the focus should be on improving the methodologies used to engage with citizens.

This research has detailed how the general population and specific groups, such as women or the elderly, see their participation in smart cities' policymaking and how they wish to engage.

The main conclusion out of this data is that there is significant heterogeneity. Therefore, evidence suggests that policymakers should tailor their participatory methodologies to different groups and be careful about how their methodologies might leave out parts of the population. For example, there was a significant difference between men's and women's willingness to participate anonymously or not. Therefore, to be inclusive, both options should be provided. Otherwise, the policymakers risk excluding one of the groups.

Therefore, as a summary of the contribution, this paper enunciates several guidelines to promote citizens' involvement, which should be considered for future development studies and methodologies' proposals. First, women and people between the ages of 25-34 are less likely than men to want to be identified when giving their opinion. Second, women outline a greater preference than men for online methods of participation and channels through the municipality and prefer health. Third, young people prefer giving their opinion about the strategic vision and projects that will take place in the following months (something that decreases with age). In addition, the higher the literacy, the higher the preference to give opinions about a long-term strategic vision for the city and lower the preference for personal channels of engagement.

This should lead to a change in future developments, moving from the focus on creating optimal tools for cities' design (recurring to niche and specific stakeholders) to studying what democratic participation methods work best for different groups. Making sure that whatever tools are being used, they do not by design leave out certain target groups.

In terms of limitations, this paper only analyzed a small subset of the population. Thus, it is proposed to extend this study to a larger sample in the future so that the results can be generalized. Overall, and despite this limitation, the study provides important information for anyone analyzing citizen engagement methods and smart cities' policymaking in a Portuguese context.

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Appendix 10.1 - Main questions of the interviews and the questionnaire

Method	Question
1. Interview	Q1.1. Is there a smart city strategy in your city? How was it developed? Q1.2. What were the main challenges? Q1.3. Do you agree that citizens should be involved? Why? Q1.4. Ideally, how and when should citizens be involved? Q1.5. What are the barriers/challenges to citizen participation? Q1.6. What principles should guide citizens' participation? Q1.7 What is missing to facilitate participation in decision-making?
2. Questionnaire	Q2.1. Have you ever been contacted by the City Council to give your opinion? *[Never, Few Times, Some Times, A Lot of Times]* Q2.2. Have you ever participated in a public policy decision-making process? *[Never, Few Times, Some Times, A Lot of Times]* Q2.3. Would you like to participate in the decision-making process? *[1 - Would not like, 5 – Would like a lot]* Q2.4. What is the reason why you are not involved? *[No time, Lack of Motivation, My opinion is not important, My opinion was never asked, Other]* Q2.5. In your opinion, how involved do you feel that the following actors should have in defining a public policy? *[Chamber Executive, Chamber Technicians, Citizens, Enterprises, Knowledge Centers and Political Parties]* Q2.6. Do you usually vote in local elections? *[1 – Never, 5 - Always]* Q2.7. Did the elected mayors (and their city executives) seek to resolve the problems you cared about? *[1 – Never, 5 - Always]* Q2.8. By electing a mayor, do you think your interests are represented? *[1 – Never, 5 - Always]* Q2.9. By not electing the mayor you wanted, do you feel the need for more active participation? *[1 – Never, 5 - Always]* Q2.10. In your opinion, how important is citizens' opinion to the City Council? *[1 – Not important, 5 – Extremely important]* Q2.11. Are you familiar with the term "smart city"? *[Never heard, I have heard but do not know its meaning, I think I know what means, I know what it means]* Q2.12. What do you associate with the term "smart city"? *[Technology, Sustainability, Quality of Life, Citizen Participation]* Q2.13. When it comes to "smart cities", you consider that: *[Have enough information to have an opinion, Need more information to have an opinion, Do not have know-how to give your opinion]* Q2.14. Have you ever heard the term "smart city" be associated with your municipality? *[1 – Never, 5 – Always. By whom? [City council, City technicians, Community, Other]* Q2.15. From the following list, choose the options you would most like to give your opinion on: *[How the city could be better for me, How the city could be better for my family, How the city could be better for your professional group, How the city could be better for the community, Would not like to give my opinion]* Q2.16. If you had to give your opinion on any matter involving your municipality, how would you like to do it? *[Anonymously, With personal identification]* Q2.17. If you had to participate with your opinion, what means would you like to use? *[Email, Phone Call, Text message, Voice message, Telephone interview, Face-to-face interview, Online questionnaire, Questionnaire at the door of the house, Group discussion (6 - 10 people), Debate in auditorium]* Q2.18. If you had to participate with your opinion, which channel would you like to use? *[Phone, WhatsApp, Messenger, Mobile application of the municipality, Chat on the website of the municipality, Form on the website of the municipality]* Q2.19. How would you like to be involved? *[Once a year, Once a month, Once a week, Never]* Q2.20. In your opinion, how should the opinion of the citizen be transmitted to the City Council? *[The citizen directly, An elected representative by the citizens, Through associations and specific initiatives]* Q2.21. On which of the following subjects would you like to give your opinion? *[Daily problems, Next months projects, Long-term goals, Nothing]* Q2.22. On which of the following areas would you like to give your opinion? *[Energy, Environment, Infrastructures and housing, Mobility and transports, Health, Digitization and Technology, Economy and local commerce, Education, Safety and security, Community, Culture, Other]*

Appendix 10.2 – Results of the Principal Component Analysis

A) Citizens' opinion about the actors that should be involved in defining a public policy (Q2.5).

	Component		
	1	2	Factors' Name
Citizens	0,88		Inclusion
Companies	0,87		
Knowledge Centres (e.g. Universities)	0,83		
Town hall executive	0,75		
Town hall technicians	0,75		
Political parties		0,95	Exclusion
Total Variance Explained	**56,1%**	**22.7 %**	

Extraction Method: Principal Component Analysis/ Rotation Method: Varimax with Kaiser Normalization/ Rotation converged in 3 iterations.

B) Citizens' opinion about the terms they associate to Smart Cities (Q2.12).

	Component
	1
Quality of Life	0,95
Sustainability	0,95
Technology	0,89
Citizen Participation	0,85
Total Variance Explained	**82,9%**

Extraction Method: Principal Component Analysis

C) Citizens' opinion about their preferred channels of engagement (Q2.17).

	Component			
	1	2	3	Factors' Name
Phone call	0,79			Via Phone Methods
Voice Message	0,77			
Phone interview	0,74			
Text message	0,62			
Door-to-door questionnaire	0,54			
Focus Group (6 - 10 people)		0,87		Face-to-Face Methods
Auditorium discussion		0,86		
Face-to-face interview		0,66		
Online questionnaire			0,83	Online Methods
Email			0,83	
Total Variance Explained	**35.8%**	**17.9%**	**11.4%**	

Extraction Method: Principal Component Analysis/ Rotation Method: Varimax with Kaiser Normalization/ Rotation converged in 7 iterations.

D) Citizens' opinion about their preferred means of engagement (Q2.18).

	Component		
	1	2	Factors' Name
Form on the municipality's website	0,88		Municipality Channels
Chat on municipality website	0,87		
Municipality mobile application	0,83		
Whatsapp		0,89	Personal Channels
Messenger		0,82	
Phone		0,78	
Total Variance Explained	**47,7%**	**22.2 %**	

Extraction Method: Principal Component Analysis/ Rotation Method: Varimax with Kaiser Normalization/ Rotation converged in 3 iterations.

Appendix 10.3 – Disaggregated results on gender, age, and educational attainment

	Variable*	Findings	Test	Level of significance
Motivation of Citizens	Age	Lack of the participation of young people of 18-24 in the process of defining a public policy of the city.	Chi-Square	(p-value=0.019)
	Educational attainment	The higher the educational attainment, the higher the number of times a respondent has participated in defining a public policy.	Chi-Square	(p-value=0.031)
Knowledge of the Matter	Educational attainment	The familiarity with the Smart City concept decreases with the decrease in educational attainment. A residual percentage (3.2%) of respondents with up to the 9th grade know the meaning of the term Smart Cities. The same happens with being comfortable enough to give their opinion.	Kruskal-Wallis	(p-value=0.000)
	Gender	24.7% of men know exactly what the Smart City concept mean. Women only 9.7%.	Chi-Square	(p-value=0.002)
		30.1% of men consider that they have the knowledge to have an opinion on Smart Cities. Only 18.5% of women consider the same.	Chi-Square	(p-value=0.029)
Interests Represented	Age	Young people between 18-24 are neutral about giving their opinion on their professional group. The willingness increases with age.	Chi-Square	(p-value=0.000)
	Educational attainment	The willingness to give such an opinion on their professional group increases with the literacy.	Chi-Square	(p-value=0.000)
Topics of Participation	Age	Younger people tend to prefer giving their opinion about projects that will take place in the next few months contrary to people over 65 years. Youngers from 18 to 34 years prefer strategic projects.	Chi-Square	(p-value=0.001) (p-value=0.000)
		Technology/digitalization is not preferred by elders nor economy and commerce. 25-34 years prefer the topics of economy and commerce. 50 – 64 years people do not prefer education.	Chi-Square	(p-value=0.001) (p-value=0.044) (p-value=0.024)
		The group age from 50 to 64 years old does not prefer education.	Chi-Square	(p-value=0.024)
	Educational attainment	The higher the literacy the higher the preference for giving their opinion about any strategic vision. 9th and 12th graders do not prefer.	Chi-Square	(p-value=0.000)
		9th graders do not prefer giving their opinion about next months' projects.	Chi-Square	(p-value = 0,034)
		People with the 12th grade, bachelorette, or a master prefer to give their opinion about the environment.	Chi-Square	(p-value=0.034)
		Regardless the literacy, people do not want to give their opinion about Technology/Digitization or Energy;	Chi-Square	(p-value=0.070) (p-value=0.059)
		9th graders do not want to give their opinion on education contrary to people over the bachelor's degree, and community contrary to bachelor's. The remaining want to give their opinion about mobility.	Chi-Square	(p-value=0.003) (p-value=0.000) (p-value=0.065)
	Gender	Men tend to have a higher preference for the strategy and long-term objectives (5 or more years).	Chi-Square	(p-value=0.001)
		Male prefer infrastructure and do not prefer culture	Chi-Square	(p-value=0.017) (p-value=0.036)
		Females prefer health and do not significantly choose energy or digitization/technology or economy and commerce.	Chi-Square	(p-value=0.000) (p-value=0.039) (p-value=0.000)
Modes of Participation	Age	People in retirement age (over 65 years old) prefer being identified at a much higher rate than, for example, those between 25-34 who prefer anonymity.	Chi-Square	(p-value=0.002)
		Older people, after 50 years, tend to prefer fewer personal channels and more municipality channels. The opposite for young people between the ages of 18 and 49.	Kruskal-Wallis	(p-value=0.093)
	Educational attainment	9th graders prefer a representative who communicates the opinion of citizens. Medium levels of educational attainment are associated with a neutral position with a tendency for citizens. Doctorates prefer that opinions are communicated via organizations and dedicated movements.	Chi-Square	(p-value=0.000)
		The lower the educational attainment, the higher the preference for Personal channels.	Kruskal-Wallis	(p-value=0.000)
		The higher the literacy, the higher the preference for online methods.	Kruskal-Wallis	(p-value=0.000)
	Gender	70.5% of men prefer to be identified when participating. The women only 54.6%.	Chi-Square	(p-value=0.002)
		Men have higher preference for face-to-face methods. Females prefer online methods.	Mann-Whitney	(p-value=0.016) (p-value=0.076)
		Women prefer municipality's channels. Men prefer personal channels.	Mann-Whitney	(p-value=0.099)

* Although some of the variables are ordinal, they were considered in this analysis as nominal to evaluate differences between groups (as the age groups, and qualification level).

Part IV

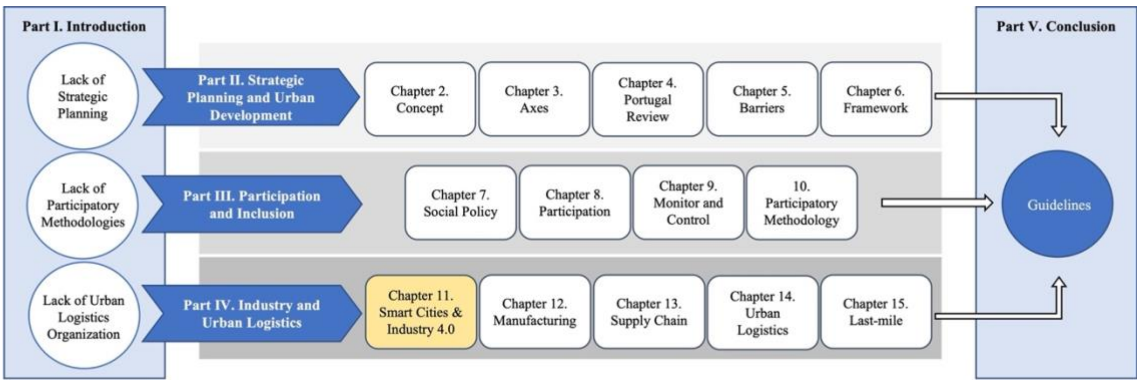
Industry and Urban Logistics

Chapter 11

Study and analysis of the relationship between Smart Cities and Industry 4.0: A systematic literature review

Reference

Correia, D., Teixeira, L., & Marques, J. (2021). Study and analysis of the relationship between Smart Cities and Industry 4.0: A systematic literature review. *Technology Management & Sustainable Development.*



11. Study and analysis of the relationship between Smart Cities and Industry 4.0: A systematic literature review

Abstract

Smart Cities evolved to include citizens as co-creators. Industry 4.0 enhances personalized supply chain models arranged according to citizens' wishes. The interconnection of the concepts is most likely to change transport and manufacturing processes, enhancing social development, and promoting sustainability. However, it lacks in the literature a clear understanding of their influence on each other and related connection points.

This paper develops a rigorous systematic literature review to make an in-depth analysis of the relationship between Smart Cities and the Industry 4.0. Quantitative and qualitative analyses are performed.

The connection points found are Technology, Process, People, and Planning. Their relationship is almost unanimous. Smart Cities are influenced by Industry 4.0. The evidence of the Smart City influence in Industry 4.0 does not exist separately from the Industry 4.0 on Smart Cities. Although several authors smoothly refer to the influence that Smart Cities may have in the Industry it lacks a greater understanding.

Furthermore, this study advocates the need to understand how the new Smart City paradigm of promoting collaborative planning and design methodologies will impact the development of the Industry. Social sciences literature might have a significant role in future work.

Keywords: Smart City, Industry 4.0, Systematic Literature Review, Urban Planning, Internet of Things, Artificial Intelligence, Social Sciences.

11.1. Introduction

Smart Cities and Industry 4.0 have been mostly associated with technological developments. Internet of Things (IoT) enhanced the connectivity between devices and brought cities the possibility of looking at urban furniture and turning static elements into active agents of data collection and monitoring, allowing the city to obtain real-time data to substantiate its decisions. It has allowed cities to build control centers where data is analyzed and allow instantaneous actions (Townsend, 2000). The functioning and regulation of the city are managed by city governments who base their decision on real time-analytics and predictive models built from data aggregation (Kitchin, 2014). User-oriented access and sensor devices are increasingly present in cities or industries (Baccarelli, Naranjo, Scarpiniti, Shojafar, & Abawajy, 2017). Moreover, IoT is leading the emergence of Smart Cities and Industry 4.0, increasing connected objects (Sapienza et al., 2016).

Smart Cities emerged in the 1990s to answer the challenges of urbanization and globalization. However, the Smart City concept is still ambiguous and lacks proper understanding (Batty et al., 2012; Bibri & Krogstie, 2017; Hollands, 2008; Nam & Pardo, 2011; Venkat Reddy, Siva Krishna, & Ravi Kumar, 2017). From a technical understanding led by private companies (Mora, Bolici, & Deakin, 2017), where Information and Communication Technologies (ICTs) were seen as the end and not the mean (Ahvenniemi, Huovila, Pinto-Seppä, & Airaksinen, 2017), it started to strive for human and social capital (Caragliu, del Bo, & Nijkamp, 2009). Therefore, the Smart city concept has evolved and is already in its third stage, also known as Smart City 3.0, where is noted a co-creation paradigm, based on citizens' engagement and active participation (Albino, Berardi, & Dangelico, 2015; Cohen, 2015). Moreover, the Smart City axes can be summarized to innovation, quality of life, and sustainability (Correia, Teixeira, & Marques, 2020).

On the other hand, the decreasing of raw material supply, rising energy prices, rapid market changes, and product personalization made companies upgrade their processes and integrate technologies to automatize and exchange real-time manufacturing data (Lin, Lee, Lau, & Yang, 2017; Nick, Pongrácz, & Radács, 2018). The incorporation of the Internet of Things, Cloud Technology, and Big Data into the production created Industry 4.0. The nomenclature was for the first time introduced in 2011 at the Hannover Fair on behalf of an initiative to increase the competitiveness of Germany in the manufacturing industry (Kagermann, Wahlster, & Helbig, 2013). Despite its complexity, Industry 4.0 can be defined by the integration of technologies to adapt value chain processes based on real-time data acquisition and transmission to flexibly provide personalized services and products (Dinardo, Fabbiano, & Vacca, 2018; Hermann, Pentek, & Otto, 2016; Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, & Barbaray, 2018; Pisching, Junqueira, Filho, & Miyagi, 2016; Schumacher, Erol, & Sihn, 2016; Trappey, Trappey, Hareesh Govindarajan, Chuang, & Sun, 2017).

Past authors have focused on individual characteristics of Smart Cities and Industry 4.0 (U. Singh & Sharad, 2020). Although, they have approximate backgrounds and challenges, it lacks in the literature a study that crosses both concepts to comprehend their relationship further.

Therefore, this paper aims to perform a systematic literature review to understand their connection points and the existing interrelationship, uncovering joint literature.

The article is structured as follows: firstly, it is described the literature review methodology and the search results. Secondly, is employed a quantitative analysis to explore the results and a thematic analysis of the preliminary data to find the correspondent themes of the relevant body of literature. Finally, the authors highlight the findings and discuss the influences and future directions.

11.2. Methodology

The systematic literature review is characterized by the scanning of the relevant body of literature with comprehensive search choices and criteria selection. It strives to create a reproducible search record to enable its reusage (Vom Brocke et al., 2009; Webster & Watson, 2002). The systematic approach differs from the narrative by clearly specify the criteria selection and exclusion of the search results (Cook, Mulrow, & Haynes, 1997). This rigorous method transparently identifies the relevant published articles, assesses their quality, and extracts the necessary data according to the research question and the defined exclusion criteria in order to obtain a summary of the results on a specific area (Siddaway, Wood, & Hedges, 2019).

Moreover, it was verified whether there were already systematic reviews of the literature on the topic. According to the obtained results, the answer was negative. Therefore, it represents a gap the present work intends to answer.

First, was formulated the research question and defined the investigation protocol. The defined research protocol followed the following organization: (1) Definition of databases; (2) Definition of inclusion and exclusion criteria; (3) Development of a research strategy; (4) Collection and Selection of the articles; (5) Analysis and synthesis of data.

To draft the research protocol and support the review process were used the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews). This methodological procedure starts from the total number of references found in the literature, followed up by a graphic explanation of how many were excluded in the various phases, to present the papers that constitute the final sample (Page et al., 2021).

Thus, this paper develops a rigorous systematic literature review to make an in-depth analysis of the relationship of the Smart City and the Industry 4.0 concepts. Therefore, the proposed research question is: “What is the influence between Smart Cities and Industry 4.0 concepts?”.

11.2.1. Research Protocol

The relevant body of literature was compiled from the collection, analysis, and categorization of preliminary data to aggregate and find the existing relationships. The present study serves the purposes of assessing the joint state of the art and the disclosure of future research areas.

Table 11.1 mirrors the research protocol that guided the study, from selecting the Databases and the Keywords for defining the search parameters until the collection and filtering of the papers.

Table 11:1 Research protocol

Stage	Description
0. Identification of the Research Question	The purpose was to define a research question that served the research objectives, concrete, and likely to be generalized. This article aims to understand the relationship between Smart Cities and Industry 4.0, how both concepts appear together in the literature and study their connection points. Moreover, the initial research question is: “What is the influence between Smart Cities and Industry 4.0 concepts?”.
1. Database Selection	This study uses the Scopus and Web of Science online databases, which index and house up to date scientific documents across all disciplines. The fact that the Scopus and Web of Science provide data as research output enables the conduction of a dedicate bibliometric analysis.
2. Definition of the Strategy	The research strategy was elaborated to balance sensitivity (identification of as many relevant articles as possible) with accuracy (exclusion of as many irrelevant articles as possible). Thus, to ensure that all potential, revealing articles were included, a rigorous and sensitive research strategy was developed. The keywords used in the databases considered the primary concepts and their secondary synonym terms. Moreover, the search Keywords were: “Smart Cit*”, “Sustainable Cit*”, “Digital Cit*”, “Intelligent Cit*”, “Industry 4.0”, “Fourth Industrial Revolution”, “4th Industrial Revolution”, “Smart Manufacturing”, “Intelligent Manufacturing” and “Advanced Manufacturing”.
3. Definition of Inclusion and Exclusion Criteria	The first exclusion criteria were based on the published year and the written language. Repeated and the non-existence of the full-text paper also meant the exclusion of the documents. Mendeley was used to manage, store and organize the references and initially facilitate the identification and elimination of duplicates. Were only considered the research works of Journals or Conference Proceedings. To balance sensitivity and accuracy quantitative approaches were combined with qualitative. It happened when it was verified the existence of the search initial terms within the titles or the keywords, combined with the subjective evaluation of the novelty of the title or the abstract for the authors.
4. Collection and Selection of the Articles	After filtering the initial results, careful analysis and evaluation of the titles, abstracts, introductions, and conclusions were performed. The articles' bodies were analyzed in the following step to exclude false positives and select the final papers for quantitative and qualitative analysis.
5. Analysis of Results	The quantitative analysis aimed to study the range of years of the final sample, citations, publishers, and authors, quantify the existence and distribution of the keywords, and appearance of keywords in titles. Finally, thematic analysis aimed to allocate codes and themes to each article based on their contributions. The qualitative analysis looked for evidence within the body to ultimately analyze the influence and relationship orientation of the concepts of Smart Cities and Industry 4.0 to answer the initial research question.

The search query took place from April 9 to April 16 of 2021. Scopus results and the results from the core collection of the Web of Science (default option) were considered to ensure the best relationship between sensitivity and accuracy of the investigation. For Scopus, the oldest document obtained from the initial search was from 2012, while on the Web of Science, the oldest had the date of 1992. Scopus results from 2016 onset reflected 98% of the total obtained documents. On the Web of Science 88%. Therefore, it was decided to refine the results from 2016 to 2021.

Their publication area or scope was not an exclusion criterion because it was understood that Smart City and Industry 4.0 have a large spectrum of applications. It was preferable to exclude them in a later stage of the methodology according to the careful evaluation of their content.

The papers where at least one of the initial search terms was present in the title or as keywords were included for accurate results. However, to have a greater sensitivity, this iteration still considered all the titles that seemed framed with the topic of investigation. All the remaining were excluded.

The abstracts, introductions, and conclusions of each document were analyzed. Those who essentially did not contemplate a relationship between industry and cities were excluded. Most excluded articles mentioned technological applications and theoretical frameworks within Smart Cities and Industry 4.0 (the topics were used only as a context).

Regarding the final analysis of the documents' bodies, as in the previous step, the exclusion criterion was essentially maintained. Only articles that directly or indirectly (in which the terms Smart Cities, Industry 4.0, and related are not used) showed an influence between the development of cities and the development of the industry were kept. Thus, articles that only focused on the topic of Smart Cities and Industry 4.0 as application areas, e.g. (Costa, Vasques, Portugal, & Aguiar, 2020), were excluded. Therefore, in the case of Smart Cities, articles that contemplated only the development of cities by the social component without connecting to the impact that this would have on industry were excluded. On the other hand, the same happened to the articles whose concern was on the development of the industry without contemplating an association with the cities. Were also excluded the papers whose contribution was confused, e.g. (Ślusarczyk, Haseeb, & Hussain, 2019), unclear, vague, or that only enunciated other works, e.g. (Dinardo et al., 2018). Papers that proposed technological applications in intelligent traffic systems, e.g. (Dey, Sharma, Shit, Meher, & Pati, 2019; Hassan, Azab, & Mokhtar, 2019; Hossain, Hossain, & Sunny, 2019), waste management, e.g. (Tamakloe & Rosca, 2020) and water quality monitoring, e.g. (Pasika & Gandla, 2020), and was not any mention to Industry 4.0 and Smart Cities or related concepts were also excluded. The methodology is graphically detailed below in Figure 11.1.

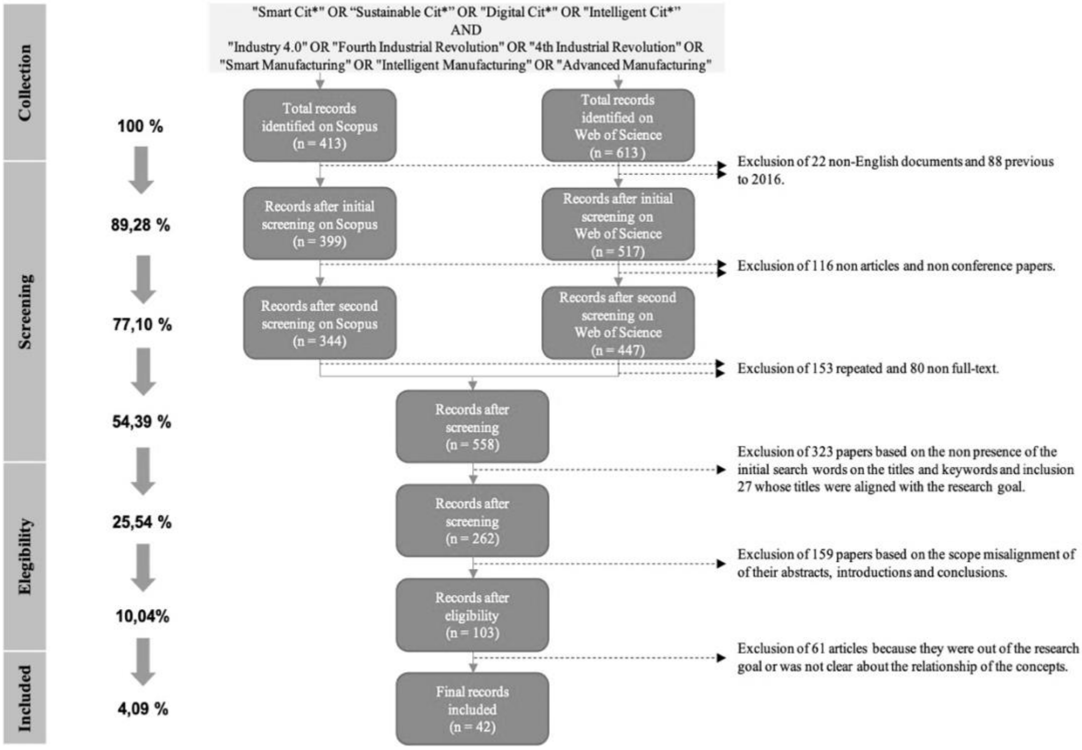


Figure 11:1 Methodology

The full text of the 103 articles were read, and only 42 deserved further analysis and exposure in the present work given the framing with the research question.

11.2.2. Analysis of the Results

Following the final sample selection, quantitative and qualitative approaches were conducted to organize and analyze the results.

The quantitative analysis aimed to give a bibliometric overview of the final sample, providing information about the years, authors, publishers, sources, and keywords associated with each paper.

A bibliometric analysis consists of the application of statistical methods to understand the profile of publications and tendencies on the topic and the collection of information about the current scientific activity (De Bakker, Groenewegen, & Den Hond, 2005; Duque Oliva, Cervera Taulet, & Rodríguez Romero, 2006).On the other hand, the qualitative analysis aims to find patterns within and across data from the careful reading of the documents (Rice & Ezzy, 1999). It was performed an inductive thematic analysis where codes and themes were developed according to each paper's contribution. After the codes aggregation and identification of the themes, the existing relationship and influence were studied. The articles were classified as "Direct" and "Indirect" depending on the type of relationship. As for the influence it was attributed according to the perceived orientation. The papers which demonstrated the existence of a direct relationship were further studied. Finally, the analysis of the results states the future directions of the joint literature.

11.3. Results and Discussion

11.3.1. Articles and Citations

The 42 final works were published between 2016 and 2021 (Figure 11.2). Regarding the number of citations, the average number of the final sample is approximately 11 citations. Two-thirds have less than five citations, and almost 40% have less than two citations, which can be explained by the fact that it is a recent topic.

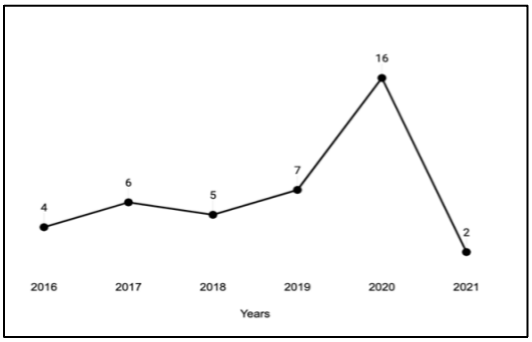


Figure 11:2 Number of Published Articles per year

11.3.2 Publishers and Sources

From the 42 selected documents (see Appendix 11.1), more than 26% of the papers were published by IEEE (Institute of Electrical and Electronics Engineers), 21,4% of the articles were published by MDPI (Multidisciplinary Digital Publishing Institute), and 16,7% by Elsevier. Nevertheless, the publishers of at least two papers are also represented in Figure 11.3.

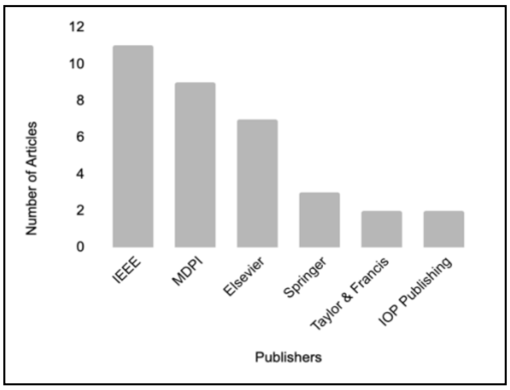


Figure 11:3 Number of Articles per Publisher

As for the publication cites, 26 papers were published in Journals, and the remaining 16 in Conference Proceedings. Sustainability Journal had four articles published from the final sample. The International Journal of Production Research and the Journal IEEE Access had two publications. Regarding the conference proceedings, the conference Smart Cities Symposium Prague, SCSP 2016 and 2017 obtained two publications. However, these publications were performed by the same authors.

11.3.3. Authors

From the list of authors, Miroslav Svitek was the author with more papers (five publications), three of them in co-authorship with the second author with most articles, M. Postranecky. Only five additional authors have more than one paper, as demonstrated in Figure 11.4.

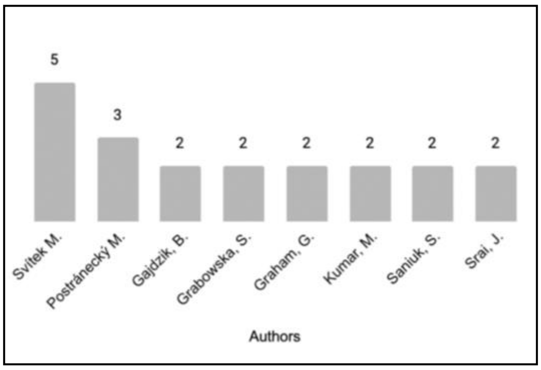


Figure 11:4 Number of Articles per Author

11.3.4 Keywords

By analyzing the article's keywords and the presence of the initial search words in titles, the word "Smart City" is present in the most significant number of articles, followed by "Industry 4.0". Figure 11.5 shows the main terms in the 42 papers (present in more than one article) concerning their presence in the titles and as authors' keywords.

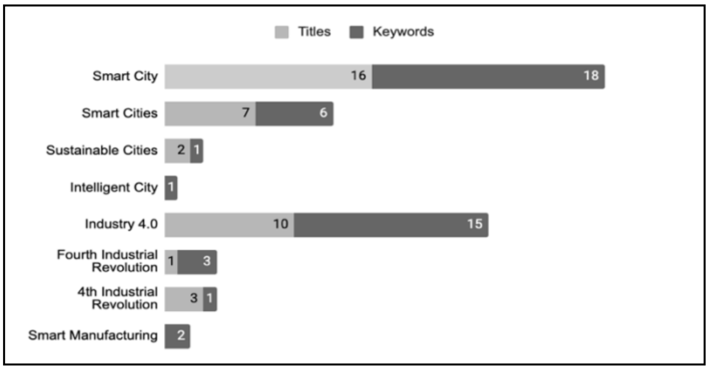


Figure 11:5 Search Keywords presence in the Titles and as Articles' Keywords

11.3.5 Categorization of the Articles based on their Contribution

After the careful reading of the papers, a thematic analysis was performed. At the first step, each paper was summarized to a single contribution sentence. Considering each contribution, the authors allocated a code to aggregate data, categorizing the connection areas of Smart Cities and Industry 4.0. Table 11.2 summarizes the initial step of the qualitative analysis.

The fact that it is a recent topic may also explain why 31 of the 42 articles are conceptual pieces of research (theoretical works) without empirical testing or experimentation.

Table 11:2 Thematic Analysis first step

N	Approach	Contribution	Code (Category)
1	Conceptual	Policy Proposal for Open Access Network	Infrastructure
2	Case Study	Development of an integrated middle layer between Smart city and Industry 4.0 to take the order from customers and transfer it to factory environment	Manufacturing/ Supply Chain
3	Conceptual	Adaptation of the Digital Twin to Smart Cities, providing citizens a 3D model of the city to experiment and propose changes in urban planning and policy.	Urban Planning
4	Conceptual	Bibliometric Analysis about Artificial Intelligence, Smart Cities, Transport and related concepts	Transportation
5	Conceptual	Bibliometric Analysis about the relation between Smart Cities dimensions and Industry 4.0 technological tools.	Concept
6	Conceptual	Definition of the concept Smart City 4.0, in which the same six principles of Industry 4.0 are applied to Smart Cities	Manufacturing/ Supply Chain
7	Conceptual	Reflection on the Challenges and Trends of CPS	Manufacturing/ Supply Chain
8	Case Study	Public transport framework and case study based on Industry 4.0 principle	Transportation
9	Conceptual	Virtual City application to promote citizens' engagement and study complex social behavior	Urban Planning
10	Conceptual	The exploitation of the foundations of the green jobs	Jobs
11	Case Study	A framework that integrates the interplay of Smart Cities with the supply chain design	Manufacturing/ Supply Chain
12	Conceptual	Reflection on the combination of Industry 4.0 and Smart Cities concepts.	Transportation
13	Conceptual	Framework with the integration of Smart Cities and Industry 4.0.	Concept
14	Conceptual	Comparison and correlation of innovation, Smart City and Industry 4.0 concepts	Concept
15	Case Study	Quantitative and qualitative impact the development of blockchain and IoT technologies will have on Smart Cities	Architecture
16	Conceptual	Reflection on the impact of 3D printing can have on the community	Manufacturing/ Supply Chain
17	Conceptual	Mapping characteristics of urban human (decomposition) tasks and problem-solving strategies onto an indoor manufacturing environment	Optimization
18	Conceptual	Development of a framework and study of the relationships between 4th revolution, the organizations, and employee’s citizenship behavior.	Work Environment
19	Conceptual	Study of the Smart City concept and the digital transformation on society	Society
20	Conceptual	Definition of a future Smart City model based on the perspective of costs/benefits that is consistent with the 4th Industrial Revolution and a 4-stage smart transformation strategy to realize the model	Concept
21	Conceptual	Definition of a new approach contemplating the adoption of Industry 4.0 concept on Smart City theoretic model	Concept
22	Conceptual	Study of the impact of 4th Industrial Revolution in Urban Areas	Rural
23	Case Study	Study and development of a method to optimize machine downtime and reduce human resources training need	Human Resources
24	Case Study	Development of a framework by integrating the living data center with the social function library to accumulate a wide variety of stakeholders’ functions as reusable knowledge	Society
25	Survey	Study of the consequences and impact of 4th Industrial Revolution may have in society	Society
26	Conceptual	Development of a matrix where Industry 4.0 related technologies and concepts are categorized in how to benefit transportation	Transportation
27	Conceptual	Bibliometric analysis of Sustainability and Industry 4.0	Sustainability
28	Conceptual	Study of the Society 5.0 Japanese initiative	Society
29	Conceptual	Review of the current status of AI and Smart and Sustainable Cities literature	Artificial Intelligence
30	Conceptual	Reflection on the responsibility and challenges that Universities have in Smart Cities developments	University
31	Conceptual	The proposition of the urban production concept to achieve a socially sustainable symbiosis between companies and cities	Work

32	Conceptual	The proposition of new infrastructure and performed a quantitative analysis to compare with another research	Infrastructure
33	Case Study	Development of an algorithm to study the implementation of an electric-powered bus system in the city	Transportation
34	Conceptual	Conceptualization of architecture to manage energy production and consumption	Energy
35	Conceptual	Critical reflection on the Society 5.0 concept	Society
36	Conceptual	Reflection on the role of Industry 4.0 on the implementation of Intelligent Transport Systems	Transportation
37	Conceptual	Investigation of the Smart City's systems security threats and attacks scenarios	Security
38	Conceptual	Discussion about the applications and opportunities of Digital Twins from industrial and engineering fields	Urban Planning
39	Conceptual	Reflection on the challenges and research areas of the Digital Twin	Urban Planning
40	Case Study	Experimental study of a fog and edge architecture based on object recognition	Architecture
41	Case Study	Discussion about use cases, emerging topics, and trends of distributed manufacturing	Manufacturing/ Supply Chain
42	Case Study	Proposes and discusses, and integrated sustainable waste management (ISWM)	Waste

The five articles in grey represent reflections about the concepts. Storolli, Makiya and César (2019) refer that Industry 4.0 technological tools enable Smart Cities. The same vision is shared by Nick et al. (2018) that state that Industry 4.0 has a fundamental influence on the development of Smart Cities. On the other hand, Safiullin et al. (2019) refer that Smart Cities have an impact on promoting new industrializations. Yun and Lee (2019) say the future Smart City is a self-organizing city optimized by prediction and customization, that reflects itself on the cloud (digital twin). Postranecky and Svítek (2016) associate Smart Cities with the physical and virtual model of Industry 4.0, where collaborative instruments can connect the stakeholders and build virtual cities to study behaviors.

To understand the connection points that ground the relationship between Smart Cities and Industry 4.0, the themes that emerged from the codes of Table 11.2 are described in Table 11.3.

Table 11:3 Thematic Analysis second step

Codes	Themes	Description
Infrastructure Architecture Security	**Technology**	Standardization and the existence of a reference architecture are among the common objectives. The massive data makes it necessary to process part on edge. Therefore, fog computing has a vital role in both Industry 4.0 and Smart Cities. IoT allows the integration of systems and devices, promoting a deep learning-based infrastructure. Industry 4.0 and Smart Cities share the same technological tools as Big Data and Analytics, Deep Learning, Internet of Things, Cyber-Physical Systems, Cloud Computing & Augmented Reality. Predictive maintenance has been attracting interest because the out-of-service times are due to machinery faults. Sensors are now installed to collect relevant information and make the diagnosis about the machine's performance condition. Data integrity is increasingly a significant concern of Smart Cities and Industry 4.0. Blockchain and artificial intelligence algorithms have been studied and will be extremely important to prevent cyber-attacks.
Manufacturing/ Supply Chain Transport Optimization Energy	**Process**	The applications are mostly connected to transportation and mobility, from traffic management to intelligent and integrated transport systems and assets. Technologically they strive to promote an open-access environment to enhance innovation and new collaborations. The relation between the City and the Industrial worlds may enhance the creation of new and collaborative business models among stakeholders improving resource efficiency and reduce costs. The transference of manufacturing closer to the client and optimizing the last-mile can disrupt the supply chain.
Jobs Work Environment University Human Resources	**People**	The lack of qualified personnel and the lack of innovative potential and predisposition are among the most critical challenges. The need for Smart Cities and Industry for qualified workers will impact society. The impact that industrial developments may have on human resources training and replacement is a concern. On the other hand, new jobs will emerge motivated by sustainable guidelines.
Urban Planning Rural Society Sustainability	**Planning**	Both concepts' significant goals are present in the Green Deal. They share the same concern regarding resource usage, sustainability, and circular economy. The rural areas are sometimes forgotten, and the technologies developed only to address City problems.

		Virtualization and digital twins can leverage industrial tools and processes to enhance more outstanding urban planning and promote co-creation with citizens.

Furthermore, the connection points of Smart Cities and Industry 4.0 can be summarized as Technology, Process, People and Planning. Both concepts share the same technologies. Sustainable planning and the efficiency of processes are mutual goals. People emerge as their need for skilled human resources.

11.3.6 Relationship and Influence of Smart Cities and Industry 4.0

Following the thematic analysis, the authors allocated to each article the orientation of the relationship between the topics, the perceived influence, and the existing evidence within the body text.

Moreover, the relationship was considered “Direct” when Smart City and Industry 4.0 terms were explicitly used in the text, and the article approached or reflected on their direct relationship. The “Indirect” evaluation was given when although there was a relationship among the subjects, it was subjective and did not directly mention the Smart City and the Industry 4.0 terms or synonyms. Regarding the influence aspect, the papers were categorized within three different options of scope:

1. Smart City - If Industry 4.0 was influenced by Smart Cities;
2. Industry 4.0 - if Smart City was influenced by Industry 4.0;
3. Both - if Smart City and Industry 4.0 were influenced by each other.

The evidence was transcript from the papers to support the classification. Table 11.4 mirrors the relationship, influence, and evidence for each of the papers.

Table 11:4 Analysis of the relationship orientation and existing evidence of each Article

N	Relationship	Influence	Evidence
1	Direct	Industry 4.0	"As the fourth industrial revolution has not yet fully arrived or established, Smart City services and business models are still in the process of being built."
2	Direct	Both	"Industry is a part of city and there are common interests between Industry 4.0 and Smart City concepts. They both aim to minimize human interaction and the energy consumption."
3	Indirect	Industry 4.0	"Digital twins have primarily been used in the manufacturing sector, but other areas of study and business are beginning to find new potential uses."
4	Indirect	Industry 4.0	"The two more important facilitators of the AI–transport–Smart City nexus will be the Physical Internet (PI, π) and Industry 4.0”
5	Direct	Industry 4.0	"Smart Cities are using common technological tools of I.4.0, and these have relevance as main booster for Smart Cities concept giving a guidance to the managers for a strategic development orientation"
6	Indirect	Industry 4.0	"Adoption of Industry 4.0 on entire city system, and subsystems, to control balanced upgrade and redevelopment of all subsystems connected in one holonic multi-agent CPS.
7	Indirect	Industry 4.0	"The Cyber-Physical System (CPS) is becoming pervasive in every aspect of Smart City daily life and considered as one of the four fundamental conceptual approaches of the fourth generation industrial revolution (Industry 4.0)."
8	Indirect	Industry 4.0	"Industry 4.0 is based on the basic general idea of where the manufactured product determines the most appropriate manufacturing process itself. The same principle can be used in public transport system"
9	Direct	Industry 4.0	"Authors of paper are also proposing an implementation of Industry 4.0 principles. The city is acting as an Industry 4.0 factory"

10	Indirect	Both	"Green jobs are associated with the implementation of sustainable development policies and socio-economic changes as well as the development of green technologies in the field of Industry 4.0."
11	Indirect	Industry 4.0	"these technologies can be part of Smart Cities development framework inclusive of manufacturing."
12	Direct	Both	"Interconnection of these systems can be expected to change transport processes. Linking information from process-based Industry 4.0 with intelligent transport systems of the Smart City could create very effective, demand-oriented and higher productivity of manufacturing enterprises as well as sustainable development of society"
13	Direct	Both	"Technologies of the Industry 4.0 create fundamentally new infrastructure of the "Smart City" (...) to solve problems of resources utilization and energy efficiency improvement, organize urban production and demographic changes in megacities. On the other hand, development of 'Smart City" promotes new industrialization, creates new conditions for living, work, education, accumulates social and human capital, and attracts financial resources for business development"
14	Direct	Industry 4.0	"The essence of the Smart City approach is to put the latest tools of technological advancement in serving the social, economic and ecological sustainability of cities' lives for the inhabitants as well as for the enterprises of the city. Industry 4.0 (...) have a fundamental influence on Smart Cities and their environment and regions, given that their primary goal is to improve a country's competitiveness"
15	Indirect	Industry 4.0	"Smart cities are built on top of different technologies such as blockchain and the Internet of Things (IoT)"
16	Indirect	Industry 4.0	"Makerspaces, this essay argues, can serve as hubs and vehicles for citizen driven transformation and, thus, play a key part in a more inclusive, participatory and commons-oriented vision of the Smart City"
17	Indirect	Industry 4.0	"The authors formulate the hypothesis that any manufacturing environment may be regarded as a "mini-version" of an urban environment as a prerequisite (...). This hypothesis is based on the commonalities between the indoor manufacturing environment and the elements of a city.
18	Indirect	Industry 4.0	"The pressure to keep employment in the face of automation and rapid industrial change in the 4th industrial revolution, has also had negative effects on maintaining a healthy work/life balance and forces workers to maintain their citizenship behavior far beyond formal office hours, thus introducing forms of citizenship extremism."
19	Indirect	Industry 4.0	"Fourth Industrial Revolution, the social environment and a whole society are undergoing radical changes under the influence of new technologies"; "The most popular concept associated with the application of artificial intelligence in the field of urban planning and management of territories in the digital society is the creation of "Smart Cities"
20	Direct	Industry 4.0	"Through the 4th Industrial Revolution technology, the advantages of Smart City are estimated to overcome the city's expenses with city platformization"
21	Direct	Industry 4.0	"Optimization of all processes inside systems and layers of Smart City following the logic of Industry 4.0 Concept"
22	Indirect	Industry 4.0	"Rural areas may also be in danger of being excluded from the development of the next generation of technologies being developed as part of 4IR. (...) many of the technologies are being developed to address issues of density facing cities and urban areas"
23	Indirect	Industry 4.0	"A smart society evaluates human needs through AI to implement the best automated operational processes, taking into account problems and stimuli in a humane way, with a structure that can collect and learn people's habits in the modern digital context"
24	Indirect	Industry 4.0	"transforming social living problems into solutions via industrialization";" transform social problems into industrial solutions by selecting the necessary functions from the social function library, and then linking and integrating the living data center with those social functions"
25	Indirect	Industry 4.0	"Industry 4.0 sets new areas of change in the sphere of production and management but also exerts an impact on various aspects of society's life."
26	Indirect	Industry 4.0	"for all different transportation modes (...), Industry 4.0 related concepts, technologies and developed systems might be applied"
27	Indirect	Industry 4.0	"detailed analysis of the content of the selected papers shows that the Industry 4.0 implementation in the sustainable environment most often concerns urban spaces and creates a research area: Sustainable Smart Cities"
28	Indirect	Industry 4.0	"The Society 5.0 things and technologies are out of the narrow traditional boundaries, which are typical for the Industry 4.0 concept studying";"The Industry 4.0 digital leap success in the social mind creates the new behavior models of the population cyber-interaction where the highly advanced cyber-systems eliminate the barrier, which is typical for the Smart Cities world."
29	Indirect	Industry 4.0	"AI technology is evolving and becoming an integral part of urban services, spaces, and operations, we still need to find ways to integrate AI in our cities in a sustainable manner, and also to minimize the negative social, environmental, economic, and political externalities that the increasingly global adoption of AI is triggering"
30	Direct	Industry 4.0	"Smart cities are also manifestations of the 4th industrial revolution and industry 4.0, which emerging phenomena imply innovations, better planning, a more participatory approach towards higher energy efficiency, better transport solutions, and intelligent use of information and communication technologies"
31	Indirect	Both	"The future economic, ecological and social development of the cities leads to a reorientation and redesign of production in the form of urban production sites"; "At the same time, production and resource-conserving production processes and production technologies are used in urban production to minimise pollution and noise emissions for residents. Urban production will be based on a symbiosis between companies and urban populations."
32	Indirect	Industry 4.0	"Deep Learning-based IoT-oriented infrastructure for a secure Smart City where Blockchain provides a distributed environment at the communication phase of CPS, and Software-Defined Networking (SDN) establishes the protocols for data forwarding in the network"

33	Indirect	Industry 4.0	"simulation-optimization approach and Industry 4.0 is applied for modeling, analyzing and evaluating the feasibility of an electric-powered bus system in Dehradun Smart City's public transportation system."
34	Direct	Industry 4.0	"the importance and inclusion of Smart Cities within the framework of industry 4.0 is argued"
35	Indirect	Industry 4.0	"The Japanese approach to Society 5.0 ever goes far beyond Industry 4.0, and the visionary declarations are of high ethical and moral value." ; "Knowledge and information can build a better society, but also be used against you by criminals or organizations. This requires careful European and international legislation and control to avoid the worst outcomes of these new technologies, and requires high public awareness"
36	Indirect	Industry 4.0	"Intelligent Transportation system will be an essential part of that development and entering the stage of access to the 4.0 industrial revolution, building a Smart City applying 4.0 technology to bring convenience, friendliness, and safety to people in each city"
37	Direct	Industry 4.0	"Smart cities are futuristic state-of-the-art cities wherein all components of the urban infrastructure are inter-operated through networks using the core technologies in the Fourth Industrial Revolution and ICT(Information and Communication Technology)."
38	Indirect	Industry 4.0	"Digital twins, traffic planning, and general transport systems of cities; Preparation of emergency plans and determination of response methods in natural disasters such as floods, fires, and earthquakes; It can help governments detect pollution in the city and make landscaping. It can allocate resources, plan operations, and optimize traffic by having realtime information about any emergency"
39	Indirect	Industry 4.0	"The use and the potential for Digital Twins to be dramatically effective within a Smart City is increasing year on year due to rapid developments in connectivity through IoT" ; "Open areas to be researched come in the form of applying data analytics, such as predictive analytics applied to a Digital Twin for developing Smart City"
40	Indirect	Industry 4.0	"Object recognition is a necessary task in Smart City environments. (...) architecture that integrates heterogeneously distributed information to recognize objects in intelligent environments. The architecture is based on the IoT/Industry 4.0 model to interconnect the devices, which are called smart resources"
41	Indirect	Industry 4.0	"The 'Future city production system' for luxury fabrics combines DM (3D weaving), logistics and spatial dispersed units. These cooperate and communicate over processes and networks in order to achieve the optimum localised manufacturing output (per day) to meet city demand."
42	Indirect	Industry 4.0	"The placement of household goods manufacturers directly in the residential part of a city allows the needs of the customer to be quickly met. The Smart City Initiative and the concepts of Industry 4.0 (I4.0), Internet of Things (IoT), Internet of Services, and Social Manufacturing are aimed at the sustainable development of regions"

From the content analysis of Table 11.4, the answer to the research question: "What is the influence between Smart Cities and Industry 4.0 concepts?" is almost unanimous. Smart Cities are influenced by Industry 4.0. The evidence of the Smart City influence in Industry 4.0 does not exist separately from the Industry 4.0 on Smart Cities. Although several authors smoothly refer to the influence that Smart Cities may have in the Industry it lacks a greater understanding.

The papers which make a direct articulation between Smart Cities and Industry 4.0 focus mainly on the technological aspect, where Smart Cities can use the same principles and infrastructure of Industry 4.0. Only 5 of the 42 articles saw their categorization as "Both". Of those, only three were associated with "Direct" relationship. Karakose and Yetis (2017) link the two concepts in a production environment where the order and shipping are part of the Smart City and Industry 4.0 fulfills the request from manufacturing to delivery. Safiullin et al. (2019) refer that even though Industry 4.0 technologies allow Smart Cities, the last improve living and working conditions and attract investment, promoting new industrialization. Lom, Pribyl and Svitek (2016) states that the interconnection of Smart Cities and Industry 4.0 is expected to change transport processes, and therefore, production, mobility, and consumption are related areas between Smart Cities and Industry 4.0.

In summary, given the vision advocated by Smart Cities, citizens will increasingly be empowered by policymakers, whose inclusion and participation became highly relevant to the Smart City strategy's success. The evolution of city dynamics may lead Industry to adapt to their social needs and adopt new practices. Society's evolution has always been associated with the Industrial developments. With the advancement on Artificial Intelligence there is the need to reflect on the scenario where technology does not improve citizens' quality of life and is restricting the freedom to live and think. When data, automation, and robotics are hot topics, it is necessary not to neglect ethics and privacy. The concept of Smart Cities started from a technological perspective and has derived from the social and co-creation perspective with the citizens. Moreover, it is vital to understand how collaborative city design processes and need for social relationships will impact the development of the industry. Social sciences literature might have a significant role in the following discussions around the joint literature. Furthermore, the influence of Smart Cities in Industry may be characterized by the emergence of the new concept of Industry 5.0 (European Commission, 2021) as human-centric, resilient, and sustainable, promoting the achievement of societal goals, prosperity, and placing the worker in the center. However, no mention was made of this new concept within the final sample's papers, which undermines the fact that the discussion of this topic is still at an early stage.

11.4. Conclusions and Future Work

Smart Cities started to be techno-centric and moved to focus on sustainability and the citizens' quality of life, breaking silos and promoting interoperability among solutions, allowing the city to have a real-time and integrated perspective. At the same time, Industry 4.0 emerged to provide personalized products and real-time services to consumers, based on vertical, horizontal, and end-to-end integrations through Cyber-Physical Systems (CPS).

Nowadays, cities are increasingly co-created with the citizens. Simultaneously, Industry is arranged from consumer (citizen) specifications. Therefore, the moment that Industry 4.0 and Smart Cities are facing is at all similar. The placement of the end-user at the center of decision-making is increasingly present and moving them forward.

This paper produced a systematic literature review to study the existing relationship between Smart Cities and Industry 4.0. After a rigorous methodological process, where the investigation protocol and each step were further detailed, a final sample of 42 papers was obtained. Quantitative and qualitative analysis were conducted.

For each article, it was summarized its contribution in one sentence and allocated a code based on thematic analysis. The themes represented the connections between Smart Cities and Industry 4.0. Moreover, their collusion is assumed by sharing technologies, the common goal of continuously looking for ways to turn processes more efficient and personalized, the concern about qualified jobs, and adequate planning.

Nevertheless, to answer the initial question, each article was classified according to the type of the relationship (direct or indirect) and their influence.

Their relationship is almost unanimous. Smart Cities are influenced by Industry 4.0. The evidence of the Smart City influence in Industry 4.0 does not exist separately from the Industry 4.0 on Smart Cities.

In summary, only 6 of the 42 pointed to a bidirectional relationship. The remaining highlighted the influence that Industry 4.0 has in the development of Smart Cities, which raised concerns about if academia has been properly reflecting on the role of Smart Cities in Industry 4.0.

Moreover, this research pointed to an existing gap in the literature. The inexistence of produced investigations about the influence of Smart Cities development in Industry 4.0 is seen as valuable future work. In summary, this study grounds a new research direction of specific literature applied to the relationship of the Smart City and the Industry 4.0 concepts.

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Appendix 11.1 - Final sample selected papers

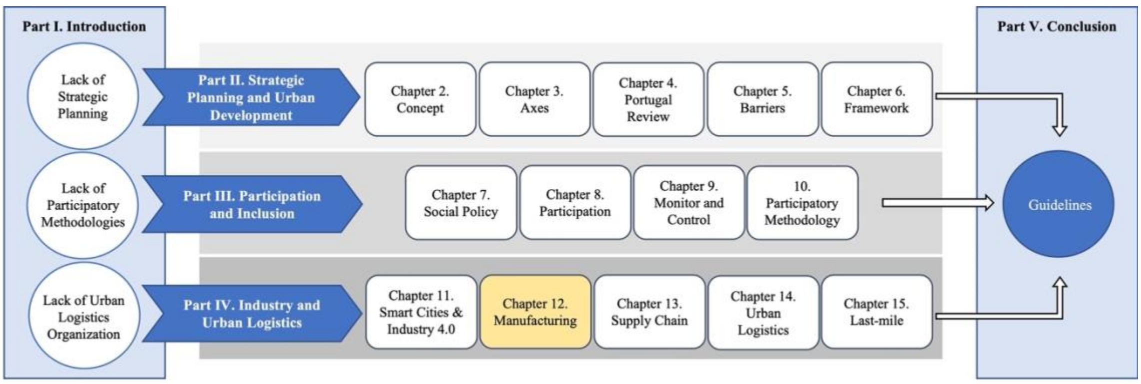
N	Reference	Source Title	Publisher	Type
1	(Park & Kim, 2018)	2018 Portland International Conference on Management of Engineering and Technology, PICMET 2018	IEEE	Conference
2	(Karaköse & Yetiş, 2017)	Wireless Communications and Mobile Computing	Hindawi Limited	Article
3	(White, Zink, Codecá, & Clarke, 2021)	Cities	Elsevier	Article
4	(Nikitas, Michalakopoulou, Njoya, & Karampatzakis, 2020)	Sustainability (Switzerland)	MDPI	Article
5	(Storolli et al., 2019)	Independent Journal of Management & Production	Inst Federal Educacao, Ciencia e Tecnologia Sao Paulo	Article
6	(Postránecký & Svítek, 2017)	8th International Conference on Industrial Applications of Holonic and Multi-Agent Systems, HoloMAS 2017	Springer	Conference
7	(Juma & Shaalan, 2020)	5th International Conference on Advanced Intelligent Systems and Informatics, AISI 2019	Springer	Conference
8	(Horažďovský & Svítek, 2017)	2017 Smart Cities Symposium Prague, SCSP 2017	IEEE	Conference
9	(M. Postranecky & Svítek, 2016)	2016 Smart Cities Symposium Prague, SCSP 2016	IEEE	Conference
10	(Rutkowska & Sulich, 2020)	24th KES International Conference on Knowledge-Based and Intelligent Information and Engineering Systems, KES 2020	Elsevier	Conference
11	(M. Kumar, Graham, Hennelly, & Srai, 2016)	International Journal of Production Research	Taylor & Francis Ltd	Article
12	(Lom et al., 2016)	2016 Smart Cities Symposium Prague, SCSP 2016	IEEE	Conference
13	(Safiullin et al., 2019)	2nd International Scientific Conference on Digital Transformation on Manufacturing, Infrastructure and Service, DTMIS 2018	Institute of Physics Publishing	Conference
14	(Nick et al., 2018)	Deturope - The Central European Journal of Regional Development and Tourism	Regional Science Association of Subotica	Article
15	(Khrais, 2020)	International Journal of Advanced Computer Science and Applications	Science and Information Organization	Article
16	(Niaros, Kostakis, & Drechsler, 2017)	Telematics and Informatics	Elsevier	Article
17	(Schabus, Scholz, & Lampoltshammer, 2017)	ISPRS International Journal of Geo-Information	MDPI	Article
18	(Coldwell, 2019)	International Journal of Environmental Research and Public Health	MDPI	Article
19	(Erokhina, Mukhametov, & Sheremetiev, 2019)	2019 Wave Electronics and its Application in Information and Telecommunication Systems, WECONF 2019	IEEE	Conference
20	(Y. Yun & Lee, 2019)	Journal of Open Innovation: Technology, Market, and Complexity	MDPI	Article
21	(Michal Postranecky & Svitek, 2017)	2017 Smart Cities Symposium Prague, SCSP 2017	IEEE	Conference
22	(Cowie, Townsend, & Salemink, 2020)	Journal of Rural Studies	Elsevier	Article
23	(Foresti, Rossi, Magnani, Guarino Lo Bianco, & Delmonte, 2020)	Engineering	Elsevier	Article
24	(Nishida, Kitamura, Oono, & Yamanaka, 2017)	2017 International Smart Cities Conference, ISC2 2017	IEEE	Conference
25	(Saniuk, Grabowska, & Gajdzik, 2020)	Sustainability	MDPI	Article
26	(Erkollar & Oberer, 2018)	Sigma Journal of Engineering and Natural Sciences	Yildiz Technical Univ	Article
27	(Gajdzik, Grabowska, Saniuk, & Wieczorek, 2020)	Energies	MDPI	Article
28	(Gurjanov, Zakoldaev, Shukalov, & Zharinov, 2020)	Journal of Physics: Conference Series	IOP Publishing Ltd	Conference
29	(Yigitcanlar & Cugurullo, 2020)	Sustainability	MDPI	Article
30	(Anttila & Jussila, 2018)	Total Quality Management and Business Excellence	Routledge	Article
31	(Matt, Orzes, Rauch, & Dallasega, 2020)	Computers and Industrial Engineering	Elsevier	Article
32	(S. K. Singh, Jeong, & Park, 2020)	Sustainable Cities and Society	Elsevier	Article
33	(A. Kumar et al., 2020)	IEEE Access	IEEE	Article
34	(Sánchez Naranjo, Molano, & González Rojas, 2018)	3rd International Conference on Data Mining and Big Data, DMBD 2018 held in conjunction with the 9th International Conference on Swarm Intelligence, ICSI 2018	Springer	Conference
35	(Schoitsch, 2019)	27th Interdisciplinary Information Management Talks: Innovation and Transformation in a Digital World, 2019	Trauner Verlag Universitat	Conference
36	(Nguyen, 2020)	International Journal on Advanced Science, Engineering and Information Technology	Insight Society	Article
37	(Lee, Kim, & Seo, 2019)	6th International Conference on Platform Technology and Service, PlatCon 2019	IEEE	Conference
38	(Erol, Mendi, & Dogan, 2020)	4th International Symposium on Multidisciplinary Studies and Innovative Technologies, ISMSIT 2020	IEEE	Conference
39	(Fuller, Fan, Day, & Barlow, 2020)	IEEE Access	IEEE	Article
40	(Poza-Lujan, Posadas-Yagüe, Simó-Ten, & Blanes, 2020)	Sensors (Switzerland)	MDPI	Article
41	(Srai et al., 2016)	International Journal of Production Research	Taylor & Francis Ltd	Article
42	(Dzhuguryan & Deja, 2021)	Sustainability	MDPI	Article

Chapter 12

The Hourglass Model: From Consumer's Behavior to Delivery

Reference

Correia, D., Teixeira, L., & Marques, J. (2021). The Hourglass Model: From Consumer's Behavior to Delivery. *Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management (IEOM)*, Singapore, March 9-11, 2021.



12. The Hourglass Model: From Consumer's Behavior to Delivery

Abstract

Through an empirical study of 74 Portuguese e-commerce brands, from the fashion, cosmetics, supplements, jewelry, beverages, utilities, orthopedics, book, sports, technology, decoration, pet, printing, and flowers' sectors, it was noticed that consumers still do not have the possibility to personalize their products neither to request immediate deliveries or choose an exact delivery time. Nowadays, the Industry is striving to allow consumers to buy the product they want, as they wish, and be delivered in the time and place they choose. The purchase personalization and the supply chain's arrangement to attend to the demand are expected to be increasingly based on predictive analytics. Prediction shall guide the definition of the supply chain. Moreover, the collaboration between stakeholders through an open marketplace is required to fulfill clients' needs and desires. Given the observed facts and empirical evidence, this paper highlights the importance of integrating manufacturing and delivery, supported by an Hourglass sharing economy prediction-oriented supply chain model.

Keywords: Smart Manufacturing, Hourglass Model, Industry 4.0, Supply Chain, and Smart Cities.

12.1. Introduction

Information and Communication Technologies (ICTs) are increasingly present in our daily life. The line which separates the real from the virtual worlds is fading up. The new industrial revolution emerged to find the right balance between large-scale manufacturing and demand diversification with increase customization of a wide range of products under an unprecedented competitive and challenging market (Y. Wang, Ma, Yang, & Wang, 2017).

Clients' requirements have increased in terms of personalization and complexity. The global competitive environment increases the market's volatility and trends, presenting enormous challenges for the Industry to follow it and deal with shorter product life cycles (Hofmann & Rüsch, 2017).

The uncertainties with costs and available resources have accelerated the move to agile, high-performance, and sustainable manufacturing (Shin, Woo, & Rachuri, 2014).

The manufacturing industry urges to integrate all the processes to meet consumer demands, market changes, and production uncertainties (Anand & Ward, 2004; Lu & Ju, 2017) within a short period without compromising product's quality (Paritala, Manchikatla, & Yarlagadda, 2017).

Planning and scheduling can be fully integrated with operations with coordination and optimization models across the value chain (Kang et al., 2016). Moreover, a data-driven revolution will transform traditional manufacturing facilities smart enough to support real-time, accurate, and timely decision-making (Peter O'Donovan, Leahy, Bruton, & O'Sullivan, 2015).

To evidentiate the existing inefficiency on the market and the fact that delivery is still arranged separately from manufacturing and order's management, a case study in the Portuguese context is highlighted in this paper.

Based on the Smart Manufacturing revision of literature and empirical evidence, this paper enunciates the importance of integrating manufacturing and delivery and proposes an Hourglass model to define the supply chain's new paradigm guidelines.

12.2. Smart Manufacturing Literature Review

Compared with prior industrial revolutions, Industry 4.0 or Smart Manufacturing's primary goal is not to replace the existing manufacturing assets but to ensure interoperability and interconnectivity among players using ICTs and standards (Trappey et al., 2017).

Manufacturing has passed through many advanced paradigms (Lean, Agile, Green, and Sustainable) with a typical lack of linkage of physical and virtual objects through a dynamic infrastructure network, lack of interoperability and data management, and analytics to perform in-depth analysis (Ren et al., 2019).

Over the past century, there was a shift from the Ford Assembly Line to the Toyota Production System, Flexible Manufacturing, Reconfigurable Manufacturing, Agent-Based Manufacturing, and now the Cloud Manufacturing (Putnik et al., 2013; Y. Tina Lee, Senthilkumaran Kumaraguru, Sanjay Jain, Stefanie Robinson & Helua, Qais Y. Hatim, Sudarsan Rachuri, David Dornfeld, Christopher J. Saldana, 2017).

The Internet of Things (IoT) is gaining momentum and leading manufacturing to focus on integrating physical assets with cyberspace to form cyber-physical systems (CPS). These advancements enable collecting and processing data at all stages (J. Wang, Ma, Zhang, Gao, & Wu, 2018) through processes' virtualization (Bag, Telukdarie, Pretorius, & Gupta, 2018).

Smart manufacturing emerged due to the disturbances in operation caused by the fact that there was no real-time analysis of the dynamic changes and real-time production performance. Therefore, an occurrence could affect and spread gradually throughout the entire value chain. With the new technologies, the manufacturing process can be monitored in real-time. The obtained data mined to perform continuously improved diagnosis and executions (Zhang, Wang, Wu, & Qian, 2016).

Smart Manufacturing also aims to improve product quality, systems productivity, and sustainability while reducing production costs. The six pillars are manufacturing technology and processes, materials, data, predictive engineering, sustainability, resource sharing, and networking (Kusiak, 2018).

The comprehensive definitions available underlie the use of advanced data analytics and ICT to improve operations over the supply network (shop floor, factory, supply chain, and life cycle). The three main objectives are plantwide optimization, sustainable production, and agile supply chains. Smart Manufacturing can generate the optimal value stream and new business models based on better predictive maintenance, robustness in product design, and adaptive logistics (Thoben, Wiesner, & Wuest, 2017).

Traditionally, manufacturing was seen as just an in-line process or sequence where raw materials were turned into goods. It was challenging to monitor and predict manufacturing processes due to the lack of ICT supporting the supply chain. Business is becoming demand-dynamic with the need for real-time integrated computational, engagement, and involvement of the different stakeholders and workforce, and demand-driven supply chain processes (Davis, Edgar, Porter, Bernaden, & Sarli, 2012). Traditional distribution and supply chains are not capable of dealing with the future development in production. It is needed to be highly flexible to provide robust customization of products and tailor the products for specific clients (Schlingensiepen, Nemtanu, Mehmood, & McCluskey, 2016).

Today manufacturing is seen as a set of practices that use ICT to govern operations, control production, and plan every step of the supply chain (Mittal, Khan, Romero, & Wuest, 2019).

Therefore, traditional techniques are no longer applicable. They were too time consuming and relied on the knowledge and experience of engineers for problem-solving. Because of consumer demand, production is becoming more involved in tasks and constraints and operating performance uncertainty. There is a need for accurate prediction and processing methods capable of responding in a shorter time, controlling every detail of the operation to identify faults, defects, and abnormal occurrences (Y. Cheng, Chen, Sun, Zhang, & Tao, 2018).

As it happens with Smart Cities, the secret is once again on data. Advanced data analytics to improve system performance and decision-making are the ground basis of Smart Manufacturing (J. Wang et al., 2018). Nowadays, there is a need to handle vast amounts of data with high volume, velocity, and variety from multiple sources. Product quality inspection, fault diagnosis, and defect prognosis need Deep Learning advanced analytics to detect emerging problems early (Wen, Li, Gao, & Zhang, 2018).

Equipment maintenance can represent a total of 30% of the operational cost. The constant machinery diagnosis for prevention is essential to promote machine uptime (P. O'Donovan, Leahy, Bruton, & O'Sullivan, 2015).

Deep learning techniques play a vital role in the automation of learning, pattern identification, and decision making. Its benefits can be explained by reducing operational costs, facing consumer demand changes, increasing productivity, and reducing downtime. Cloud computing and big data analysis allow identifying the bottlenecks of manufacturing processes, realizing the causes, and finding solutions (Qi & Tao, 2018).

Data analytics can have different levels: descriptive (to summarize what happens), diagnostic (to examine the problem's cause), predictive (prediction based on statistical models), and prescriptive (recommendation of action courses) (J. Wang et al., 2018). The mining of structured and semi-structured data from every source of the product's life cycle fuels the final applications (Tao, Qi, Liu, & Kusiak, 2018).

Because the handling of high volumes of data urges the need for big data analytics (machine learning and predictive analytics), enabling timely and accurate insights to help decision making (Shin et al., 2014). New technologies such as robotics, hybrid processes, laser, and net-shape manufacturing will emerge and different forms and modes of transportation for the distribution channels and supply chain (Kusiak, 2018).

12.3. Empirical Study

Industry moves towards a reality where it will be possible for the consumer to control all the decision phases in the supply chain process.

A case study was performed to get a more in-depth insight about the local Portuguese reality to evidence the existing gap. This research method examines complex phenomenon and intensively studies something with the goal of generalize it to a broader perspective (Gustafsson, 2017).

This empirical study intended to analyze, in the Portuguese context, the brands' capacity to provide an end-to-end personalized service, from the definition of requirements to delivery to the client. Companies from the fashion, cosmetics, supplements, jewelry, beverages, utilities, orthopedics, book, sports, technology, decoration, pet, printing and flowers' sectors were considered. The search engine was Google. The results were obtained from the combination of the keywords "E-commerce"; "Companies" and "Portugal".

Data was taken from each entity's websites and analyzed later. Four different criteria were defined to standardize the comparison between the entities. Therefore, it was intended to study whether each entity allowed the client to:

C1: Change aspects of the product with personalized requirements – "Yes"/"No"

C2: Choose the exact time of delivery – "Yes"/"No"

The third and fourth criteria aimed to collect the sample's delivery data to understand how far the brands are from the ultimate personalization:

D1: Delivery time within the country – "Number of Days"

D2: The delivery is performed by a third-party service provider – "Yes"/"No"

From the initial 118 companies, only 74 were considered on the final sample due to insufficient available data. The results are detailed in Table 12.1.

Through the analysis of Table 12.1, it is possible to confirm the gap previously mentioned in this paper. There is still a general shortage in the possibility of the client purchasing a personalized product with the desired requirements and with a convenient delivery service. Only 5 of the 74 companies allow product's personalization. However, just 1 allows the choice of the exact time for the delivery, recurring to its delivery resources.

Company number 52 can be seen as an outlier of this sample. Personalizing its product only allows a delivery after 30 days. Companies 7 and 68 allow same-day delivery. However, they use their means to perform it. On the other hand, only company 68 allows the consumer to choose the exact delivery time. Many companies that allow the delivery in one or two days require the purchase to be made by a specific time in the previous day and charge an extra fee.

Table 12:1 Case study

Company	Sector	C1	C2	D1	D2
1	Groceries	No	No	1 – 2	Yes
2	Groceries	No	No	1 – 3	Yes
3	Beverages	No	No	1 – 4	Yes
4	Supplements	No	No	1	Yes
5	Beverages	No	No	1 – 5	Yes
6	Pet	Yes	No	1 – 2	Yes
7	Pet	No	No*	0 – 5	No
8	Cosmetics	Yes	No	1 – 3	Yes
9	Cosmetics	No	No	1 – 2	Yes
10	Cosmetics	No	No	1 – 2	Yes
11	Orthopedics	No	No	2 – 4	Yes
12	Cosmetics	No	No	1 – 3	Yes
13	Cosmetics	No	No	1	Yes
14	Cosmetics	No	No	1 – 2	Yes
15	Ceramics	No	No	3 – 4	Yes
16	Utilities	No	No	2 – 5	Yes
17	Utilities	No	No	1 – 3	Yes
18	Technology	No	No	4 – 5	Yes
19	Technology	No	No	1 – 2	Yes
20	Technology	No	No	1 – 7	Yes
21	Sports	No	No	2 – 5	Yes
22	Printing	Yes	No	2 – 8	Yes
23	Gaming	No	No	1 – 3	Yes
24	Gaming	No	No	3 – 5	Yes
25	Books	No	No	1 – 2	Yes
26	Fashion	No	No	1 – 2	Yes
27	Sports	No	No	1 – 3	Yes
28	Fashion	No	No	1 – 4	Yes
29	Fashion	No	No	2 – 3	Yes
30	Fashion	No	No	1 – 3	Yes
31	Fashion	No	No	2 – 3	Yes
32	Fashion	No	No	3 – 5	Yes
33	Fashion	No	No	3 – 5	Yes
34	Fashion	No	No	1 – 5	Yes
35	Fashion	No	No	1 – 4	Yes
36	Fashion	No	No*	2 – 5	Yes
37	Fashion	No	No	2– 3	Yes
38	Fashion	No	No	3 – 7	Yes
39	Fashion	No	No	1 – 5	Yes
40	Fashion	No	No	1 – 5	Yes
41	Fashion	No	No	1 – 2	Yes
42	Fashion	No	No	1 – 2	Yes
43	Fashion	No	No	1 – 5	Yes
44	Fashion	No	No	3 – 5	Yes
45	Fashion	No	No	1 – 2	Yes
46	Fashion	No	No	2 – 3	Yes
47	Fashion	No	No	2 – 3	Yes
48	Fashion	No	No	1 – 5	Yes
49	Fashion	No	No	1 – 2	Yes
50	Jewelry	No	No	2 – 5	Yes
51	Jewelry	No	No	3 – 5	Yes
52	Fashion	Yes	No	30	Yes
53	Fashion	No	No	2 – 5	Yes
54	Fashion	No	No	1	Yes
55	Fashion	No	No	1 – 2	Yes
56	Fashion	No	No	1 – 5	Yes
57	Technology	No	No	1 – 5	Yes
58	Flowers	Yes	No*	1 – 2	No
59	Fashion	No	No	1 – 3	Yes
60	Fashion	No	No	2 – 3	Yes
61	Fashion	No	No	2 – 7	Yes
62	Fashion	No	No	3 – 7	Yes
63	Fashion	No	No	1 – 4	Yes
64	Fashion	No	No	2 – 4	Yes
65	Fashion	No	No	2 – 4	Yes
66	Fashion	No	No	4 – 5	Yes
67	Fashion	No	No	3 – 5	Yes
68	Mall	No	Yes	0 – 5	No
69	Cosmetics	No	No	2 – 5	Yes
70	Cosmetics	No	No	1 – 3	Yes
71	Fashion	No	No	2 – 5	Yes
72	Fashion	No	No	1 – 3	Yes
73	Fashion	No	No	2 – 4	Yes
74	Fashion	No	No	1 – 7	Yes

* It is allowed the choice of the day and time range period for delivery within a nearby confined small region

Additionally, all companies safeguard immediate delivery with the existing stock. It would be necessary to integrate stock management and delivery to know it in real-time.

They also warn that after the delivery carrier's first attempt, the delivery will be left at the nearest pickup point.

12.4. The Hourglass Model

Industry 3.0, in the 1980s, was known as Mass Customization Production because of consumers' demand for a wider extensive variety of products.

Mass customization can be summarized in 3 ways: Make-to-stock, where the product is manufactured uniformly, and then the user-customized as he wants; Assemble-to-order, a combination of has been the modules produced with the client's request; Make-to-order, production only starts after the client's order.

However, mass customization presents limitations as: (1) the fact that the consumers do not participate in the design phase; (2) the potential combinations are usually made by designers and (3) the concept is not necessary to satisfy individual interests (Y. Wang et al., 2017).

The consumers' ongoing desire to participate in the design phase upgraded it to a personalized production model (Bortolini, Ferrari, Gamberi, Pilati, & Faccio, 2017). The flexible manufacturing of mass customization products in small series (up to one sample) (Prause, 2016) emerged to respond to the preferences of individual users (Hozdić, 2015). Industry 4.0 and related technologies will enable personalization with shorter cycle-times and lower costs (Y. Wang et al., 2017). Fulfill consumer desires at a lower price will always be the ultimate goal (Karaköse & Yetiş, 2017). Therefore, personalized products are increasing at the same time as personalized added value services.

The evolution of ICTs and the IoT and Cloud-Computing's growing role turns simple production into automated global value chains. It connects the different stakeholders (manufacturers, suppliers, and clients) (Safiullin, Krasnyuk, & Kapelyuk, 2019), in a service-based model. Three dimensions are outlined in the Industry 4.0 paradigm: (1) cross-company horizontal integration throughout the value chain; (2) end-to-end engineering with intelligent cross-linking and digitalization from the raw material until the product's end of life; (3) vertical integration of the departments with associated value chain activities (Stock & Seliger, 2016; Zhou, Liu, & Zhou, 2016).

The future lies in digitization and automation, requiring minimal manual interventions (Monostori, 2014).

The decentralization of operations will permit facing unforeseen changing conditions. The integration of the horizontal and vertical axes across stakeholders of the entire value chain at all organizational levels will achieve manufacturing efficiency (Erol, Jäger, Hold, Ott, & Sihn, 2016). The product will control production (Nick, Pongrácz, & Radács, 2018).

Industry 4.0 is characterized by the fusion of physical and virtual worlds (Kagermann, Wahlster, & Helbig, 2013). This fusion is demonstrated in Figure 12.1, where the product's journey is showcased. The consumer's footprint will confirm the exact moment the product needs to be available, identifying if it is needed to manufacture or if there is a stock of it. When the client actually purchases the product, it is available to be delivered. Depending on the delivery requirements, it can be immediate or need the combination of multiple transport and storage assets.

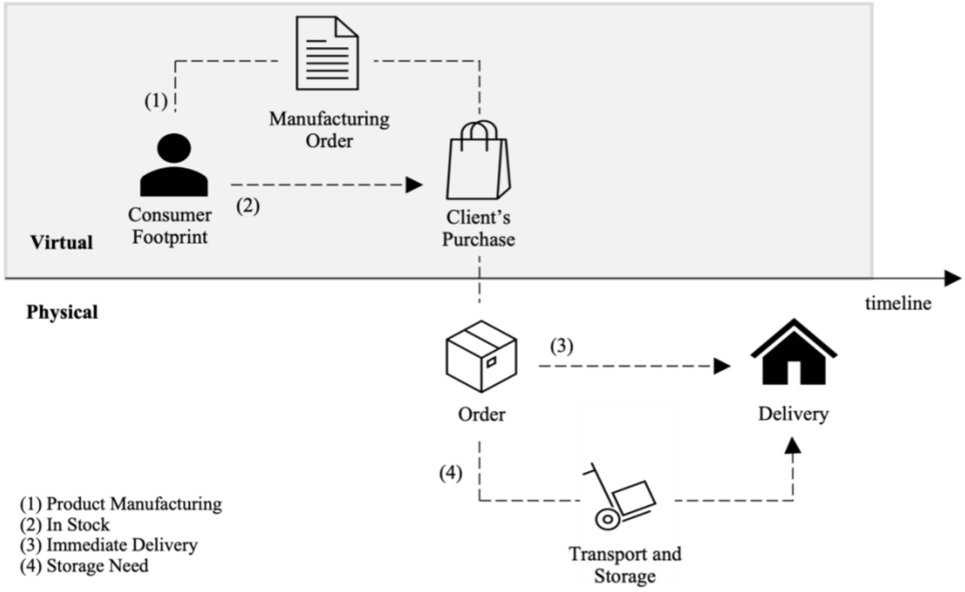


Figure 12:1 Product's Journey

The cyber layer is responsible for commanding machines at the physical layer according to the orders and their prediction. The Digital Twin is a virtual counterpart used to simulate real-time synchronizations of the field's sense-data (Negri, Fumagalli, & Macchi, 2017). The creation of virtual models of the physical objects permits the simulation of their behavior to optimize the entire chain by continuously evaluating the scenarios considering the combinations of possible perturbations in the system. Instead of an in-line process, the digital technology turns it into a cyclical process where the product is conceptually designed and passes through simulation and feasibility assessment. Its quality is inspected at every stage, as inventory and marketing are also taken into account (Paritala et al., 2017).

Cyber Physical Systems (CPS), constituted by sensors and actuators at the physical layer, will enhance algorithms' creation from processing the collected data at the cyber layer (Karaköse & Yetiş, 2017). It aims to plan, configure, optimize and schedule production, manage inventory and simulate decisions, synchronizing manufacturing processes between the physical and the cyberspace (J. Cheng, Chen, Tao, & Lin, 2018), covering production and logistics in the supply chain (Lu & Ju, 2017). CPS will enable the creation of Smart Factories with decentralized and autonomous control and organization (Hofmann & Rüsch, 2017). Although there is no consistent definition (Hozdić, 2015), Smart Factories can be comprehended as self-behaving factories in a human-free production environment (Oztemel & Gursev, 2020).

On the other hand, to meet the demand, computational resources and the internet providing responsiveness to manufacturing systems are needed. At this co-creation stage, with the adaptation of manufacturing to the individual requirements in real-time, 3D printing will mean a new manufacturing paradigm with a promising strategy in the one-of-a-kind products possible. 3D printers with personalized manufacturing technology can be distributed throughout different locations and households. These can potentially change the manufacturing and supply chain industry, reducing interurban freight transport and warehouse storage needs (Chen, Pan, & Ouyang, 2014; Taniguchi, Thompson, & Yamada, 2016).

The goal is to provide the most comfortable experience to consumers, allowing them to buy whatever they want and have it at the place and time they choose. Empirically, it is possible to notice that marketing and sales have been becoming increasingly target and niche-oriented to improve client acquisition costs throughout the years. For a long time, companies have followed consumer' journey and targeted them according to their shopping choices. Today, there are technologies as "Smartlook" (Smartlook, 2020) that allow companies to monitor and understand the consumer's digital journey.

While traditionally, the manufacturing order was given only after the client's purchase. In the future, purchases are expected to be instantaneous since there is a prediction of the client's choice and purchase time.

With the collected historical data, the purchase personalization and the supply chain's arrangement to attend to the demand are expected to be increasingly based on predictive analytics. It is expected that each consumer be associated with a footprint based on historical information. The prediction will be the first step before the definition of the entire chain. It is therefore said that the manufacturing order is given even before the consumer makes the purchase. The lead and delivery times will be shorter because of the possibility of optimizing the supply chain and bringing manufacturing closer to the delivery location, possibly already within the last-mile.

Additionally, each return shall correspond to a new delivery. When the client makes a return request, the driver who picks up the product to be returned delivers the new one (Figure 12.2).

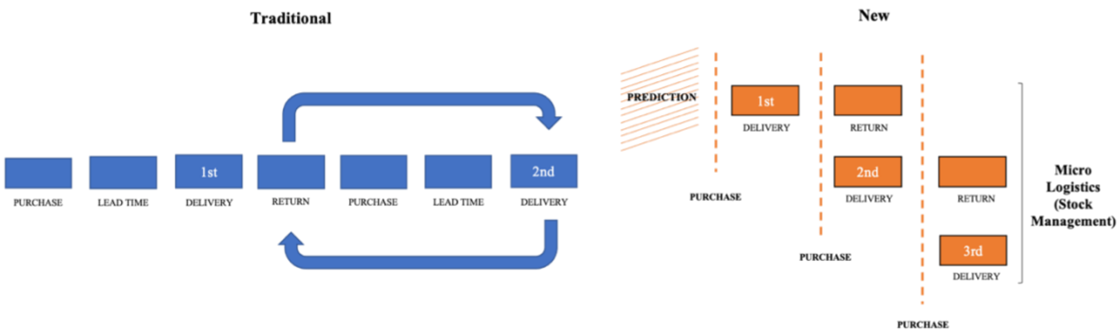


Figure 12:2 Traditional vs New

The differences between the traditional and the emergent model are described in Table 12.2.

Table 12:2 Comparison between the Traditional and the New models

Subject	Traditional	New
Purchase	Limited to the existing items	Personalized, infinite solutions and combinations
Lead time	It depends on manufacturing agility	It depends mostly on prediction capacity and manufacturing location
Delivery	Rigid transportation and delivery options	At the chosen exact time and location
Return	Two steps additional delivery process	At the same time as the following delivery

This perspective moves from a reactive to a proactive approach. Moreover, the prediction is not just expected to be about the product's requirements but also about the delivery's convenience.

Pattern behaviors will be obtained, and companies will understand precisely what phase of their lives the consumers are, to target them with the right products and promotions.

Following the technological improvements, data will be the engine to perceive consumers' behaviors triggering the entire manufacturing process. The step where the client feels that he is buying something is a further step from the cyber layer's manufacturing order.

These premises are illustrated in Figure 12.3 as the shape of an Hourglass figure.

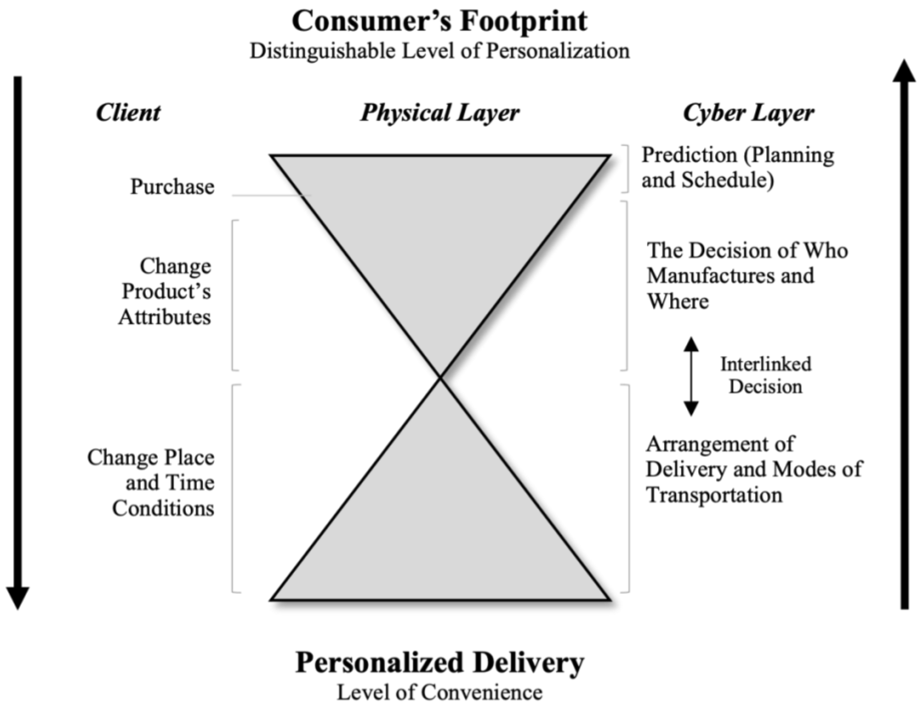


Figure 12:3 The Hourglass Model

Personalization can be found at the beginning and the end of the value chain. Each client's requirements will be different from each other, which will dictate the top of the chain. On the other hand, the ways of executing the individual delivery will dictate the bottom. In the middle is the transference of the goods from manufacturing to their transportation. The process is increasingly intended to be automated and standardized.

Delivery is expected to have an increasing preponderance in the entire process. The difficulty of making personalized deliveries, decreasing stock periods, and needs as possible makes the production timing increasingly aligned with the availability of resources to carry out transportation.

Manufacturing and logistics are linked. Moreover, the decision is at the same time top-down and bottom-up. Based on the purchase's prediction on the top, the supply chain is organized from the bottom. The fulfillment of the last-mile delivery step, a concept that emerged in the telecommunications industry to refer to the network's final leg (Xiao, Wang, Lenzer, & Sun, 2017), will be the input to define the manufacturing timing.

The ultimate fulfillment of personalization will be made when the consumer has the chance to modify every aspect of the process in real-time. Because of that scenario, the capacity to adapt to the always-changing conditions is exceptionally complex. It is only possible due to the vertical integration between departments of the same company and horizontally, where physical assets and information details can be shared throughout the network (Figure 12.4).

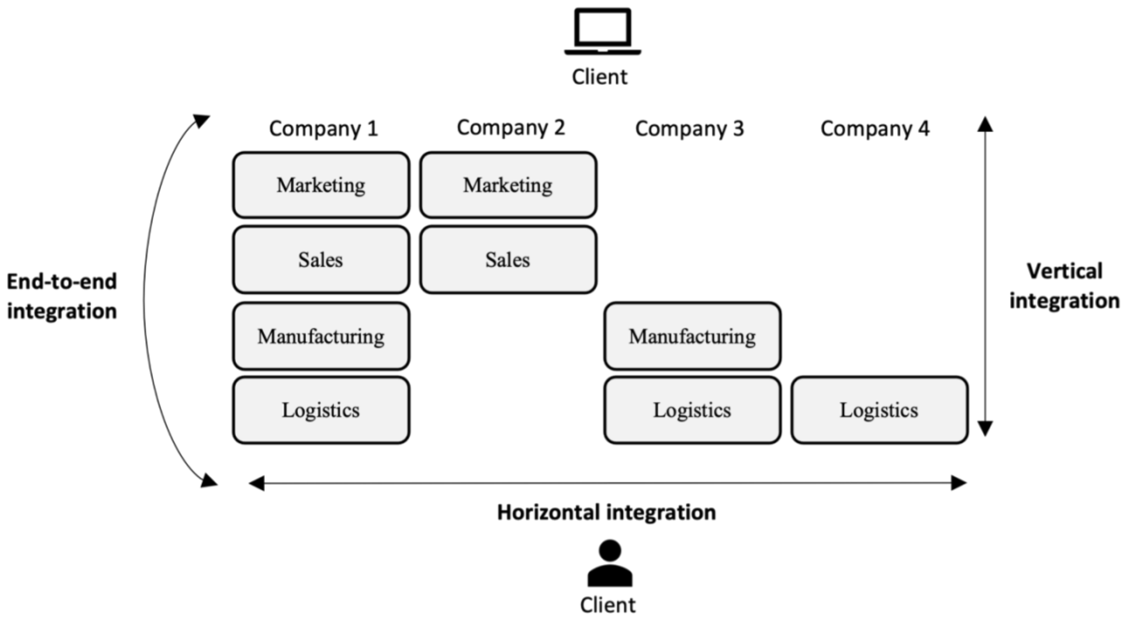


Figure 12:4 Industry 4.0 axes integration

The vertical integration allows better coordination among the different departments of the company. As previously mentioned, this coordination is expected to be made from logistics until the prediction of purchases based on data analytics.

Horizontal integration can be found at all stages. The knowledge about consumers can be shared, and the strategies to reach a specific target can be shared. Business models based on shared revenues will reinvent how the ecosystem interacts and how they are sold. The resource sharing in manufacturing and logistics will reduce operational costs and improve the competitiveness among the sectors.

With a resource share and flexible model, it is expected that proprietary operations may extinguish. Companies will focus on increasing the value of intangible aspects of their products and leave logistics or manufacturing to others. Alongside the evolution of Industry 4.0, shared business models are expected to grow, making the vertical and horizontal integration a diagonal integration.

The Industry is striving to a point where the process starts before the manufacturing order and may have the most diverse constraints. However, like when an Hourglass is turned upside down, the process keeps moving forward because there is no way to turn back as the client is waiting to the purchase delivery. People will increasingly want their purchases as soon as possible. Thus, the Hourglass way of thinking refers to the constant challenge of aligning the means for the necessary production and distribution, based on the sharing economy, to reach the goal of delivering as soon as it is possible.

After having the consumer's purchase time prevision, two options should be considered for manufacturing: 3D Printing and Smart Factory. The decision between the two options will be closely linked to the logistics component and the ability to satisfy the desired convenience level. According to manufacturing location, freight transportation may not be necessary if production is made closer to the client. In this case, the delivery will focus mostly on the last-mile. Figure 12.5 shows several examples of each step.

The level of convenience can be summarized by the client's choice of the delivery option. That can range from the delivery at a desired place and time or the choice of a pickup point in the city to pick up the purchase.

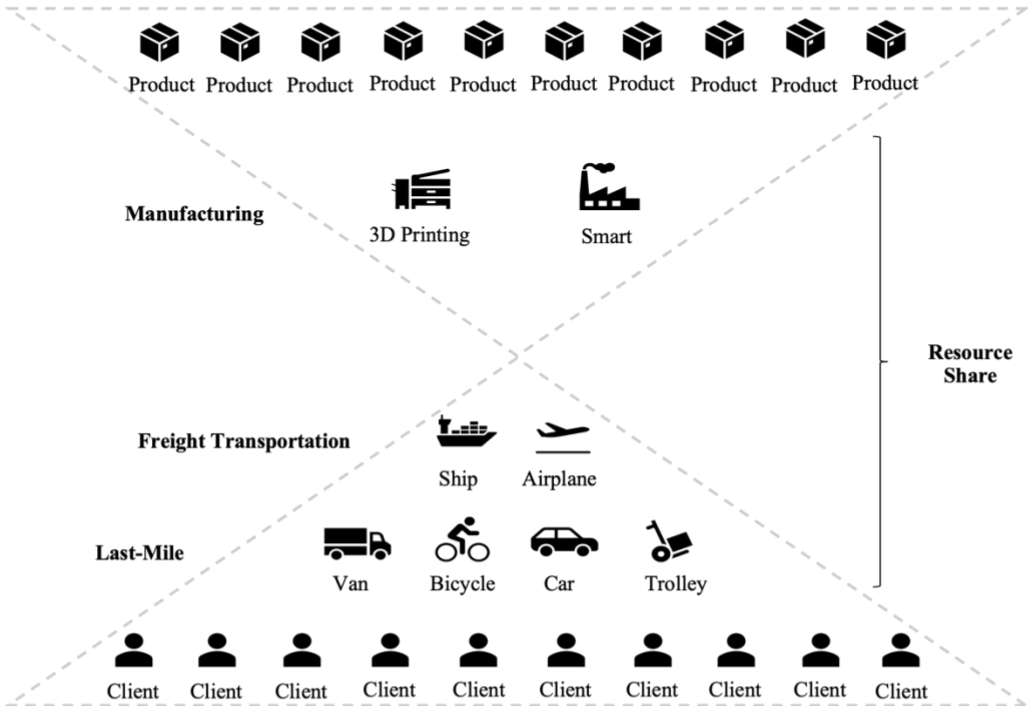


Figure 12:5 Physical Layer

12.5. Conclusion

From the study of 74 companies, it was possible to confirm that consumers still do not have the chance to purchase a personalized service in terms of product specifications and delivery convenience. The empirical study showed that only 5 of the 74 companies allow product’s personalization. Only one allows the choice of the exact time for the delivery, using its delivery assets. Additionally, many companies that allow the delivery in 1 or 2 days require the purchase to be made by a specific time in the previous day and charge an extra amount.

Personalization is characterized by producing what the client wants (distinguishable level of product’s personalization) and delivering it at the place and time he wants (level of convenience). The supply chain will increasingly be arranged from predictive analytics of the combination of consumers' behavior and the resources' availability to perform the delivery. The vertical, horizontal, and end-to-end integration will allow creating an open network where assets and resources are flexibly shared to provide more connection points throughout the globe to enhance the supply chain processes' interoperability. On the other hand, with a resource share and flexible model, it is expected that proprietary operations may extinguish. The decentralization of operations will permit facing unforeseen changing conditions.

Moreover, the Industry is striving to allow immediate deliveries. Real-time fulfillment will only be possible when manufacturing is transferred closed to the client, and the supply chain moved to the last-mile. The distribution of 3D printers throughout different locations and households and the capacity to perform real-time deliveries, can potentially disrupt the Industry.

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Chapter 13

Smart Supply Chain Management: The 5W1H open and collaborative framework

Reference

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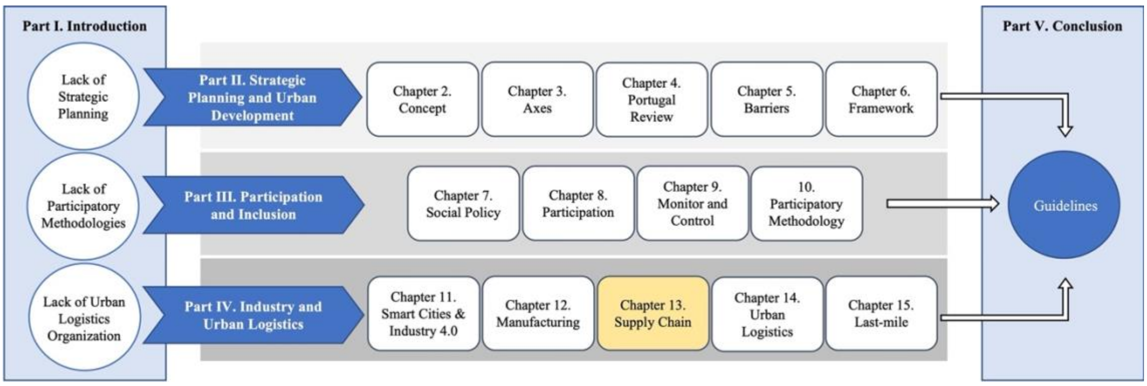

13. Smart Supply Chain Management: The 5W1H Open and Collaborative Framework

Abstract

During the Covid-19 pandemics, many companies had to cease their activities due to the scarcity of raw material supply or availability of goods' transportation modes. Simultaneously, vehicles from different enterprises were still performing similar routes, delivering goods to the same clients or nearby locations, with a small percentage of their capacity filled. The ability to optimize resource usage, re-adjust, and search for alternatives should depend on an integrated real-time decision. Open collaboration between stakeholders in terms of human resources, assets, and data sharing is vital. Industry 4.0 and mostly additive manufacturing can leverage the production closer to the client, eliminating logistic intermediaries' steps, cutting warehouse expenses and delivery costs, and promoting sustainability. Therefore, this paper proposes an adapted framework from the 5W1H (Who, Why, What, Where, When, and How) quality management methodology to organize the supply chain based on the client's personalized inputs and stakeholders' integration.

Keywords: smart logistics, industry 4.0, Smart Cities, supply chain and 5W1H.

13.1. Introduction

One of the most natural resource consumer and greenhouse gas emission sectors is logistics. Congestion has an estimated cost in the European Union of 100 billion per year (European Commission, 2007). Urban logistics is one of the leading causes of congestion in cities representing between 8% and 18% of urban traffic. It decreases road capacity by 30% because of pick-up and delivery services (Nocerino, Colorni, Lia, & Luè, 2016).

On behalf of the Green Deal, the European Commission has the ambition of achieving carbon neutrality in the European Union by 2050. Sustainable industry and sustainable mobility are among the policy areas of the Green Deal (EC, 2019). Moreover, two of Green Deal goals are shifting to sustainable and smart mobility and the industry's mobilization to a clean and circular economy (European Commission, 2019).

Throughout time, the aim was to find standardized ways to optimize material flow and logistics. Nowadays, the Industry is striving to provide a personalized real-time service to consumers (Kaoutar Douaioui, Mouhsene Fri, Charif Mabroukki, 2018), allowing them to have the right product at the right time in the right place with the proper condition (Uckelmann, 2008; Wang, Ma, Yang, & Wang, 2017).

The use of Information and Communication Technologies (ICTs) in the supply chain to improve sustainability are still limited. Therefore, to increase resource efficiency, there is a demand to create new solutions and approaches (Hilpert, Kranz, & Schumann, 2013).

The mobility of people and transportation of goods are critical challenges for the future. The reliability of transport systems is crucial since most (smart) city services will depend on them (Schlingensiepen, Nemtanu, Mehmood, & McCluskey, 2016). Moreover, they will increasingly be flexible and multi-modal (Prause & Atari, 2017). Nevertheless, traffic congestion is still affected by individual decisions. Technological routing tools have brought some advances in decision support to avoid congestion. However, these are ineffective because they do not tackle the major problems of having complex supply chains and the inefficiency associated to the lack of collaboration among stakeholders.

This area urges to face a disruption capable of guaranteeing a better service to fulfill personalization in less time and resources. Therefore, resources must be predictively allocated to follow an overall benefit. Peaks must be eliminated, and faults must be overcome.

Moreover, there is a lack of a framework to enable collaboration among stakeholders to avoid congestion by reducing circulating vehicles.

13.2. The Importance of Logistics in Smart Manufacturing

Industry 4.0 or Smart Manufacturing's primary goal is not to replace the existing manufacturing assets but to ensure interoperability and interconnectivity among players using ICTs and standards (Trappey et al., 2017).

Smart Manufacturing can generate the optimal value stream and new business models based on better predictive maintenance, robustness in product design, and adaptive logistics (Thoben, Wiesner, & Wuest, 2017).

Traditionally, manufacturing was seen as an in-line process or sequence where raw materials were turned into goods. It was challenging to monitor and predict manufacturing processes due to the lack of ICT supporting the supply chain. Traditional distribution and supply chains are not capable of dealing with the future development of production. It is needed a supply chain highly flexible to provide robust customization of products and tailor the products for specific clients (Schlingensiepen et al., 2016).

Smart Manufacturing links networked manufacturing, cross-company production, and logistics through an Internet-based machine-to-machine (M2M) interaction, allowing the tracking, control, and organization of goods during their entire lifecycle. Logistics with the premise of providing real-time handling and transport tracking is what makes Industry 4.0, in its pure vision, a reality (Hofmann & Rüsch, 2017).

Products are becoming smart because intelligence is being added to the manufacturing process and handling. The entire process is submitted to continuous monitoring. With the interconnection of systems, there is a possibility of creating an effective demand-oriented manufacturing process (Lom, Pribyl, & Miroslav Svitek, 2016).

Wasteful travel time due to the significant variation of today's demand, the complexity of transportation networks, and increasing vehicle fleets are some of today's problems (Lee, Kang, & Prabhu, 2016). There is the need to have logistics systems to help, in a cost-effective way, to design, plan, implement and control the forward and reverse flow of goods from the origin point to the destination, according to client's requirements and guaranteeing resources efficiency, the security of goods, and on-time distribution (Jabeur, Al-Belushi, Mbarki, & Gharrad, 2017).

The inclusion of Industry 4.0 technologies, namely the Internet of Things (IoT) and Cyber-Physical Systems (CPS), providing real-time data and updates to environmental changes, turns logistics into a flexible, scalable, and intelligent process. Stakeholders' relationships can be linked through a Multi-Agent System (MAS) (Karakikes & Nathanail, 2017).

Thus, the embracement of networked manufacturing, adaptive logistics, and client co-design will turn the value chain open, collaborative, and evolutionary (Prause, 2016).

13.3. Smart Logistics

The growth of the urban population has also caused an increase in goods transportation in the city center. This has an impact on traffic congestion, the environment, and energy consumption. Therefore, a cooperative logistics with win-win business collaborations scheme must be put in place to optimize urban freight transport contributing to cities' sustainability and livability, mitigating the evident problems (Nathanail, Gogas, & Adamos, 2016).

Korczak and Kijewska (2019) noticed that the term "Smart Logistics" emerged at the beginning of the 21st century and was known as decentralizing decision-making to local systems. The concepts of interaction, sharing, and autonomy were introduced to improve the efficiency of transport and storage processes, trying to solve the last-mile delivery costs. The goal was to strive for an integrated model where ICTs help schedule and plan the entire process faster and provide a larger spectrum of products to the clients. On the other hand, Smart Logistics is also related to planning and controlling logistics processes from the data gathered with the tracking and identification of elements until the detection of the problem, choice, and automatic execution of the solution (McFarlane, Giannikas, & Lu, 2016).

Nowadays, the supply chain is evolving into an open cross-company network with short-term collaborations (Kirch, Poenicke, & Richter, 2017; Uckelmann, 2008). However, there is still a lack of coherent strategy to manage all supply chains sustainably and efficiently (Bag, Telukdarie, Pretorius, & Gupta, 2018). Information processing and sharing capacity to fulfill client expectations are becoming vital among logistic service providers (Kawa, 2012).

Logistics evolution is aligned with the complexity of client requirements. It has passed from the logistic operation managed by manufacturing companies themselves to the outsourcing transportation and warehousing to the organization and managing information flow by third parties, to, at last, the inclusion of fourth-party logistics, which serve as planners, mediators, and integrators of the entire supply chain. The emerging concept of "one-stop logistic" (1SLP) aims to cover the full spectrum of the service from manufacturing and delivery to sales and marketing (Trappey et al., 2017).

Therefore, last-minute and individual demand emerge the importance of defining new dynamic business models (Kagermann, Wahlster, & Helbig, 2013), embracing cooperation and integration among all stakeholders. Moreover, the supply chain will be modular or fractal, decreasing the entry barriers for other companies (Prause & Atari, 2017). There will be a promotion of global connection and understanding between companies from different locations and sectors through the supply chain (Oztemel & Gursev, 2020). The process may include manufacturing, warehousing, freight transportation, and last-mile delivery.

There is a need to have an automated decision system to control all elements and deal with the need to provide immediate deliveries and dynamic order fulfillment (Lv, Tu, Lee, & Tang, 2018), i.e., a system that incorporates the knowledge from the behavior and coordinates predictive manufacturing timings with logistic processes. (Nick, Pongrácz, & Radács, 2018).

13.4. The 5W1H Framework: Proposed Conceptual Model to Arrange the Supply Chain

The path to a more sustainable supply chain involves transitioning to a circular economy model where all agents in the chain are integrated and can collaborate. Unlike the traditional vertical standard model, the emerging paradigm does not require single-agent control but maximum collaboration between the various actors thanks to the digital transition. Moreover, digital transformation in the supply chain enables sharing data between actors and real-time data analysis, breaking organizational silos and increasing collaboration and communication.

Sharing economy services are gaining momentum at the same time that retailers consider crowdsource transportation of goods. Smart Logistics will promote the optimization throughout the value and supply chains, reducing stocks and shortening stoppages striving the concept of "1SLP" to increase quality, customization, and value to products. To accurately answer the individual needs of the design promoted by clients and individual orders, new business models and players (startups) enter the sector (Korczak & Kijewska, 2019).

Artificial Intelligence (AI) will be a critical element in transportation. Mobility provision and transportation of goods impact shall be improved by intelligent transport systems (ITS). This automated decision support tool understands and satisfies the demand (Nikitas, Michalakopoulou, Njoya, & Karampatzakis, 2020). This IoT-CPS-based application integrates transportation systems, communication networks, control and, computing technologies (Nguyen, 2020). Thanks to 5G, the vehicular network will allow vehicles to connect, exchanging massive real-time (and historical) data to guide, predict and offer the most efficient and secure route to clients (and goods) from their initial locations to their final destinations (Lin, Yu, Yang, et al., 2017; Lin, Yu, Zhang, et al., 2017; Min & Wynter, 2011).

Purchases will increasingly be made online, meaning that logistics will have a strong preponderance on the success of e-commerce. It is necessary to define a new paradigm — a supply chain based on a revenue share basis and adaptable to its needs. Sustainability will only be achieved through the breakdown of the traditional supply chain and the collaboration of stakeholders and individuals.

So far, companies have increasingly recurred to third party's private e-commerce platforms to sell their products and external logistics services. However, they still face a significant challenge of delivering in real-time and make personalized deliveries at the place and time the client wants. Mostly because it is still produced in a central location (far from the consumer) or there is not a collaboration between stakeholders to allow real-time deliveries according to the client's requirements.

Moreover, 3D printing brings companies' the ability to become more responsive. Production is done closer to the client, reducing the lead time (Kang et al., 2016). Mass production will move to an individual personalization with low volumes (or unique) of production through additive manufacturing, ensuring the client's fundamental wishes and the planet's sustainability (Paritala, Manchikatla, & Yarlagadda, 2017).

People who (will) have 3D printers can produce components for the open network. That can be assembled in a common point, or the client himself can do the assembly. It may be easier and cheaper to manufacture in the destination country than to transport from the country of origin, even with a wholly optimized standard supply chain. In this way, the production can be transferred closer to the client, reducing transport costs and customs import or export fees. Furthermore, the supply chain process turns out to be composed mainly through last-mile fulfillment. Where vans and cars can be replaced by smooth transportation modes to deliver the goods from local manufacturers or warehouses.

Industry 4.0 brings two paths (Figure 13.1), namely the real-time setup of the supply chain depending on the ability to transfer production closer to the client or whether different warehouses and means of transportation can be flexibly organized for a competitive delivery. All connected, share-revenue biz models, shared spaces, and assets, reducing the needed resources. Before production, the whole process is designed in terms of raw materials and the necessary infrastructure.

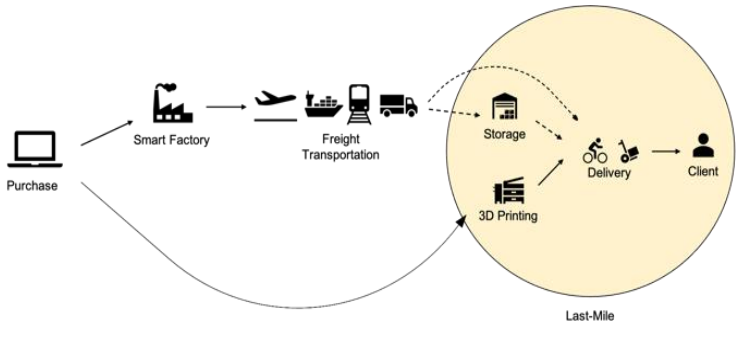

Figure 13:1   Product journey

This interoperability will enhance the combat to extreme events as the Covid-19 pandemic, breaking silos and dependencies, permitting companies to find solutions for manufacturing, transport, or warehousing dynamically.

The business model itself should be on the way. Suppliers are often paid 30 or 90 days, which causes cash flow issues. Therefore, for each step performed, a specific amount should be debited. Billing integration plays a vital role in the given definition of Smart Logistics. Nevertheless, up to now, there has not been a comprehensive approach for an open and integrated billing solution (Uckelmann, 2008).

Moreover, there is a need for an open platform to allow non-dependency on specific suppliers. This platform would serve as a digital marketplace to integrate all supply chain elements, from factories and micro manufacturers to warehouses and transportation modes.

After a purchase is made, the supply chain is built from scratch to enhance one (or more) of the three main objectives:

X - Objective 1: Fastest Shipping;

Y - Objective 2: Cheapest Shipping;

Z - Objective 3: Least Environmental Impact Shipping.

"a", "b" and "c" are the weights of each objective, respectively. The weights are defined by the client in the purchase moment, as shown in Figure 13.3. They are related between themselves and can be represented by the function:

$$W = f(aX, bY, cZ), (a, b, c, X, Y, Z \in \mathbb{R}^+).$$

That will be the input to arrange the supply chain accordingly to the client's specifications.

Usually, the client does not have the chance to choose the exact time of delivery. It is only granted the option of delivering the products in a range of days without any indication of the hour probability at which the delivery will take place. This causes discomfort and an unpleasant experience for the client. It happens because of the logistical incapacity, lack of monitoring and interoperability between systems, and inefficient stock and production control.

To allow the option of choice of the exact time for the delivery is necessary to perfect coordination between the various actors, avoid mistakes, and guarantee smooth trespassing of goods by the various elements of the constituted supply chain.

The transparent and open collaboration between elements of the supply chain, dynamized through information and communication technologies, will dictate whether it is more feasible to produce closer to the client or not. It will also allow companies to recur to local warehouses and retain stock, even if it is just raw materials to supply the micro manufacturers. Each phase of the process will take the initial definition of the objectives into account.

Assuming that there is a Marketplace where all elements of the supply chain can be considered, it will be verified for each step, which is the most appropriate option to achieve the objectives according to the client's weights. In practice, after the purchase, the client will choose the exact day, time, and place for the delivery (after defining the personalization of the product) and associate a percentage (weight) to each of the supply chain's objectives.

Any decision-making time during the process will base a new search on the marketplace for the option that will maximize and minimize each of the delivery objectives stated. Although there will be predictive data analytics to prepare the supply chain, it will ultimately depend on the client's final decision to be set up. The data sources will mostly be retailers' websites. They shall be integrated into the Cyber-Physical System, linked to the collaborative marketplace to efficiently enhance the best supply chain, as represented in Figure 13.2.

Figure 13:2 Open Collaborative Model

The front end of this integration on each retailer's websites through a dedicated API (Application Programming Interface) is mirrored in Figure 13.3.

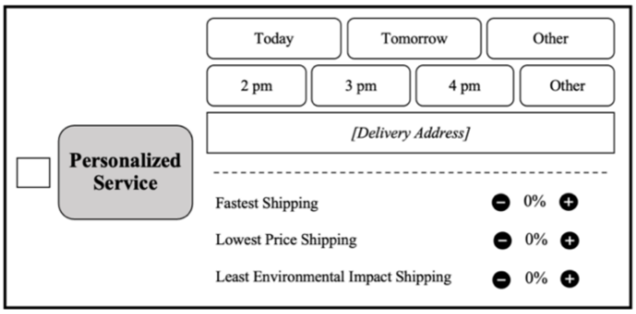

Figure 13:3 API Website Integration

Therefore, the supply chain will be planned based on the adaptation of the quality management 5W1H methodology (What, Why, Who, Where, When, and How). It is usually used to map a specific process or task, define responsibilities and allocate resources. The order requirements will first be described in terms of the product's typology, the level of personalization required, and the conditions of transport and storage are necessary since the most appropriate logistics solution will have to take this into account. The manufacturing process will be adjusted accordingly. The available options will be chosen as the best ones according to the above equation result and the associated weights. The same criteria will be used to set up the delivery option in the last part of the process to allow the client to know the exact time that the order will be delivered.

It will always be searched within the options obtained, the one that represents the best combination of the three objectives identified above (or one in particular to the detriment of the others). The output will be the suitable supply chain that answers the order's specific requirements in terms of *what to produce, how, who, where, when, and why*, as represented in Figure 13.4.

Therefore, the best combination of collaboration will be searched within the Marketplace, open to all stakeholders, whose results are the best towards the considered goals. Depending on the product specifications, the most suitable option is to manufacture it combined with the logistic and delivery combination of assets to deliver the product at the place and time the client chose.

Figure 13:4   5W1H Framework

This conceptual model will depend on the existing interoperability and resource sharing.

13.5. Conclusions and Future Work

The Supply Chain is evolving into a shared-revenue multi-modal model where vertical, horizontal, and end-to-end integrations are vital. Moreover, warehouses, physical assets, and human resources from other stakeholders can make part of the supply chain to fulfill a specific request.

Following a new purchase, must be considered the product specifications (What) to understand the manufacturing process (How) to allocate the order for a specific manufacturer

(Who) of a specific location (Where), at the right time (When) to meet the client's requirements considering the results of the equation based on the associated weights (Why). The real-time supply chain must be based on the capacity to leverage production close to the client and breakdown traditional supply chains.

Personalization and small series manufacturing are increasingly disabling the rationale of mass production and standard supply chains. Disruptive models and concepts need to emerge to promote sustainability and tackle inefficiency. There are still many challenges to address, as the impact that the break down of the traditional supply chain may have on society, environment, and economy. This paper's input is expected to base forward investigation and empirical testing about the real-time and flexible collaboration among stakeholders.

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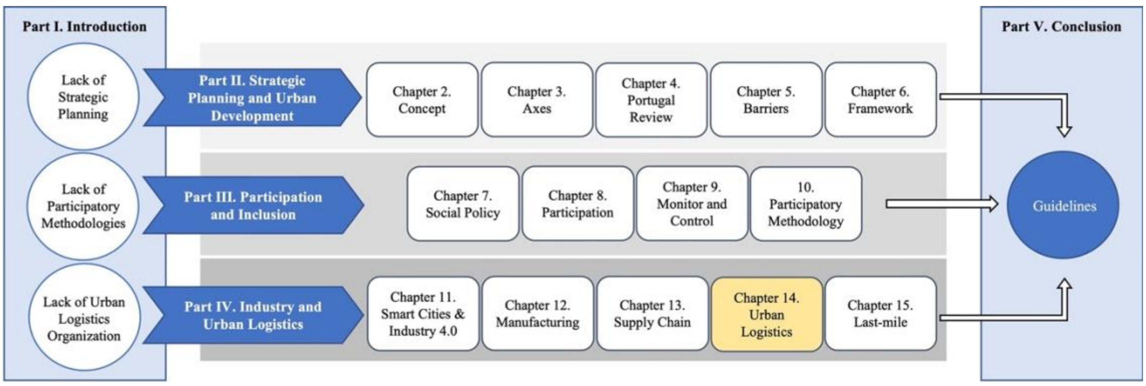
Chapter 14

Logistics 4.0 applied to Urban Planning: last-mile fulfillment for sustainable and inclusive Smart Cities

Reference

Correia, D., Vagos, C., Marques, J. L., & Teixeira, L. (2022). Logistics 4.0 applied to Urban Planning: last-mile fulfillment for sustainable and inclusive Smart Cities. *Logistics*.



14. Logistics 4.0 applied to Urban Planning: last-mile fulfillment for sustainable and inclusive Smart Cities

Abstract

Urban Logistics is being challenged to decrease circulating vehicles and their travelled distances in city centers. In addition, the COVID-19 pandemic exposed the inefficiency of current urban logistics to fulfill citizens needs and accelerated the necessity to rethink cities. Urban planning lacks the consideration of innovative logistics models to increase city responsiveness and meet citizens' real-time necessities while optimizing resource usage. In line with these concerns, empirical evidence was collected through a questionnaire to Portuguese policymakers, and the results were discussed in a focus group with experts. Results suggest the dependency of cities on the human resources and logistics coordination capacities of the private sector. Thus, this paper proposes a tool to help decision-makers guarantee that citizens' necessities are fulfilled within a timeframe of 15 minutes while sustainable urban logistics schemes are set up based on the dynamic cooperation of stakeholders and sharing of resources.

Keywords: Urban Logistics, Smart Cities, Industry 4.0, Logistics 4.0, Last-mile and Urban Planning.

14.1. Introduction

While consumers demand is pushing for real-time personalized fulfillment, entities' resources are putting pressure on the last-mile. One of the current cities' challenges is to promote the integration and interoperability of stakeholders to combat the spread of individual companies' vehicles and warehouses in the city center. Unintegrated logistics activities challenge cities sustainability (Bibri & Krogstie, 2017). Furthermore, it is cities' primary cause of congestion representing between 8% and 18% of urban traffic and 21% of CO2 emissions in residential areas (Nocerino, Colorni, Lia, & Luè, 2016; Russo, Rindone, & Panuccio, 2016). Local authorities have a growing concern about the concentration of parcel deliveries in cities because it is disturbing citizens' quality of life (Behrends, 2016; Ducret, 2014). Thus, innovative and integrated approaches are necessary since the regulation role of policymakers on organizing urban logistics has not been effective.

Policymakers have enjoyed the emergence of Smart cities to fill the existing gap on the lack of urban data to base their decisions (Batty et al., 2012; Chourabi et al., 2012; Hall, Bowerman, Braverman, Taylor, & Todosow, 2000; Harrison & Donnelly, 2017). Internet-of-Things (IoT) increased authorities' responsiveness and promoted the creation of standards (for the integration of different platforms and applications) to allow cities to have a centralized operating picture (Jin, Gubbi, Marusic, & Palaniswami, 2014; Mulligan & Olsson, 2013). This has permitted cities to build control centers (also known as urban platforms) where data is analyzed and promptly taken action (Cheng, Longo, Cirillo, Bauer, & Kovacs, 2015; Gutiérrez, Amaxilatis, Mylonas, & Muñoz, 2018; Townsend, 2000). Policymakers have been allowed to base their decision on real-time analytics and predictive models associated with historical information (Correia, Teixeira, & Marques, 2021b, 2021a; Kitchin, 2014). Nevertheless, the optimization of urban logistics and the automation of stakeholders' relationships have been neglected.

Urban planning, on behalf of Smart Cities development, has been focused on the proactivity to respond in case of a service disruption (e.g., traffic accident, water supply or energy breakdown), and on taking urban infrastructures closer to citizens to increase their quality of life. Moreno et al. (2021) noted the need to assist citizens with closer public services. The authors proposed a "15-Minute city" conceptual approach of making essentials available by foot or bicycle. The availability and diversity of local urban amenities are expected to increase walkability and local mobility within residential areas (Graells-Garrido, Serra-Burriel, Rowe, Cucchietti, & Reyes, 2021). This approach poses alternative thinking to traditional urban planning about optimal resource allocation on a citywide scale. The main objective is to bring activities to the neighborhoods rather than taking people to activities (Pozoukidou & Chatziyiannaki, 2021). Nevertheless, the COVID-19 pandemic deprived citizens of their basic freedom right and demanded their lockdown. This fact revealed the importance of optimizing urban logistics to meet citizens' needs without leaving their houses.

In this matter, literature still lacks the integration of city planning with urban logistics to promote citizens inclusion and fulfill their necessities. Furthermore, the same understanding of Moreno et al. (2021) can be applied in the reverse direction, without the need for the citizen to move.

Therefore, this paper aims to design an open logistics model to help policymakers adjust the storage locations and delivery means to meet real-time citizens' needs. Thus, this study seeks to answer the question, *"How can cities meet citizens' needs in 15 minutes while reducing the number of vehicles and their travelled distance?"*.

A two-folded objective empirical study was conducted. First, to ask policymakers about their readiness to solve logistics issues arising from unexpected events (worst case scenario context) and their opinion about the challenges they would face to provide a 15-minute response to citizens' needs. Second, a focus group was set up to discuss the results of the quantitative and qualitative analyses of the questionnaire to conceptualize a solution to support policymakers' decision.

The paper is structured as follows: in section 14.2, a literature revision is performed to have background information on the evolution of urban logistics and last-mile deliveries, the state-of-the-art of vehicle routing, and the selection-location problem. In section 14.3, a two-step empirical research that considers a questionnaire and a focus group are detailed. In section 14.4, quantitative and qualitative analyses are performed. The significance of the characteristics of respondents (gender, age, city dimension and their position) are evaluated. Ultimately, a solution based on the empirical findings is designed. Section 14.5 presents the discussion of the results. Finally, conclusions and future work are highlighted.

14.2. Theoretical Background

This section first reviews the current Urban Logistics approach and the need to integrate Logistics 4.0 background to increase cities responsiveness. Second, it gives an overview of the evolution of last-mile delivery models and optimization rules. Finally, the selection and location problem methods are reviewed, focusing on the placement of warehouses.

14.2.1. Urban Logistics and Logistics 4.0

The capacity of the physical systems (e.g., buildings, communication, and energy) to survive extreme stresses, or the capacity to cities face an unexpected event without suffering devastating losses, damage, diminished productivity, or decreased quality of life, defines a

Resilient city (Godschalk, 2003). Nevertheless, to events as the COVID-19 pandemic, the resiliency of cities may be explained by their preparation to coordinate real-time urban logistics to answer citizens' needs, since it does not represent physical damages to infrastructures rather than the forbidden of the right of freedom to inhabitants

Urban logistics or city logistics refer to the urban goods movements that result from logistics decisions that are intrinsically related to the existing demand and the behavior of economic agents (Laetitia Dablanc, 2007). The concept is usually described as optimizing the transport activities in urban areas (Taniguchi, Thompson, Yamada, & van Duin, 2001). Thus, it refers to the proper planning of goods distribution within a city, managing and controlling the freight movements considering the integration and coordination among stakeholders (Amaral & Aghezzaf, 2015; Morfoulaki, Mikiki, Kotoula, & Myrovali, 2015). Public authorities' goals have been twofold: high accessibility of their city-region and an effective intra-urban transport network, and reduction of the impacts of freight traffic for a high quality of life increase (Behrends, 2016).

Dablanc (2007) stated that goods movements were indifferent to cities, freight mobility policies were inefficient, and the trend for appropriate logistics services and population needs were growing and concluded that transport practitioners had to work closely with planning departments. Furthermore, Lagorio, Pinto and Golini (2016) reviewed the main topics of urban logistics and concluded that stakeholder involvement (engagement in the development of city logistics' projects) was one of the most frequently related subjects.

Throughout the years, several reflections emerged on how urban freight activities could work towards cities' sustainability. Usually, they were attached to the introduction of policies by government bodies to force companies to change their actions or company-driven changes (Anderson, Allen, & Browne, 2005; Muñuzuri, Larrañeta, Onieva, & Cortés, 2005).

The subject has concerned both private and public decision-makers. However, the discussion shall advance to the role that policymakers shall undertake to promote the integration of stakeholders and sharing of resources.

Moreover, innovative approaches connected with Industry 4.0 technologies could be considered to increase the logistics responsiveness of cities while promoting their sustainability and increasing inhabitants' quality of life.

Logistics 4.0 derived from the Industry 4.0 background to tackle the new challenges in the sector, such as the transparency and integrity of the supply chain providing real-time information and guaranteeing that the right products are delivered at the right time, place, quantity condition and the right cost (Barreto, Amaral, & Pereira, 2017). The concept was characterized by Timm and Lorig (2015) as the pivoting from hardware-oriented to software. Thus, it represents the satisfaction of individualized customer demands, supported by intelligent systems to achieve a significant automation degree and data visualization (Facchini, Olésków-Szłapka, Ranieri, & Urbinati, 2020).

Strandhagen et al. (2017) attributed five characteristics: real-time Big Data analytics, reduced storage requirement, autonomous robots, information exchange in real-time, and no information disruption. Winkelhaus and Grosse (2020) reviewed the Logistics 4.0 litera-ture and defined a framework considering human factors, logistics tasks, and the applica-tion domains. Nevertheless, a domain was not found related to urban planning and the relationship of private stakeholders with governmental bodies. Thus, the advancements in logistics lack application (a public integrated omnichannel) on the organization and allocation of city resources to the population's needs.

14.2.2. Last-Mile Fulfillment and Instant Deliveries

The classical Travelling Salesman Problem (Jünger, Reinelt, & Rinaldi, 1995), in which the vehicle starts from a warehouse visits several customer locations to minimize the total traveled distance, has evolved to the Single Depot Vehicle Routing Problem (SDVRP), where the goal is to minimize the traveled distance of all the vehicles while meeting customer demand and operating constraints (Dantzig & Ramser, 1959). Later, Multi-Depot Vehicle Routing Problem (MDVRP) extended the SDVRP model, or simply VRP, by dispersion of multiple depots where multiple vehicles can originate (Gillett & Johnson, 1976). Recently, emerged a variant of the MDVRP, called the min-max Multi Depot Vehicle Routing Problem (min-max MDVRP), to minimize the total distance travelled by each vehicle instead of the total distance travelled, promoting a more equitable sharing of load (Carlsson, Ge, Subramaniam, Wu, & Ye, 2009; Venkata Narasimha, Kivelevitch, Sharma, & Kumar, 2013).

The evolution of the Vehicle Routing Problem is intrinsically connected with the demand of the market and the tendency to provide instant deliveries. This refers to on-demand delivery within two hours performed by either independent contractors or couriers via a digital platform (Laetitia Dablanc et al., 2017). The high time-sensitivity concept, immediately executed after orders are placed, is developing rapidly. (Gu, Fan, Pan, & Zhang, 2020). First and last-mile optimization (referring to the end or beginning of the supply chain) had taken greater importance due to the wish of people to have instant deliveries (Bányai, Illés, & Bányai, 2018).

This poses a significant challenge to the traditional supply chain and exiting resources to meet the schedule. Moreover, the sharing economy has set the foundations of new innovative models (Li, Lim, Tan, Lee, & Tseng, 2020).

The fifth wave of logistics, also known as Consumer Logistics, considers three key elements: Omnichannel Retailing, the Internet of Things, and 3D Printing (Rimmer & Kam, 2018).

Supply chain will move towards local realization and the real-time urban adjustment based on the study of the most appropriate locations to store goods to deliver the goods to citizens (Shi, Liu, & Zhang, 2021; Srivatsa Srinivas & Marathe, 2021). Correia, Teixeira and Marques (2021c) envisioned a new paradigm on the last-mile that can bring manufacturing closer to consumers (recurring to 3D printing technologies) to allow the real-time fulfillment of personalized requests. Nevertheless, until there is a network of manufacturers to produce the product in real-time, the supply chain needs to be arranged to ensure the goods are available in the last-mile. Thus, to achieve this paradigm, new logistics models based on transport co-modality and sharing of mobile stock points shall emerge (Daugherty, Bolumole, & Grawe, 2019; Lim, Jin, & Srai, 2018; Srivatsa Srinivas & Marathe, 2021; Taniguchi, Thompson, & Yamada, 2016). These data-driven logistics models will depend on the collaboration schemes among stakeholders and the defined objectives (Dolati Neghabadi, Espinouse, & Lionet, 2021; Gläser, Jahnke, & Strassheim, 2021; Sundarakani, Ajaykumar, & Gunasekaran, 2021).

The routing optimization criteria depend on the initially considered assumptions. Thus, it is necessary to understand how the delivery will be performed to focus on routing optimization. At the same time, the choice of the vehicles to perform the deliveries is one of the most critical decisions to base a logistics model (Crainic, Ricciardi, & Storchi, 2004). Sharifi and Khavarian-Garmsir (2020) reflected on the central issues revealed by the COVID-19 pandemic and the recommendations post-COVID. Among them is "greening the transportation and industry sectors". Villa and Monzón (2021) noticed that, in Madrid, during the pandemic period, CO2 emissions related to e-commerce last-mile increased 43.1%. Thus, there is the need for public-private collaboration for transport and logistics operators throughout the supply chain, especially on the last-mile, and recurring to environmentally friendly vehicles (Settey, Gnap, Beňová, Pavličko, & Blažeková, 2021).

Ranieiri et.al (2018), reviewed recent scientific literature contributions on innovative strategies for last mile logistics and pointed five categories: Innovative vehicles, Proximity station, Collaborative and cooperative logistics, Optimization of transport management and routing, and Innovations in public policies and infrastructures.

Furthermore, are pointed two main options to bridge the "last-mile": pick-up points and home delivery (Daduna & Lenz, 2005; Morganti, Dablanc, & Fortin, 2014). A hybrid or integrated model may emerge where similar pick-up points can work as decentralized warehouses. Machado, Teixeira, Ramos and Pimentel (2021) proposed public transportation (bus network) to act as an integrated urban logistics option combining cargo flow with passenger transportation. Srinivas and Marathe (2021) proposed a mobile warehouse based on a moving truck with stock inventory. In addition, autonomous vehicles are expected to disrupt passenger transportation and delivery fulfillment, combating the ageing of population, isolation and promoting inclusion of the disabled (Hwang, Li, Stough, Lee, & Turnbull, 2021; Prattley, Buffel, Marshall, & Nazroo, 2020; Yang, Yeung, & Feng, 2018).

14.2.3. Warehouse Selection Location and Spatial Indexing

The location selection of warehouses may be one of the most important logistical decisions for policymakers to allow faster response while decreasing the number of needed re-sources.

Multi-criteria decision making is most widely used to solve the selection location problem (Özcan, Elebi, & Esnaf, 2011). There are many factors to consider according to the structure of the decision problem and the implicit preferences. Nevertheless, it has historically been focused on costs or service levels. Nowadays, with the increasing emphasis on social responsibility and environmental aspects, sustainability-related criteria have been intro-duced (He, Wang, Lin, Zhou, & Zhou, 2017). Therefore, one of the essential criteria is the travelled distance from the warehouse to the end-user.

In the early days, Crainic, Ricciardi and Storchi (2004) found that satellite warehouses reduced trucks' travel distance in the urban center but increased the number of vehicles and the total kilometers travelled. Warehouses throughout the years moved from the city centers to metropolitan areas due to the land costs and availability, meaning more considerable distances and increasing number of vehicles (Laetita Dablanc, 2014). Moreover, land usage distribution regulation and planning have influenced logistics sprawl and urban freight transport (Combes, 2019).

Different reflections are spread throughout the literature about the optimal location of warehouses to enhance cities' sustainability and reduce the number of circulating vehicles. Some authors observe that these should move away from the city center (Laetitia Dablanc & Rakotonarivo, 2010; Hesse, 2002). Others found more significant environmental savings of moving them closer to consumers (Filippi, Nuzzolo, Comi, & Delle Site, 2010).

Recently, Wygonik and Goodchild (2018) highlighted the need to understand operational details and include them in modelling the use case.

Spatial indexing libraries are scarce topics in the literature. Nevertheless, Google in 2017 made available the S2, an open-source library that gets nearby objects through spatial indexing (Google, 2021b; Pandey, van Renen, Kipf, & Kemper, 2021). The projection is made by subdividing the planet Earth into a hierarchical decomposition of its entire surface through three-dimensional spherical projections, obtaining and analyzing regions according to the desired granularity. Uber also launched its own open-source space indexing library, the H3, which like S2, hierarchically subdivides the Earth's geographic surface using hexagons and pentagons (Uber, 2021). It is based on the projection of the Map of Dymaxion or Map of Fuller, which allows transforming the Earth's spherical surface into an icosahedron (Atlas of Places, 2018; Gray, 1994).

These flexible models allow spatial indexing to find the best option to satisfy a real-time and constantly changing need compared to the traditional selection location problem.

14.3. Research Design

The literature review acknowledged the need for new data visualization and automation tools to help policymakers integrate stakeholders' resources. The inherent goal is to promote urban logistics responsiveness rather than just managing traffic flows. In addition, routing optimization has been evolving to reduce the number of resources applied to operations and decrease greenhouse gas emissions. The choice of the type of transportation is crucial to base the logistics model. Additionally, decentralizing the distribution centers to smaller indexed options is leading a new paradigm to find an optimized solution to the last-mile fulfillment.

This section characterizes the sample, explains the methods and describes the methodology conducted in this research.

14.3.1. Method Design

The methodology followed in this research, sketched in Figure 14.1, was divided into two steps: i) a questionnaire to policymakers and ii) a focus group with industry experts.

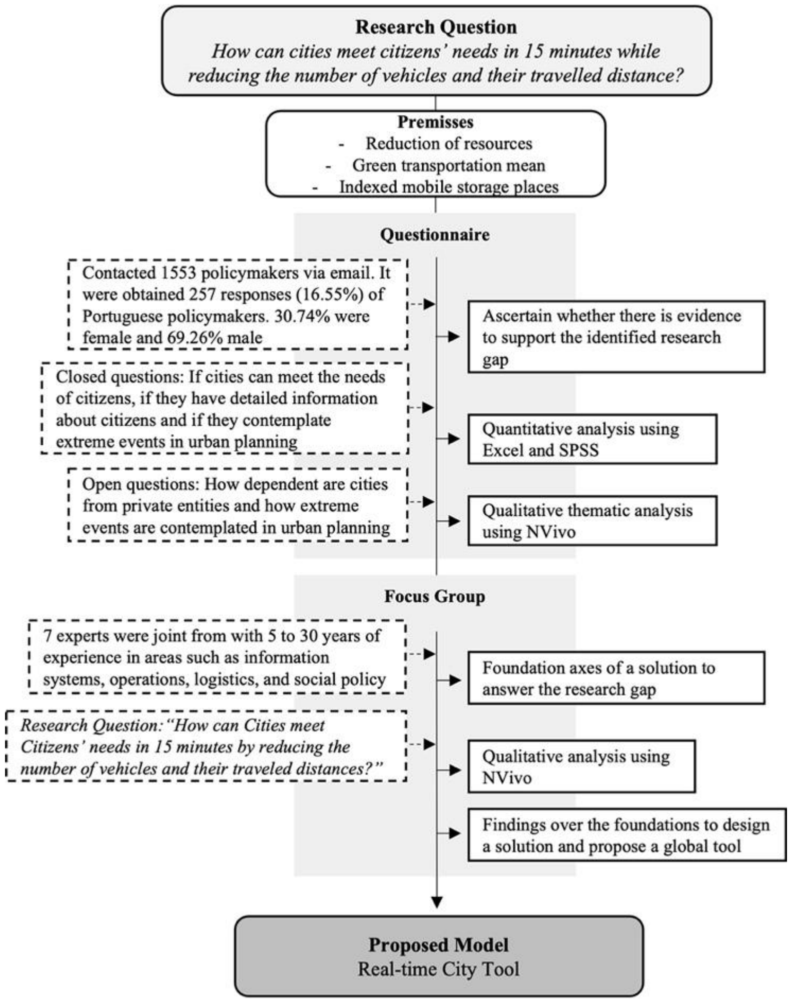


Figure 14:1 Research Methodology framework

14.3.1.1. Questionnaire to Policymakers

The questionnaire aimed to get the policymakers' views to understand whether cities have tools to characterize the territory and adjust their resources based on the analysis of citizens' needs.

The applied questionnaire (Appendix 14.1) was composed with closed and open questions. It was built using Google Forms and sent individually via email between the 6th and 25th of September of 2021. Structurally, the questionnaire was divided into three parts. First, initial questions aimed to characterize respondents according to their age, gender, and familiarity with the Smart city topic (other attributes such as the dimension of their cities and their position were also associated in the third part). In the second part, a hypothetical scenario about the occurrence of an extreme event such as a new pandemic was presented. The goal was to ask policymakers if their cities would be capable of meeting the needs of citizens and how they would depend on private entities. In the third part, the goal was to understand whether municipalities have detailed information about citizens and technological tools that help them organize the urban logistics based on these data. In addition, they were asked if they would value the existence of these tools. Ultimately, it was also intend-ed to understand how they organize urban logistics and if their urban planning considers extreme events. On the one hand, quantitative analysis was performed using SPSS software. On the other hand, a thematic analysis of the answers to the open questions was per-formed using NVivo software.

14.3.1.2. Focus Group with Experts

A focus group was held where the discussion between experts was promoted to propose a solution to answer the research question. Moreover, the aim was to find the foundations of a tool that could meet citizens' needs in 15 minutes. Therefore, based on the questionnaire findings (about the challenges that policymakers stressed to respond to the population in real-time), the experts were asked to think of features that a solution should consider.

A qualitative analysis of the discussion was performed. The focus group followed the approach defended by Morgan (1998) and Stewart, Shamdasani and Rook (2007), characterized by promoting an open and flexible discussion with a collective understanding uncovered by individual interviews, allowing the researcher's direct interaction with the experts. In addition, the exercise discipline was taken into significant consideration in fulfilling the times and the assertive moderation for the interventions' objectivity. The online focus group lasted one hour and was held via Zoom.

14.3.2. Sample characterization

The questionnaire aimed to gather the opinion of policymakers, in this case of Portuguese cities, to acknowledge their capacity to organize urban logistics. Therefore, every public contact of Portuguese policymakers of the 308 municipalities was collected, totaling a population of 1553 contacts. The final sample was composed of 295 responses (19.00%), of which 30.85% were female and 69.15% male. In addition, 46.10% of respondents were aged between 40 and 49, 36.61% aged 50-64, 9.15% aged 25-39, 7.8% over 65 and 0.34% aged 18-25 (Figure 14.2). Additionally, 91.53% of the respondents indicated they were familiarized with the Smart city concept.

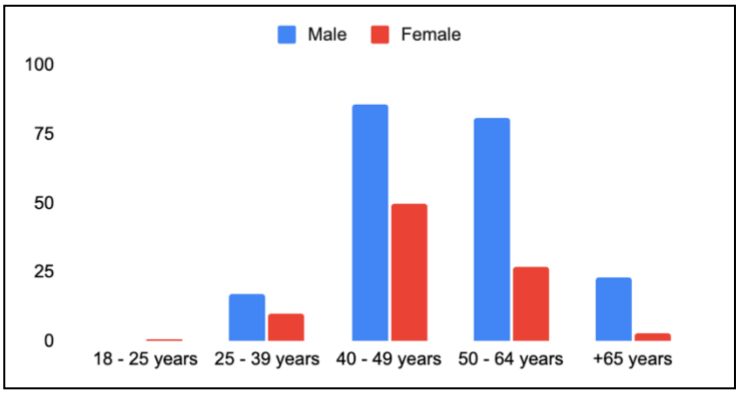


Figure 14:2 Sample identification

As for the respondents' roles, 26 are Mayors, 14 are Vice-Mayors, 170 are Councilman, 36 are Department Chiefs, 19 are Assistants or Advisors, and 30 are Technicians. Moreover, 134 policymakers of cities are represented with less than 25.000 inhabitants, 59 of 25.000 to 50.000 residents, 47 of 50.000 to 100.000 inhabitants, 42 of 100.000 to 200.000 inhabitants, and 13 of more than 200.000 inhabitants. Figure 14.3 displays the distribution of the policymakers' roles.

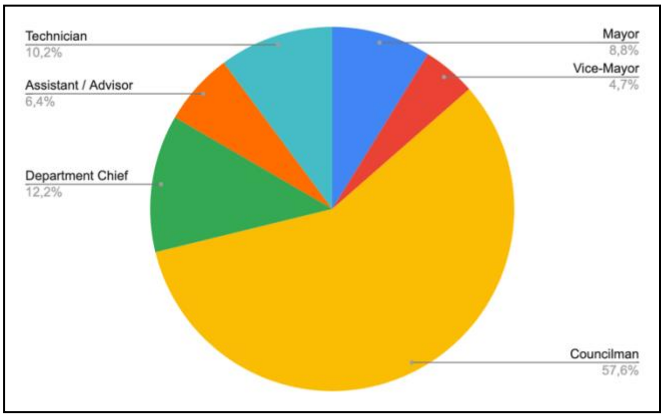


Figure 14:3 Roles of the respondents

The focus group joined a heterogeneous group of experts in the areas of social policy, information systems, manufacturing, operations management, and logistics. This way was possible to design a solution considering the knowledge about the policy's stipulation, the architecture of a software tool and the logistics optimization based on the future transportation and manufacturing schemes. Furthermore, seven experts were joint with a range of years of experience from 5 years to 30 years, combining the industry vision, with the aca-demic and regulation perspective. Table 14.1 describes the experts.

Table 14:1 Focus group' elements identification

Expert	Role	Area	Experience
1	European Commissioner Assistant	Social Policy	5 years
2	Professor	Information Systems	12 years
3	CEO	Industry 4.0	15 years
4	CTO	Logistics	8 years
5	Software Engineer	Future Mobility	10 years
6	Professor	Operations Management	30 years
7	CEO	Manufacturing and 3D Printing	20 years

14.4. Results

This section, on the one hand, summarizes the quantitative analysis' results, provides an in-depth content analysis of the questionnaire' open questions, and presents the results from the focus group discussion. On the other hand, details the model that resulted from the findings of this empirical research.

14.4.1. Policymakers' capacity to organize Urban Logistics

The questionnaire results were obtained through the quantitative analysis of the closed questions and the inductive thematic analysis performed on the open questions.

Table 14.2 details the quantitative analysis results to the central questions of the questionnaire (Appendix 14.1). These aimed first to understand if policymakers are currently considering unexpected events in urban planning (to positioning them in the worst-case scenario and the need for fast response to the population). Second, to realize if cities (decentralization) would be capable of organizing urban logistics, their dependence on private entities and their need for a logistics support tool. The median was considered as the central tendency measure. Moreover, MDA (Median Absolute Deviation) was considered for the dispersion measure of the variability of the univariate sample of quantitative data.

Table 14:2 Breakdown of the existing gap

Topic	Question	N	Answers	Median	MDA
1. Current (Appendix 14.1 – question 16)	"Currently, urban planning contemplates the possibility of extreme and unexpected events (Example: Pandemic)?"	43 44 98 73 37	14.58% – "1 Do not contemplates" 14.92% – "2" 33.22% – "3" 24.75% – "4" 12.54% – "5 Fully contemplates"	3	1
2. Decentralized Organization (Appendix 14.1 – question 4)	"In your opinion, from a decentralized point of view, do you think that cities would be able to organize urban logistics to meet citizens' needs?"	137 122 28 8	2.71% – "1 -No" 9.49% – "2 - Not much" 41.36% – "3 - More or less" 46.44 – "4 - Yes, totally"	3	1
3. Dependency on Private Entities (Appendix 14.1 – question 5)	"How dependent would you be on the responsiveness of the private sector?"	18 28 126 95 28	6.10% – "1 Nothing dependent" 9.49% – "2" 42.71% – "3" 32.20% – "4" 9.49% – "5 Very dependent"	3	1
4. Response Capacity (Appendix 14.1 – question 11)	"Considering citizens' needs had to be met in real-time (15 minutes), how difficult would it	7 28 84 89	2.37% – "1 Nothing difficult" 9.49% – "2" 28.47% – "3" 30.17% – "4"	4	1

	be for the city to move the necessary means?”	87	29.49% – “5 Very difficult”		
5. Tools (Appendix 14.1 – question 8)	“Do municipalities have technological tools that allow real-time visualization and the study of scenarios to place provisional means (delivery and storage) for the supply of goods?”	69 226	23.39% – “Yes” 76.61% – “No”	*	*
6. Importance (Appendix 14.1 – question 9)	“…how important do you think there would be the existence of a tool with these features?”	2 6 36 91 91	0.88% – “1 Nothing important” 2.65% – “2” 15.93% – “3” 40.27% – “4” 40.27% – “5 Very important”	4	1

* It is a nominal variable.

The analysis of Table 14.2 provides valuable insights that help identify the existing gap of the lack of tools to help organize urban logistics.

When asked whether the municipality currently considers extreme events in urban planning, the median response was 3 on the Likert scale (from 1 to 5). However, only 12.54% of respondents classified it as "Fully contemplates".

Regarding their capacity to organize urban logistics, 87.8% of respondents answered "Yes, totally" or "More or less" about the ability of cities to meet citizens' needs.

Furthermore, the median was 3 on the 5-points Likert scale to the question about the dependency of cities on the private sector, which reveals uncertainty in the face of dependence on private entities. Only 18 people answered, "Nothing dependent", which presupposes cities would struggle to operate autonomously in respondents’ opinion.

In addition, 76.61% of respondents reported not having tools that enable real-time visualization and study of scenarios for placing provisional means (delivery and storage) for the supply of goods. The median answer about the importance of that tool was 4 on the 5-points Likert scale. Only 0.88% of respondents answered, "Nothing important".

In terms of the level of significance of the variables gender, age, city dimension, and respondents' position, Table 14.3 summarizes the findings when applying the Chi-Square statistic test to the sample.

Table 14:3 Significant variables’ findings

Question	Variable	Findings	Test	Level of significance
Smart City Concept (Appendix 14.1 – Question 3)	**Age**	Older people are less familiar with the Smart city concept than youngers.	Chi-Square	(p-value=0.014)
	City Dimension	People from the cities with less than 25.000 inhabitants are less familiar with the concept than the remaining cities.	Chi-Square	(p-value=0.005)
Decentralized Organization (Appendix 14.1 – question 4)	**City Dimension**	Cities with less inhabitants feel less confidence about their capacity to organize urban logistics.	Chi-Square	(p-value=0.045)
	Position	Mayors and Vice-mayors are confident about their capacity to move the necessary means. Assistants/advisors and technicians are more cautions.	Chi-Square	(p-value=0.008)

Citizens' Data (Appendix 14.1 – Question 7)	**City Dimension**	People from the cities with less than 25.000 inhabitants were the only ones to answer that they have detailed information about all citizens. Cities with bigger dimension pointed they have just of a few.	Chi-Square	(p-value=0.007)
Cities' Technological Tools (Appendix 14.1 – Question 8)	**City Dimension**	Most of the respondents of the cities with more than 200.000 mentioned they have tools that allow real-time visualization and study of scenarios. Smaller cities have responded on the opposite direction.	Chi-Square	(p-value=0.014)
Real-time Logistics Challenges (Appendix 14.1 – Question 11)	**Position**	Mayors and Vice-mayors are cautions about their capacity to meet citizens' needs in 15 minutes. Councilmans are more confident.	Chi-Square	(p-value=0.037)

Results demonstrate that older people and policymakers from cities with less than 25.000 inhabitants are less familiar with the Smart City concept, which can be explained by the novelty of the concept and its association with technology. Nevertheless, this also reveals the discrepancy between territories and the access to information from the elderly. Cities with fewer inhabitants are also less confident about their willingness to organize urban logistics. This may be explained by the fact that most Portuguese cities with this dimension are in rural areas, which presents challenges to operations and their capacity to cover the entire region.

Mayors and Vice-mayors are confident about their capacity to move the necessary means. However, they are cautious about meeting citizens' needs in 15 minutes. Assistants/advisors and technicians are less optimistic which can mean cities may struggle to organize the assets.

The policymakers of the most populated cities mentioned they have only data about few citizens, which can be explained by the challenge of gathering detailed data. Another reason could be the fact they might be meticulous because of General Data Protection Regulation (GDPR) issues. On the contrary, policymakers from cities with less than 25.000 inhabit-ants were the ones to point out they have detailed information about all citizens. The close relationship with the residents can explain this. However, there are issues with data structure and digital availability. Thus, this answer can be biased by their lack of knowledge and understanding about data standardization to base software systems and applications.

14.4.1.1. Consideration of extreme events in Urban Planning

From the qualitative analysis of the answers to how extreme events are included in urban planning, the case of a pandemic is not yet contemplated in municipal strategies. It was mentioned several times that there was no planning carried out for such unique scenarios. However, there is some homogeneity in the responses when it comes to other natural disasters. Some cities mentioned having a "Municipal Safety Commission" or an "Emergency Office". However, in most cases, it seems to be considered in the Municipal Emergency Plan that integrates the Municipal Operational Plan, articulated adequately with the Land Planning Plan. Moreover, it is already present the:

- Identification of the most vulnerable areas and with occupancy restrictions;
- Definition of severity degrees for various types of extreme events, with the drawing of the responses to be taken, the actors involved and their functions;
- Identification of the accessibility difficulties in older areas and which infrastructures are unsuitable for extreme phenomena;
- Identification of existing partner entities and resources;
- Identification of emergency exits and corridors, and location of public equipment.

It was recognized that new variables related to pandemic events had been included in the existing planning instruments, which until now did not exist. However, it still lacks general digital transformation to allow real-time data collection and processing flexibility.

Furthermore, when contextualized on the scenario of the occurrence of a new pandemic, respondents were enduring in mentioning that municipalities can organize urban logistics to meet citizens' needs. Nevertheless, when asked if cities have citizens' data, as medical and diet needs, only 1.95% answered positively. In comparison, 76.26% said they do not have or have only the data of some citizens.

14.4.1.2. Capacity to meet citizens' needs in 15 minutes

When asked how cities would depend on the most on private entities (Appendix 14.1 – question 6), the responses reveal that 51.26% refer to the supporting Human Resources and 27.14% mention the ability to coordinate logistics. In addition, only 11.56% of the respondents referred to delivery vehicles and 10.05% storage spaces (the remaining response options). Moreover, most results presuppose scarcity of human resources and organization's capacity. Thus, new technological tools can help a better decision and combat this gap.

However, when positioned on the scenario of having to meet the needs of citizens within 15 minutes (Appendix 14.1 – question 11), only seven respondents said they would not struggle to move the necessary means.

In addition, the challenges raised were mainly due to the lack of logistical planning and coordination and the inexistence of dedicated resources. Table 14.4 summarizes the qualitative analysis of the challenges raised by policymakers to perform 15 minutes last-mile response.

Table 14:4 Challenges for 15 minute last-mile fulfillment

Challenge	**Description**
Data	• Lack of integration and sharing of data between cities and the governmental bodies. • Lack of updated contacts databases. • Lack of rigorous and detailed knowledge of all existing resources. • Lack of data collection and computerization.

	• Lack of data on possible logistical needs.
Human Resources	• An insufficient number of human resources. • Lack of specialized human resources. • Lack of knowledge of logistics and operations management. • Lack of training for using digital tools to organize and optimize logistics processes. • Lack of autonomy of departments.
Organization	• Lack of internal organization, previously defined plans, and established hierarchical organization for this matter. • Lack of coordination with other local and national entities and private entities. • Difficulty in communicating and coordinating tasks and responsibilities. • Difficulties in the reorganization of public services because of the rigidity of schedules.
Process	• The high bureaucratic burden of public procurement disfavors emergencies. • Difficult to establish supply contracts (physical acquisition of the necessary goods) and operationalize intermediary logistics. • Struggle to ensure the compliance of the commitment of the different entities involved.
Territory	• Population number and dispersion. • Topography of the territory. • Accessibility issues, namely rural and mountainous areas.
Means	• Lack of delivery means to respond in 15 minutes. • Low dispersion of storage warehouses. • Struggle to deliver goods that need cold storage.
Tools	• Lack of IT tools to plan and support decision-making. • Difficulty to contact and communicating with the entire population. • Difficulty in managing information.

From the analysis of the responses, it was also notorious the existing complementarity between private entities and public bodies that derives from the dependency on goods supply. Moreover, it is stressed that articulation and commitment between private entities and the municipality would be needed to avoid operational failures and allow promptly perform deliveries without interruptions and stock disruption.

14.1.2.3. Foundation axes of a solution to answer the research question

Based on the challenges pointed out by policymakers, was presented to experts the following research question: "How can Cities meet Citizens' needs in 15 minutes by reducing the number of vehicles and their traveled distances?". The focus group discussion aimed to find the foundation axes of a solution that could respond to this gap.

Furthermore, the main conclusions drawn from the focus group highlight the relevance of designing a solution that should consider the features described in Table 14.5.

Table 14:5 Findings of the Focus Group discussion

Need	**Description**
Collaborative logistics	The interoperability between public and private entities to promote an omnichannel where all resources are at citizens disposal.
Micro logistics operators	Subcontractors or voluntary helpers provide their delivery and storage resources to enhance the operation's capacity.
Flexible and multi-modal modes of transportation	Integration and consideration of multiple types and transportation, positioning them according to the needs.
Stock storage within the last-mile	Shared storage (urban) furniture to allow the needed stock to be available in the last-mile.

Geography of the territory	Software tools that enable the recognition of the territory's topography and accessibility.
Forecasting of citizens' needs	Through the forecast, cities can proactively allocate stock to storage points close to citizens in advance to meet their needs in a short period. This should be constantly updated.

Several examples were mentioned during the focus group to compare and ground the solution. Moreover, the case of delivery platforms that use subcontractors to perform the deliveries was enunciated. These platforms adopted proximity models to strict consumers to choose their meals from nearby restaurants for shorter-distance services and faster response.

In addition, software platforms (e.g., OpenStreetMaps) that have detailed information about the territory were also highlighted. The fact that mobility platforms are also focused on providing a quick response from the clients' locations closest driver, trying to position them according to historical and real-time information.

There was a general agreement that the traditional supply chain is not prepared for a territorial decentralization required to respond to any request in a personalized way in a few minutes. Moreover, to enhance the collaboration between stakeholders and transportation modes, the decentralization of processes (to the last-mile) is complemented with a logic of centralization (virtual) of an integrated open data system. Figure 14.4 graphically summarizes both approaches.

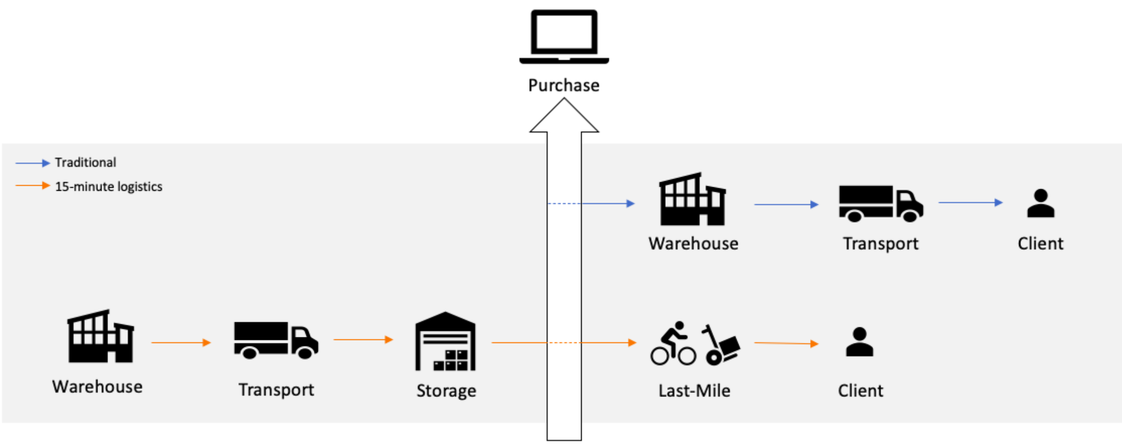


Figure 14:4 Comparison between the traditional logistic model and the 15-minute last-mile logistic model

The intermediate delivery at off-peak hours to the last-mile storage points would proactively ensure the availability of goods in real-time. Thus, the number of circulating vehicles would be reduced. Since there is no time constraint on this supply chain stage, the problem can be summarized as optimizing the maximum traveled distance by the minimum resources. In addition, the final accumulation of last-mile deliveries may be redundant in this model since they will be performed by non-pollute means of transportation.

14.4.2. Proposed Model

The literature review highlighted the evolution towards local realization and real-time urban adjustment based on the study of the most appropriate locations to store goods (based on the spatial indexing of the territory). Thus, it noted that last-mile fulfilment might recur to mobile stock points and transport co-modality, depending on the collaboration schemes among stakeholders and the defined objectives. Furthermore, the routing optimization will depend on the choice of the vehicles to perform the deliveries, which shall be environmentally friendly. Thus, the premises of the model must be innovative vehicles, proximity stations, collaborative and cooperative logistics, optimization of transport management and routing, and innovations in public policies and infrastructures.

On top of this, based on the empirical research findings, some assumptions may also be considered. Thus, the proposed model shall be based on a collaborative logistics framework to create an omnichannel that recurs to public and private resources and labor to per-form the deliveries. Thus, the model shall consider multiple transportation types and storage facilities to allow storing and delivering goods within the last-mile. The organization of the stock and the choice of the best-integrated solution shall be grounded on the forecast of citizens needs and the topography of the territory. This way, existing stock can be distributed by storage points using shared resources to optimize processes and minimize the as-sociated costs. Figure 14.5 sketches the high-level scheme of the proposed model.

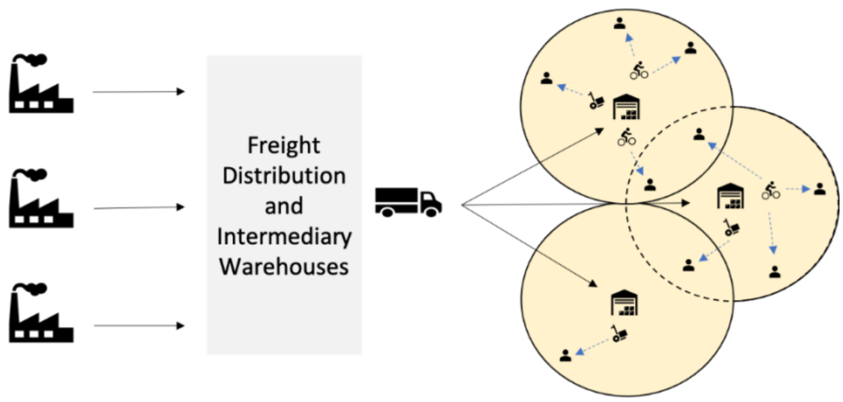


Figure 14:5 High-level scheme of the proposed model

14.4.2.1. Step-by-step Description

The designed algorithm considers the following standard steps, represented in Figure 14.6:

A. Analysis of historical data – parameterization of the citizens' locations (and potentially their individualized data).

B. Region definition - clustering of locations using a spatial clustering algorithm, and determination of the centroids of each cluster.
C. Aggregation of locations - spatial indexing, for selection of candidate storage points.
D. Location of storage points - calculation of the maximum attainable region (isochrone).

For a generic demonstration of the development of the model, a set of random data was generated. This model assumes the cooperation of stakeholders and their resources. Thus, the goal is to position them according to the demand forecast and develop a logic to choose the best solution to answer in real-time.

There was not considered any need or product. However, it should be recalled that appropriate filtering may be applied, considering the type of goods to be stored and their characteristics. They can be decisive to the optimal result.

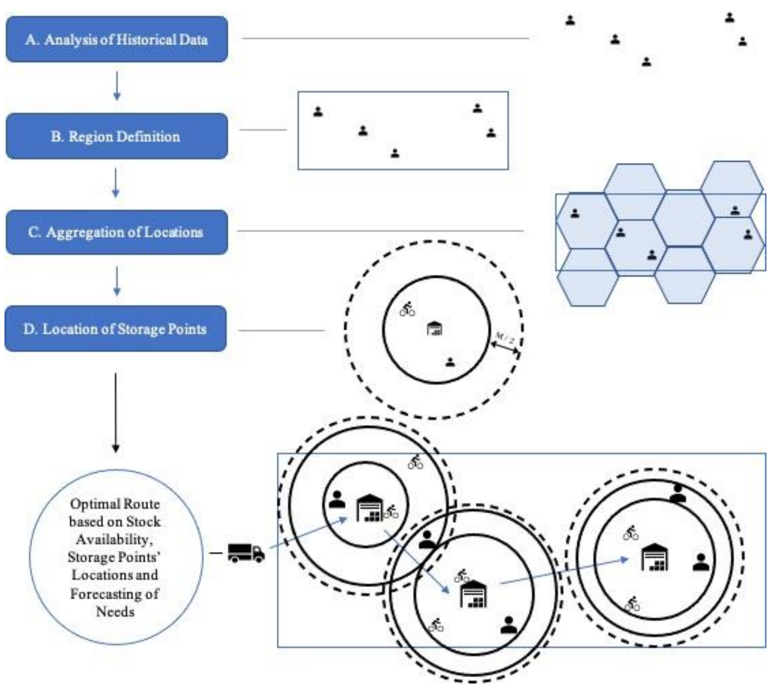


Figure 14:6 Steps of the designed solution

A. <u>Analysis of historical data</u>

The initial step is to get the necessary data depending on the use case and its parameters. Therefore, mechanisms to automatize the collection and harmonization of data of public and private bodies shall be created to ground the model.

As the system should be based on data analysis and forecasting, stock management de-pends on the expected needs to ensure the necessary goods at a future moment. Moreover, as illustrated in Figure 14.7, the citizens' locations are parametrized through data analysis. This way, it is possible to make future predictions through machine learning algorithms, e.g. Random Forest and Linear Regression (Khaledian & Miller, 2020; Poon, Kingston, Ouyang, Ngo, & Chan, 2020; Tamiminia et al., 2020). These algorithms should allow the adjustment of the warehouse location in real-time (proactive model). The premise will follow a relationship with the existence of local stock. Therefore, the traditional calculation of stock should give without Disruption with Instant Replacement (Just in Time Philosophy).

As citizens' specific needs, other attributes can be added to base the model according to the intended use case. For example, in the case that the intention was to provide citizens with their meds, the system would automatically get each citizen's medical prescriptions. In this case, as it intends to provide a generic scenario will be considered citizens' locations. This can also be dynamic if the system considers the real-time location of each citizen (from their smartphones' GPS).

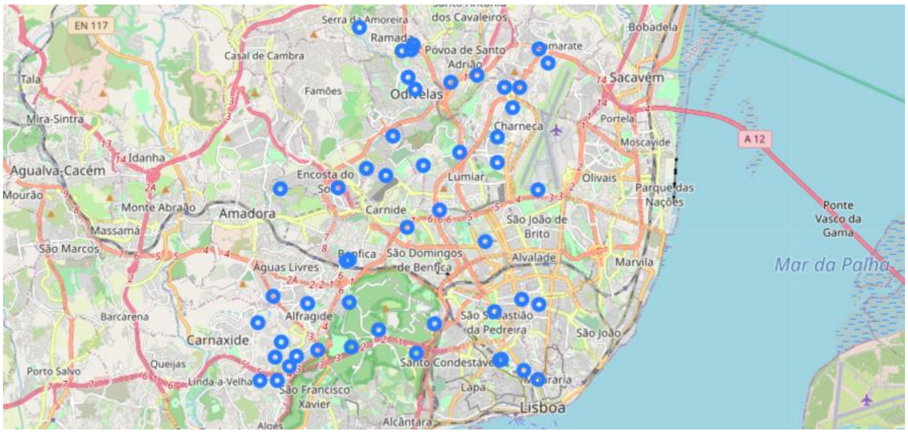


Figure 14:7 Citizens' locations

B. <u>Region Definition</u>

After having the locations (potentially attached to the personalized characteristics of every-one), their aggregation will allow to obtain storage candidate points. Since it is intended to propose a generic algorithm, shall be obtained the densest regions (clusters) and their central points. organize and position logistics resources to respond in a short period on a specific region, which may present a more significant potential compared to any other point initially provided.

This method is named clustering (and it can be performed considering multiple variables). Moreover, it is done using a clustering algorithm to automatically define regions by aggregating the most significant number of points (Wang et al., 2018). This decision will be de-pendent on the total number of requests to meet. In this case, 100% of them will be considered, i.e., every citizen's need must be met.

Thus, the DBSCAN clustering algorithm (Chen et al., 2021; Ester, Kriegel, Sander, & Xu, 1996) was used since it is a density-based algorithm that does not require the number of clusters in advance. Instead, it selects each point for a cluster according to the point density. In this case, the parameterizable maximum distance of 1.5 Km (also known as the epsilon parameter) was chosen to determine whether a location should be included in the cluster. This considers the fact that the initial position of the delivery asset can be at a 1.5 Km distance from the storage facility and therefore has to cover twice that distance (in the worst-case scenario). The distance between points is calculated by Haversine's formula (Boeing, 2018, 2019). Figure 14.8 showcases the defined regions.

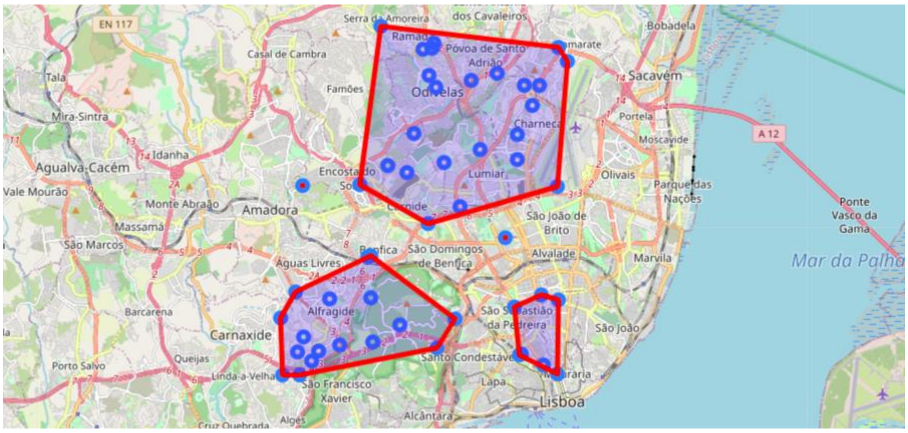


Figure 14:8 Clustering of locations to define existing regions using DBSCAN

C. <u>Aggregation of locations</u>

The clusters consideration (in this case are five) is vital to reducing the potential locations to analyze. Consequently, the computational effort allows faster analysis (otherwise, the model would have to consider every geographical position in the region).

Nevertheless, the central points of the clusters would be insufficient to find an efficient solution, therefore are needed more points to run the algorithm. Therefore, additional points within the clusters must be considered. Thus, the aggregation of the initial locations through spatial indexing (within the clusters) allows obtaining the final list of candidate storage points.

The H3 library (Uber, 2021) was used for this task, which divides the Earth's surface into hexagons (and pentagons located in the middle of the ocean). Furthermore, each H3 index area depends on the desired resolution, ranging from 0.9 square meters to more than 4,250 million square kilometers (Uber, 2021). Moreover, it was chosen resolution 8, which corresponds to approximately 737 square meters of area, representing a more outstanding balance between the number of indexes found and the area of aggregating locations. Next, the candidate point of each index is chosen as its central point, as shown in Figure 14.9.

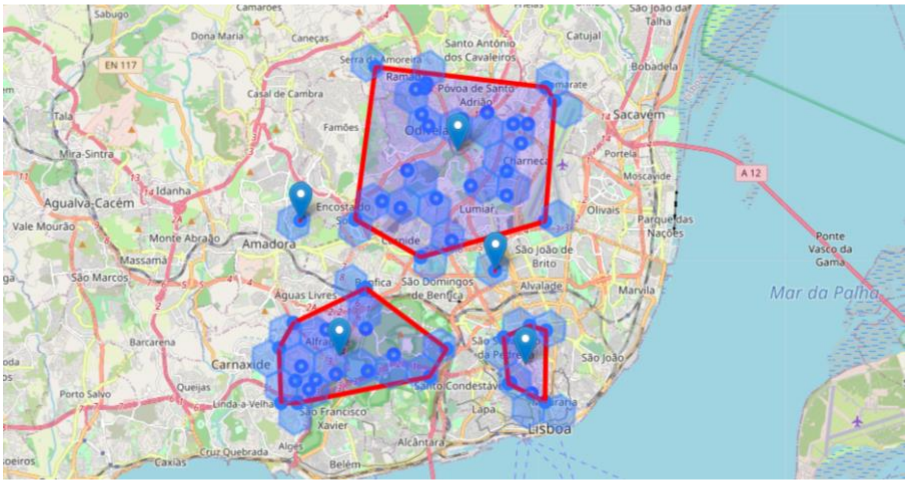


Figure 14:9 Spatial indexing using H3

D. Location of storage points

This step relates the storage locations with the delivery. The results are not affected by the delivery time in the previous steps. Thus, this step moves the model from 2D to 3D It is the most demanding calculation on the computational resource level since it uses geography and topography (as other variables such as traffic) to analyze the distances on the map. This was why previous steps tried to optimize the number of candidate points in the previous steps.

Therefore, after obtaining a set of candidate points (the central points of each cluster obtained via DBSCAN, and the central points of each H3 index, hexagon, through the aggregation of locations), should be considered a chosen mean of transport to calculate the maximum region attainable in 15 minutes (for example). This region is called isochrone. Its calculation was made by an open-source route optimization engine called Valhalla (Belikov & Afonichkina, 2021), which uses OpenStreetMaps data to provide the best route between two or more locations, among others. Thus, the calculation is not affected by existing traffic, only by the geography and road information.

The maximum time for the delivery should be defined. In practical terms, half of this value should be used since the border of the isochrone should correspond to the distance it takes to travel half of the maximum time. This covers the worst-case scenario. Thus, it is guaranteed that the temporal restriction is not exceeded. Another essential characteristic is selecting the means of transport to be used, as it will significantly influence the size of each isochrone. In this case, for each candidate point, the respective isochrones were calculated for 15 minutes, using the bicycle as a means of transport, as illustrated in Figure 14.10. The result is a polygon that represents the maximum attainable region. Thus, a solution for the location of the storage points is known.

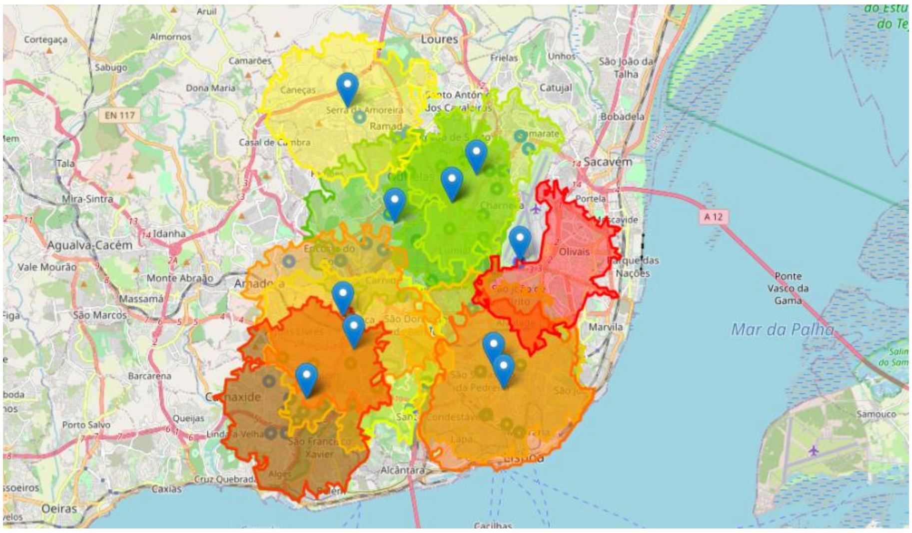


Figure 14:10 Calculation of the Isochrones with Valhalla and OpenStreetMaps

The result shown in Figure 14.10 indicates the chosen points and their attainable regions with-in the defined time interval. The choice of each point is made according to the highest coverage rate, and there is the possibility that several regions may intersect, which is the case.

Isochrones can also be refined to find the optimal centroid points (depending on the use case). Different optimization rules can be considered. Since the characteristics of the needs will be flexible, and new historical information will be added to the data set, the storage locations shall change based on the system update. Moreover, the locations are constantly corrected based on the forecast of future needs. These storage points can also be reduced if their mobility meets the system dynamics (in the case of considering innovative vehicles and mobile storage points).

14.4.2.2. Enhancing the Proposed Model to a Generic Perspective

Given the flexibility needed today, more than studying and realizing the fixed location of a logistics center, it is necessary always to know the best strategic option to satisfy citizens' real-time needs by defining the most appropriate collection pick-up point and respective position.

Moreover, citizens' data must first be structured and analyzed to adapt the model to any product or need. Furthermore, defining the restrictions related to a particular use case will help obtain a more reliable solution. Finally, the optimization rule shall be defined accordingly to the objective.

The model proposed was developed and tested on Google Collaboratory (Google, 2021a). This tool allows for the development and execution of code snippets using Python programming language, is free to use for research purposes, and is useful for data processing and analysis.

Furthermore, after defining the goal function, whatever the intended use case is, the execution of the following generic standard steps detailed in Figure 14.11 must be considered.

Figure 14:11 Traditional logistics vs Proposed model

Inputs:

- Resolution R = [0,15], to be used to retrieve H3 index.
- Cluster threshold (CT) in kilometers, maximum distance to include points in a cluster.
- Transportation type (T) to be used on isochrone computation – bicycle, car, truck, foot
- Maximum travel time (M) to consider

Output: *list of points to consider as logistic stock points.*

Description:

1 - Initialize location candidates and isochrones list
2 - Get the locations dataset to be analyzed
3 – For each location in the dataset, do:
3.1 – H3 index computation with resolution R
3.2 – Store H3 index centroid in the location candidates list
4 – Initialize DBSCAN algorithm parameters:
4.1 – Epsilon parameter = CT / 6371.0088 (kilometers by radian)
4.2 – Set distance parameter to Haversine's algorithm
5 – Compute DBSCAN for the location's dataset
6 – Store the clusters found centroids in the location candidates list
7 – For each location candidate, do:
7.1 – Compute isochrone for T transport type and M/2 maximum travel time
7.2 – Store the isochrone computed on the isochrones list
...
8 - Choose the best points

The application of the model described will naturally decrease the number of kilometers traveled. In addition, the placement of storage locations closer to citizens and their real-time adjustment, as represented in Figure 14.12, will lower the number of visiting points. Therefore, the final impact is reflected on the implemented business model, realizing the total costs involved, which depend on the use case.

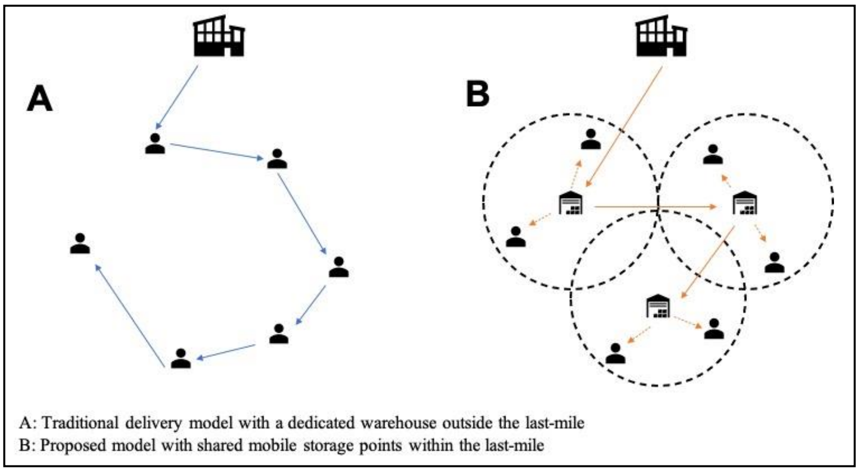


Figure 14:12 Traditional logistics vs Proposed model

14.5. Discussion

The impact that urban logistics have on cities' emissions and congestion will be reduced by decreasing circulating vehicles.

Urban planning (on behalf of the 15-minute city concept) is evolving to provide closer public services to citizens' locations. This way, their transportation needs will decrease, and their quality of life and cities livability will improve. On the other hand, Urban logistics has been focused on managing traffic flows and freight distribution. Nevertheless, it has been insufficient to overcome nowadays' challenges and the increasing number of vehicles and logistics assets in city centers. Furthermore, e-commerce is evolving to allow consumers to have the products they want, when and where they want. The reflection on the efforts needed to overcome this challenge represents a disruption of traditional logistics models. Moreover, the Covid-19 pandemic alerted citizens can be deprived of their freedom. Thus, it is urgent to reflect on urban logistics and cities' capacity to fulfill citizens' needs.

To enable instant deliveries, and thus, to meet real-time citizens needs is crucial on one side to understand the specifications of their demand and then to find the best solution available to fulfill the personalized request based on their characteristics. Since there is stock to organize and allocate, it is vital to characterize the population' needs and apply forecasting algorithms to position storage assets according to the chance of having to meet a specific need.

The proposed model of this research is aligned with the future summarizes of the supply chain to the last-mile. Thus it is developed under the Logistics 4.0 concept umbrella, where the sharing economy has a vital role and seeks to set logistics instantaneous relationships towards the fulfillment of personalized requests (Correia et al., 2021c; Daugherty et al., 2019; Dolati Neghabadi et al., 2021; Gläser et al., 2021; Lim et al., 2018; Ranieri et al., 2018;

Rimmer & Kam, 2018; Shi et al., 2021; Srivatsa Srinivas & Marathe, 2021; Sundarakani et al., 2021; Taniguchi et al., 2016).

Thus, considering any individual and sharing of storage spaces and delivery means will ground dynamic logistics schemes and reduce travelled distances. The storage points can be private warehouses, garages, or other facilities. Thus, this model assumes greater importance since it presents the first step to base a dynamic and collaborative system. With the optimal locations of storage points, policymakers can organize the stock (of essentials in the first place) and promote local businesses relationships and products. Thus, with the cooperation of stakeholders, it would be possible to decrease their costs on operations and logistics needs, which will also impact the product's final cost. This will help the microeconomic aspect adapt to the macroeconomic context and respond to inflation. Additionally, it can also promote the inclusion of citizens by answering the ageing and isolation of the population by studying the locations and local resources to fulfill their necessities.

Of the challenges posed by policymakers to respond in 15 minutes they can be summarized in the:

1. Lack of integration/sharing of updated data between stakeholders;
2. Lack of specialized human resources with knowledge of logistics and operations management;
3. Lack of coordination between departments and responsibilities among public bodies;
4. Lack of commitment of private sector and efficient public procurement;
5. Dispersion and topography of the territory;
6. Lack of delivery and storage means;
7. Lack of tools to centralize and communicate information.

The designed model aimed to answer the points mentioned above. Nevertheless, some issues deserve a broader discussion.

Although Cities have been working to gather citizens' and cities infrastructure' data, logistics data is scarce. Categorization of logistics assets of companies such as vehicles and warehouses is critical. The sharing of resources would pose challenges that need the creation of standards in terms to integrate data, hardware, and communications. Moreover, stakeholders' data should be open to municipalities always to know existing resources, locations, and capacities. This way would be possible to set up logistics schemes to guarantee that a real-time response could be provided to any necessity in a pre-defined period. Thus, in-depth discussion is also needed on these technologies. A common city application could be provided, where entities could resort to available logistics assets. Software tools must be created and integrated into existing Urban Platforms.

For public matters, each company or individual should automatically update the system with their current resources and tasks. A minimum threshold per entity to meet citizens’ needs should be defined. However, there is still an existing gap between the integration of public and private sectors. As noticed, cities feel confident about their capacity to organize urban logistics; however, they noticed their dependency on the private sector. The line begins to be tenuous between the business models associated with the Industry and the role of cities and policymakers. Nowadays, it is impossible to reflect on the Industry with-out thinking about city planning and vice-versa, since one directly impacts the other. This fact should promote the reflection about policymakers' regulatory and integrator role and the measures to be taken to allow data integration.

Finally, privacy and cybersecurity are some of the most significant challenges of future developments. Economic activities shall not be harmed by the transparency of stakeholders towards allowing an optimization of urban logistics and cities' sustainability.

14.6. Conclusions and Future Work

Urban planning (on behalf of Smart Cities advancements) has evolved to provide policymakers with a common operating picture to support their decisions. Nevertheless, this is still scarce for urban logistics' assets and organization.

COVID-19 accelerated the reflection on cities readiness to organize the means to meet citizens’ needs. This empirical study started with a questionnaire to collect policymakers' perceptions on the capacity of cities to organize urban logistics and their dependence on private entities. The findings of the responses were then discussed by a set of experts in a focus group.

Policymakers recognized the importance of having a tool that enables real-time simulation to place provisional means (delivery and storage) for the supply of goods. Furthermore, considering the mentioned barriers about the lack of human resources in cities’ structure and organization’s capacity pointed by policymakers, a decision support tool was de-signed.

On top of these findings, the focus group discussion with experts helped define a tool's foundations. This would have to consider collaborative logistics, flexible and multi-modal modes of transportation and stock storage within the last-mile. Furthermore, it was mentioned the need to consider the territory's geography and have the capacity to forecast citizens’ needs.

The 4-step logistics proposed model, on the one hand, allows the optimization of urban logistics by considering the cooperation of stakeholders, thus decreasing the number of resources and labor needed, and on the other hand, allows a real-time personalized response to citizens’ needs based on the positioning adjustment and choice of the resources to perform the deliveries. The tool can be enhanced vertically (logistics optimization) and horizontally (different sectors application).

Nevertheless, policymakers raised several challenges about the city's capacity to meet citizens' needs within 15 minutes regarding data, human resources, organization, process, territory, means, and tools. Thus, the pointed challenges set some of the takeaways of this research that are: 1) the need to educate the population and policymakers about the importance of data integration to work together with the economic agents to find ways to address nowadays challenges; 2) Methods and standards to collect citizens' data; 3) Regulatory frameworks shall be created to guide the cooperation of economic agents.

The limitation of this study is related to the fact that different policymakers of the same city may have different perspectives.

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Appendix 14.1 – Questionnaire

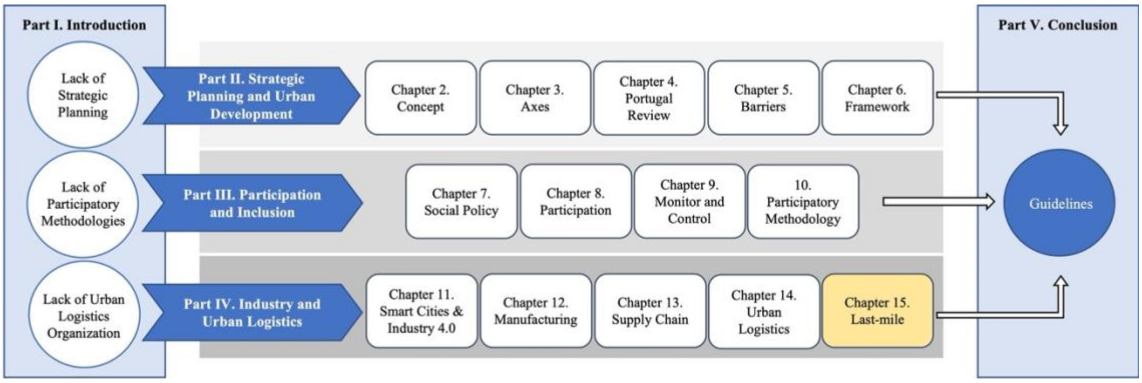
Group	Question	Answers
I Identification of the Respondent	1) What is your gender?	Female Male
	2) How old are you?	18 – 25 years old 26 – 39 years old 40 – 49 years old 50 – 64 years old + 65 years old
	3) Are you familiar with the topic of Smart Cities	Yes No
II Scenario “The emergence of a new pandemic”	4) In your opinion, from a decentralized point of view, do you think that cities would be able to organize urban logistics to meet citizens’ needs?	1 - No 2 - Not much 3 - More or less 4 - Yes, totally
	5) How dependent would you be on the responsiveness of the private sector?	Likert Scale: 1 – Nothing dependent 5 – Very dependent
	6) If you did not respond with the value 1 -"Nothing Dependent", the existing dependency would be mainly at the level of:	Delivery vehicles Storage warehouses Support Human Resources Capacity to coordinate logistics **Other option (Open)**
	7) Do cities have detailed information on citizens and their individual needs (example: address, health care, medical prescriptions, and food concerns)?	No Of some Of the majority Yes, of all
	8) Do municipalities have technological tools that allow real-time visualization and the study of scenarios to place provisional means (delivery and storage) for the supply of goods?	Yes No
	9) In case the answer is "No", how important do you think there would be the existence of a tool with these features?	Likert Scale: 1 – Nothing important 5 – Very important
	10) If you wanted to find the best location to place storage spaces for essential goods to meet a specific number of citizens, how fast could you do it accurately?	Likert Scale: 1 – Nothing fast 5 – Very fast
	11) Considering that citizens’ needs had to be met in real-time (15 minutes), how difficult would it be for the city to move the necessary means?	Likert Scale: 1 – Nothing difficult 5 – Very difficult
	12) What would be the greatest difficulties? Explain briefly	**Open Question**
III Current Urban Planning	13) Do you belong to the structure of a city hall?	Yes No
	14) If "Yes", what is your current position?	**Open Question**
	15) How many inhabitants does the city have?	Less than 25 000 inhabitants Between 25 001 and 50 000 inhabitants Between 50 001 and 100 000 inhabitants Between 100 001 and 200 000 inhabitants Between 25 001 and 50 000 inhabitants More than 200 000 inhabitants
	16) Currently, urban planning contemplates the possibility of extreme and unexpected events (Example: Pandemic)?	Likert Scale: 1 – Do not contemplates 5 – Fully contemplates
	17) If the answer is not "1 - Do not contemplates", say in brief words how it is included:	**Open Question**
	18) In your opinion, how important is it to include in urban planning the study of scenarios and the capacity to respond to unexpected events, such as the case of a new pandemic?	Likert Scale: 1 – Nothing important 5 – Very important

Chapter 15

Last-Mile-as-a-Service (LMaaS): An innovative concept for the disruption of the Supply Chain

Reference

Correia, D., Teixeira, L., & Marques, J. L. (2021). Last-Mile-as-a-Service (LMaaS): An innovative concept for the disruption of the Supply Chain. *Sustainable Cities and Society*, 103310. https://doi.org/https://doi.org/10.1016/j.scs.2021.103310



15. Last-Mile-as-a-Service (LMaaS): An innovative concept for the disruption of the Supply Chain

Abstract

Recent events such as Covid-19 vaccine distribution issues and the blockage of the Ever Given ship in the Suez Canal raised concerns about how fragile the traditional supply chain is. Last-mile personalized fulfillment can have a catalyst role in the proliferation of the Industry 4.0. This growing trend will reduce standard production, bringing manufacturing closer to the client and, ultimately, boiling down the supply chain to the last mile. However, the literature is not clear about the breakdown of the supply chain to enhance cities' sustainability and reducing the number of transports and circulating vehicles.

Stemming from an empirical study to simulate the existing gap in the market and the development of a case study through structured interviews with privileged interlocutors complemented by the document analysis, this paper highlights how the integration of local stakeholders can efficiently enhance a personalized service based on dynamic collaborations to set up the supply chain, by introducing the Last-Mile-as-a-Service (LMaaS) concept. This concept relies on a revenue-sharing framework based on an open marketplace composed by last-mile manufacturing, transport, and storage assets and stakeholders to disrupt the supply chain, enabling any company to provide personalized products in almost real-time to any location.

Keywords: Last-Mile-as-a-Service; Industry 4.0; Smart Cities; Smart Logistics; Smart Manufacturing; Smart Supply Chain.

15.1. Introduction

How many times did a client purchase a standard product because it was not possible to personalize it? How many times did a client order a product from the other side of the world based on price and it took months to be delivered? In the current technological context and in an era characterized by digitalization, these questions highlight an inefficiency on the supply chain performance where both companies and consumers are jeopardized. Over and above that, the environment is negatively impacted. Moreover, the collaboration and sharing of resources between agents is essential to provide a personalized service to consumers and combat climate change.

Nevertheless, if a client wants to purchase a product from a distant market, this action still represents a significant logistics effort, with the need to combine multiple urban and transcontinental modes of transportation to deliver the product to its final destination. Mass production has so far justified resorting to manufacturing in third-world countries, often extremely far away, derived from the cheap cost of production and labor. However, personalization and small-scale production are increasingly disabling the rationale for mass production and standard supply chains.

In 2050, around 70% of population will live in cities and neighboring regions (United Nations, 2015). Urban and freight logistics are some of the most heavy-duty activities in terms of consumer resources and greenhouse gas emissions, challenging cities' sustainability (Bibri & Krogstie, 2017). With Green Deal, the European Commission has the ambition of achieving carbon neutrality in the European Union by 2050. Sustainable Industry and Sustainable Mobility are within the Green Deal's scope. Moreover, two of the Green Deal goals strive towards sustainable and smart mobility, thus pushing the industry to a clean and circular economy (European Commission, 2019).

Recent events such as the Covid-19[2] vaccine distribution issues and the blockage of the Ever Given ship in the Suez Canal[3] raised concerns about the need for a global collaboration and knowledge sharing for local fulfillment. The Covid-19 pandemic also accelerated the necessity to re-think cities. The need to assist citizens with closer public services was noted by Moreno et. al (2021), who proposed a "15-minute city" conceptual approach to help policymakers plan cities towards the availability of essentials and basic needs, by foot or bicycle, promoting citizens' quality of life and avoiding the need to use the car. Furthermore, this concept may also be applied to the delivery of goods to citizens, breaking down the supply chain, reducing the circulating vehicles and their travelled distances, boiling down manufacturing and logistics activities to the last-mile.

[2] The COVID-19 is the global pandemic of a coronavirus (SARS-CoV-2) disease, which emerged in 2019.
[3] Ever Given ship blocked the Suez Canal in March 2021 over 6 days which had a significant impact on global economy.

Industry 4.0 is striving to base manufacturing on predictive analytics and the integration of the entire service from ideation and design to the delivery (Laplume, Petersen, & Pearce, 2016). 3D printing will allow companies to become more responsive to personalized requirements and enable production to be performed elsewhere (Kang et al., 2016).

Digital transformation in the supply chain enables sharing data between actors and real-time data analysis, breaking away from organizational silos, creating common goals, and increasing collaboration and communication. The path to a more sustainable supply chain involves transitioning to a circular model where additive manufacturing plays an important role, and all agents and individuals in the chain are integrated and can collaborate with each other.

Korczak and Kijewska (2019) noticed that the term "Smart Logistics" emerged at the beginning of the 21st century and was known as decentralizing decision-making to local systems. Furthermore, it was also associated to the capacity of planning and control logistics processes from the data gathered with the tracking and identification of elements until the detection of the problem, choice, and automatic execution of the solution (McFarlane, Giannikas, & Lu, 2016). Moreover, logistics platforms help in a cost-effective way to design, plan, implement and control the forward and reverse flow of goods from the origin point to the destination, guaranteeing resource efficiency, security of goods, sustainability and on-time distribution (Jabeur, Al-Belushi, Mbarki, & Gharrad, 2017). Barenji, Wang, Li and Guerra-Zubiaga (2019) proposed a multi agent-based platform to control and facilitate decision-making and the information exchange between end users, suppliers and the distribution center. Several authors conceptualized multiple collaborative frameworks to enable the collaboration between logistics stakeholders and individuals (Rožman, Vrabič, Corn, Požrl, & Diaci, 2019; Xu, Zheng, & Yu, 2018). However, these platforms and their related research are focused on distribution optimization and stock management, leaving aside the transfer of manufacturing and the focus on the last-mile fulfilment.

Moreover, the literature lacks a broader understanding on the impact of local collaborations for all aspects of the supply chain rather than just the logistical optimization of freight distribution and last-mile deliveries. Furthermore, there is a gap on the provision of an end-to-end framework where manufacturing, storage and delivery are personalized, and the global supply chain is open and built upon the requirements of the client.

For this purpose, this article embraces the existing literature and enunciates an empirical case study to set the foundations and present an emergent model for last-mile optimization and fulfillment, named Last-Mile-as-a-Service (LMaaS). This innovative concept for the disruption of the supply chain relies on the collaboration and integration of assets and management capabilities of different entities to provide any company with a physical and virtual infrastructure capable of providing personalized products and delivery services to their clients at any location.

The following section performs a review of the literature about the topis of Industry 4.0 and 3D printing as well as smart supply chain and last-mile. Section 15.3 proposes a two-steps methodology. Moreover, it details the current challenge and proposes an example of local collaboration to provide a personalized supply chain. The findings of the methodology procedure base the innovative concept proposed in Section 15.4. Lastly, conclusions and avenues for future research are presented.

15.2. Theoretical Background

This literature review section gives a brief explanation of the fundamentals of the Industry 4.0 concept and the current state of 3D printing, and explores the background on the supply chain management and last-mile fulfillment. Ultimately, this section aims to demonstrate the gap that exists by the lack of an aggregating platform that would allow for an open and global supply chain to all stakeholders to locally meet the personalized requirements of the client. The databases used for this research were Scopus and Web of Science. The search keywords were: Industry 4.0, 3D Printing, Last-mile, Smart Manufacturing, Smart Logistics, Smart Supply Chain, Logistics Platforms and Supply Chain Platforms.

15.2.1. Industry 4.0 and 3D Printing

The consumers' ongoing desire to participate is pushing the mass customization of the third industrial revolution to a personalized production model (Bortolini, Ferrari, Gamberi, Pilati, & Faccio, 2017), with flexible manufacturing of small series (up to one sample) to respond to individual preferences (Hozdić, 2015; Prause, 2016).

Industry 4.0 (or Smart Manufacturing) aims to integrate and take advantage of advanced technologies and information to collect real-time data from the supply chain, thus enabling a rapid and flexible response at different levels to meet the clients’ needs in a highly dynamic and global market (Lu & Ju, 2017). Therefore, there is an increasing need for big data analytics (machine learning and predictive analytics), enabling timely and accurate insights to assist decision-making (Shin, Woo, & Rachuri, 2014).

Cyber-physical systems (CPS) and system integration (across all departments and parts of the process) are vital aspects to enable a flexible control production (and its constant changes) in real-time with the concern to the efficient usage of energy and resources, as well as the reduction of carbon emissions, maximizing sustainability, health, and safety (Kang et al., 2016). The decentralization of operations will permit facing unforeseen changing conditions. The integration of the horizontal (across stakeholders) and vertical (across organizational levels) axes will improve the efficiency of the supply chain (Erol, Jäger, Hold, Ott, & Sihn, 2016). Planning and scheduling can be fully integrated with operations featuring coordination and optimization models across the supply chain (Kang et al. 2016).

Industry 4.0 is characterized by the fusion of the physical and virtual worlds (Kagermann, Wahlster, & Helbig, 2013), where the product will control production (Nick, Pongrácz, & Radács, 2018). Smart manufacturing revolves around a demand-driven, client-focused, and highly-optimized supply chain (O'Donovan, Leahy, Bruton, & O'Sullivan, 2015).

The realization of the Industry 4.0 may also be connected to the evolution of 3D printing. Moreover, several authors argue that 3D printing will lead to a new paradigm with a promising strategy in the one-of-a-kind products possible (Lipson & Kurman, 2013; Moilanen & Vadén, 2013).

Historically known as Additive Manufacturing (AM), 3D printing emerged in the 1970s and differs from Subtractive Manufacturing (SM) in the ability of building a product layer-to-layer instead of starting with a block material and removing the unnecessary material to build the final piece (Laplume et al., 2016). Thus, this technological driver of Industry 4.0 is seen as a way to achieve sustainable production — by improving resource efficiency, extending and reconfiguring value chains (Ford & Despeisse, 2016) — enabling personalization with shorter cycle-times and lower costs (Yi Wang, Ma, Yang, & Wang, 2017). This can potentially have a great impact on the supply chain and society (Chen, Pan, & Ouyang, 2014; Eiichi Taniguchi, Thompson, & Yamada, 2016). The large dimension printers, which could cost up to 300,000 USD, have evolved to affordable open-source home printers in the early years of the 21st century (Bradshaw, Bowyer, & Haufe, 2010).

From rapid prototyping and tooling, to the medical sector, the applications of 3D printing have spread throughout multiple areas. Laplume, Petersen and Pearce (2016) present a background of 3D printing where the evolution of the printer and their methods are studied, and a reflection on the impact of this technology may have on the supply chain and society is put forward.

3D printing brings companies' the ability to become more responsive, as production is brought closer to the client, reducing the lead time, ensuring the client's fundamental wishes and the planet's sustainability (Paritala, Manchikatla, & Yarlagadda, 2017).

15.2.2. Supply Chain and the Last-mile

The supply chain is becoming vertically connected. Thus, it is striving to the point of managing and delivering orders in real-time (Oztemel & Gursev, 2020).

New business models are emerging due to the infinite opportunities presented by emergent technologies and the interoperability between systems (Prause, 2016). Win-win business collaboration schemes are being increasingly considered to optimize urban transport (Nathanail, Gogas, & Adamos, 2016). Moreover, the supply chain is evolving into a sharing economy open cross-company network (Kirch, Poenicke, & Richter, 2017).

Based on the interconnection of systems, there is a possibility of creating an effective demand-oriented manufacturing process (Lom, Pribyl, & Miroslav Svitek, 2016). Thus, the embracement of networked manufacturing, adaptive logistics, and client co-design will render the value chain more complex, open, collective, and evolutionary (Prause, 2016). Therefore, last-minute and individual demand emerge the importance of defining new dynamic business models (Kagermann et al., 2013), embracing cooperation and integration among all stakeholders. There will be a promotion of global connection and understanding between individuals and agents of different locations and sectors through the supply chain (Oztemel & Gursev, 2020).

On the other hand, co-modality (or crowd shipping) can offer limitless combinations of transport modes (Gatta, Marcucci, Nigro, Patella, & Serafini, 2018) that can be fully dedicated to goods transportation or allocated simultaneously to other tasks, mostly passenger transportation, due to their underutilized capacity space (E Taniguchi & Thompson, 2014). Co-modality also presents the opportunity of replacing intermediaries warehouses with virtual exchanging points (Ducret, 2014). Lost packages, failure to deliver on time, sorting out parcels, misalignment of drivers and deliveries, and lack of interaction due to the inability to link and connect the different stakeholders compromise efficiency and flexibility of deliveries (Perboli, Rosano, Saint-Guillain, & Rizzo, 2018).

E-commerce, especially in the case of business-to-consumer (B2C) increases the difficulty of product distribution with direct impact on traffic congestion and accessibility as well as environmental pollution and climate change (Ducret, 2014; Morganti, Dablanc, & Fortin, 2014).

Nevertheless, it lacks a holistic perspective regarding the product journey since clients perceive the experience and the actors involved as one (Vakulenko, Shams, Hellström, & Hjort, 2019). The tracking is still not performed in real-time, neither there is information about the exact lead-time. The empirical study performed by Cao, Ajjan and Hong (2018) of online shoppers in China and Taiwan concludes that shipment and order tracking play a relevant role in online shopping.

Moreover, the rise of e-commerce over the past 20 years has created an increased need for a responsive omnichannel distribution to meet the last-mile challenge (Melacini, Perotti, Rasini, & Tappia, 2018).

The “last-mile” term emerged from the telecommunications industry to name the final leg of a network. Applied to the supply chain, it refers to the last segment of the delivery process from the last distribution center, consolidation point, or local warehouse (Xiao, Wang, Lenzer, & Sun, 2017). Synonyms such as final-mile, home-delivery, B2C distribution, and grocery delivery have also been found in the literature (Lim, Jin, & Srai, 2018).

Last-mile is considered in academia as the least efficient supply chain stage, comprising 28% of the total delivery cost (Yuan Wang, Zhang, Liu, Shen, & Lee, 2016), and the least environmentally-friendly (Gevaers, Voorde, & Vanelslander, 2011). A literature review carried out about last-mile logistics in Smart Cities and urban areas considered collaborative urban logistics and optimization of transport management and routing as the main innovations to reduce transport costs and inefficiency (Ranieri, Digiesi, Silvestri, & Roccotelli, 2018).

Transport systems will increasingly be flexible and multi-modal (Prause & Atari, 2017). Several authors refer to the advantages of having a simultaneous and integrated approach between home delivery and client's pick-up (Zhou, Baldacci, Vigo, & Wang, 2018; Zhou, Wang, Ni, & Lin, 2016). Furthermore, large firms, including Amazon and UPS, are increasingly investing in the ridesharing service model's adaptation, where an entity procures transportation services via a mobile or computer application. The services are performed by independent contractors using a personally owned vehicle (Boysen, Fedtke, & Schwerdfeger, 2020; Castillo, 2018; Savelsbergh & Van Woensel, 2016).

15.2.3. Research Findings

From the literature review, we can conclude that although deliveries are striving for the real-time model, promoting the collaboration of different stakeholders and transportation means, at the same time that 3D printers are becoming available for households, there is not yet a concept nor a framework capable of bridging them and providing an open and harmonized solution to breakdown the standard supply chain, thus allowing the open collaboration between stakeholders and effectively bringing the manufacturing process closer to the client.

Therefore, in line with the above-mentioned gap, this article aims to conceptualize a supply chain service model based on the personalized fulfilment of the last-mile considering local and dynamic collaborations. Thus, the research challenge underlying this study seeks to answer the question *"How can a consumer purchase a personalized product at any part of the globe and have it in (almost) real-time?"*.

15.3. Empirical Research

The solution to answer the previous mentioned research question will need to be based on an end-to-end real-time revenue-sharing service, at the disposal of consumers and enterprises, that integrates different modes of transportation, storage warehouses and manufacturing assets.

There are already entities that carry out steps of the process. However, they act in isolation and without coordination. The present methodology is aimed to simulate the existing problem and perform empirical research to identify local organizations that could support the theory that the combination of these type of entities would enable local manufacturing and delivery in real time with minimal environmental impact. The goal was not to base this research in a large-sized city location but to test the possibility of proposing a collaboration between already established companies from a small random city to provide a personalized service than it would likely be possible to extend it globally. Therefore, the corroboration of this theory for a small-sized city allows for the last step of the methodology to define a disruptive global concept.

15.3.1. Method Design

The methodology followed in this research, sketched in Figure 15.1, was divided in two steps: A) Simulation of the problem and B) Design of a local solution. Quantitative and qualitative methods were combined.

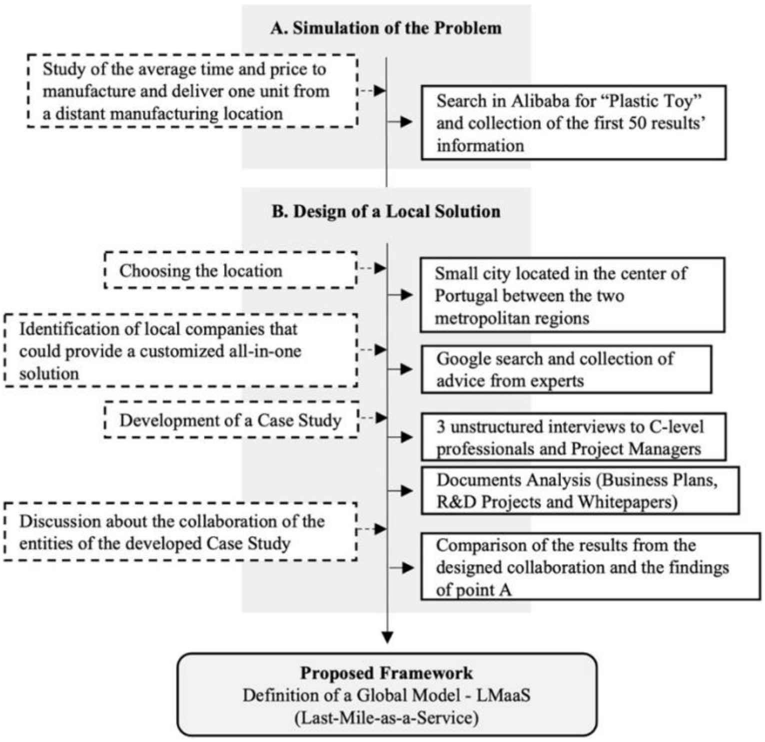


Figure 15:1 The framework of the research method

A) Simulation of the problem - To highlight the existing problem in a real context, an empirical study was conducted; its purpose was to simulate a purchase of a product from a distant location from Portugal (in this case, China). Alibaba was used for the search because it is a platform that directly links (mostly) Chinese manufacturers to consumers, allowing them to give a production order when purchasing, according to the desired quantity. To collect data for this simulation, the product sought was "Plastic Toy". The data about the costs and time of execution and delivery of the first 50 results were collected. The goal of this sub-section was to quantify the existing problem to compare it in sub-section B with the local collaboration proposed.

B) Design of a local solution - To demonstrate the possibility to locally achieve a personalized and real-time response to any purchase, an empirical search in a city of Portugal (9,000 kilometers away from China) was carried out, looking for local stakeholders whose characteristics could provide the production of any personalized item as well as its delivery. Moreover, the city of Aveiro was chosen since it is a small city located in the center of Portugal, between the two metropolitan regions (Lisbon and Porto). A case study was performed to get a more in-depth insight about the local chosen entities. This research method examines complex phenomenon and intensively studies a subject with the goal of generalizing it to a broader perspective (Gustafsson, 2017). Moreover, the case study was based on structured interviews with privileged interlocutors of each organization where the topics explored went through the content of the organization's activity, their vision about their company and the collaboration with other companies to provide an integrated and personalized service, complemented by the analysis of documents (such as business plans, R&D proposals, and whitepapers) gently provided by the organizations. In summary, three structured interviews (adapted to each interviewee's activity) with C-level professionals and project managers were carried out. In general terms, the questions which based the interviews were: *"What is the history of the company, its purpose and vision?"; "Is it (and how is it) possible to leverage your expertise to any part of the globe?"; "What are the requirements and limitations of your product/service?"; "What are the estimated costs and time?"; "What is your openness to integrate with other solutions and provide an end-to-end service?".* The overall goal was to understand the cost and time to manufacture and deliver a product in real-time within the last-mile, considering the collaboration of these entities. The results of the comparison between standard and personalized supply chains feed the discussion and ground the rationale for the model proposed in section 15.4.

15.3.2. Procedure

This sub-section details the undertaken procedure of the method design mentioned above. Moreover, on one side, Step A simulates the existing problem of traditional supply chains to perform real-time personalized requests. On the other side, Step B set up a solution that combines different local entities and compares it with Step A's results.

15.3.2.1 Step A: Simulation of the Problem

From a sample of 50 products in Alibaba, the minimum quantity order was selected, and data were collected regarding the price of the product, its shipping cost, as well as the lead time and shipping time. From the results obtained (Appendix 15.1) it is possible to notice that:

i. Only 7 products allowed for a single unit order;
ii. The average lead time is 11.52 days;
iii. The average minimum delivery time (average of the lower interval values) is 12.82 days;
iv. The average maximum delivery time (average of the upper interval values) is 19.94 days;
v. The average unit price is 5.06 USD;
vi. The average unit shipping price is 14.99 USD, representing a percentage of 296.4% of the product price;

Thus, for a "Plastic Toy" ordered in Alibaba, from China, it would take more than 32 days to be delivered to a client in Portugal, its cost averaging more than 20 USD. If the production would be carried out by a local 3D printer, it would use less raw material to produce the same product and the lead time would be lower. Also, it would allow the personalization of the product, unlike in the mentioned platform of purchase, given the inherent standardization focus.

In summary, it is noted that the traditional supply chain does not fit the needs of personalized requirements.

15.3.2.2. Step B: Design of a Local Solution

Based on the authors' search, the following organizations were identified based on the problem they address, which could contribute to organize a personalized response to local consumer's requests. The openness to collaborate and promote a sustainable solution to eradicate unnecessary emissions, waste and the inefficiency throughout the supply chain was unanimous among the interviewees.

The content collected from the three structured interviews and the documents' analysis of BeeVeryCreative (BeeVeryCreative, 2021), LUGGit (LUGGit, 2021) and EMBERS (EMBERS, 2019) is detailed in Table 15.1.

Table 15:1 Brief characterization of the parties involved: BeeVeryCreative, LUGGit and EMBERS

Entity	Description
BeeVeryCreative (Personalized Manufacturing)	BeeVeryCreative was the first Portuguese company to build a 3D printer. The company sells printers and pieces to other manufacturers. The mindset has always been and continues to be the open-source and close collaboration between the various players in the market. The strategy is varied. The ability to develop new printers has been put at the service of innovation projects in which the main concern is not economic viability, but rather the disruption in a given sector with patenting and creating intellectual property. This also comes with the willingness to openly dispose of IPs at the service of the community. BeeVeryCreative started with the home-user segment, education and third-party manufacturers. In recent years, they have entered in the industry and space (with projects for the International Space Station) markets. Furthermore, the company is currently carrying out a project for skin printing (the largest and most personalized organ) with a very interesting survival rate of living cells.
LUGGit (Personalized Logistics)	LUGGit's vision is to allow everyone to travel without carrying their luggage. Moreover, LUGGit is a platform that allows anyone to request a Keeper (driver) in real-time to pick up their luggage and deliver it at the place and time they choose. Through a revenue-sharing model (the drivers act as service providers) the service can be performed in real-time or be scheduled (in advance). Unlike other carriers, LUGGit's algorithm has the premise of setting the exact time on which the client wants the delivery to happen. The optimization rule is always according to the chosen delivery time and not according to the location of the delivery. The operators at LUGGit are entities that have drivers, vehicles and storage warehouses. They can perform multiple collections, store for the desired time and deliver at the time the client wishes.
EMBERS (Aggregated Platform)	EMBERS was an EU-funded project under the Horizon 2020 program, which developed an aggregated, harmonized, standardized open-data mobility platform where everyone could access the city's data and their mobility services from different operators. Through a Mobility-as-a-Service (MaaS) model, the information about existing mobility services was aggregated and made available to citizens. This way, users could move smoothly from point A (start) to point B (end), without the discomfort of having to buy tickets from multiple vendors, wait in queues, or visit various platforms to coordinate transportation. EMBERS goal was to help cities break existing silos (proprietary solutions). EMBERS was responsible for aggregating mobility-related data, including parks and parking spaces, maps, route generators, points of interest, traffic, which would serve as the basis for third-party applications.

The empirical case study show that BeeVeryCreative provides 3D printers (and components) that allow personalized manufacturing; LUGGit showcases how the service's personalization can be combined with logistics efficiency and the role of independent service providers to perform it, within the last-mile, and EMBERS provides a harmonized platform, as a service, open to all stakeholders and resources. In a nutshell, their best practices and interrelationship in the present solution can be summarized as demonstrated in Figure 15.2 (below).

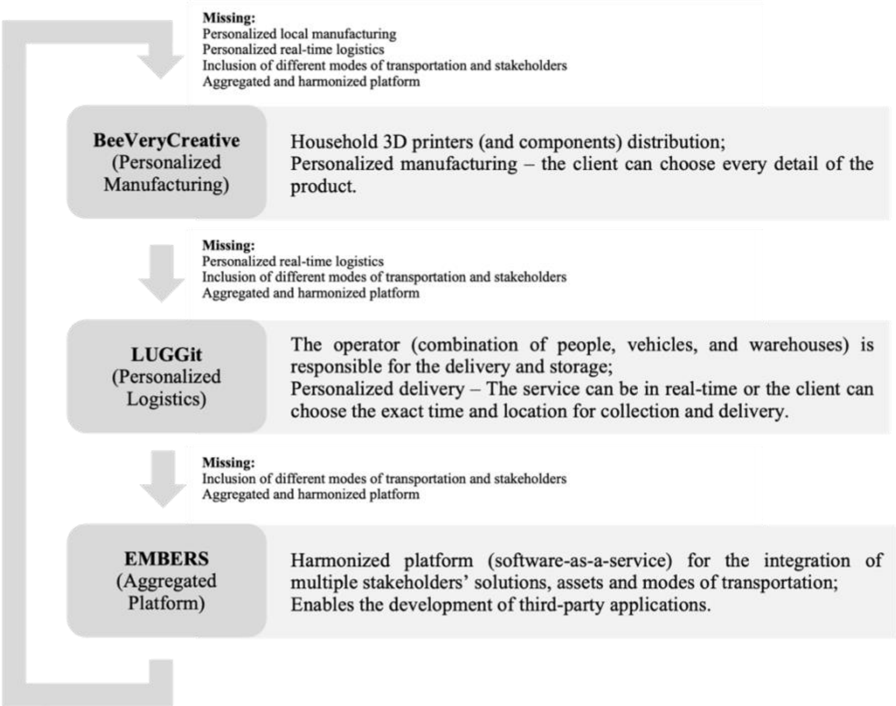


Figure 15:2 Complementarity of the contributions of BeeVeryCreative, LUGGit and EMBERS

Considering the characteristics and complementarity of the contributions of each entity involved, the high-level architecture of the solution is defined and represented in Figure 15.3.

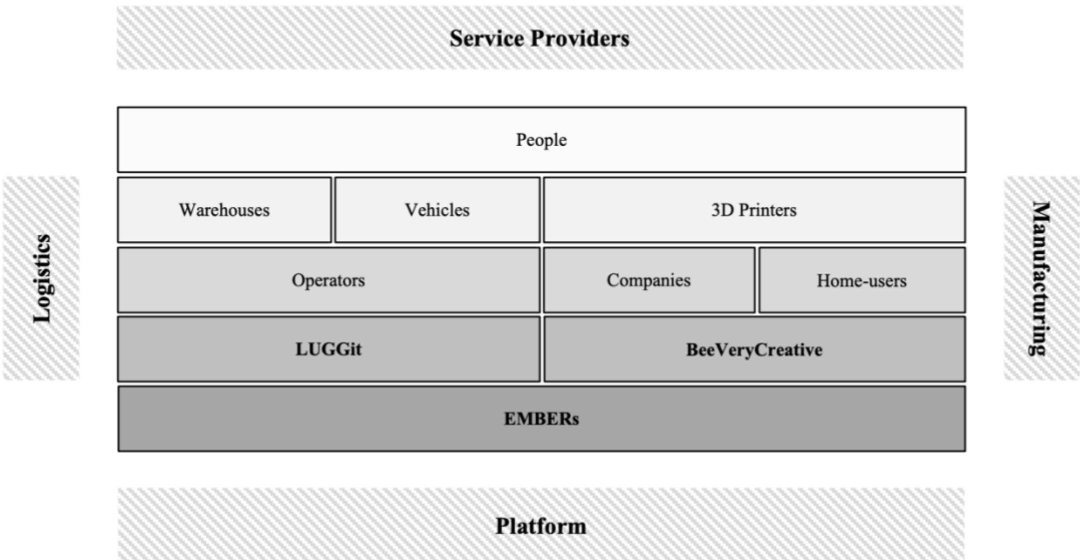


Figure 15:3 High-level architecture

To compare the results obtained in sub-section A, during the interviews, the interlocutors of BeeVeryCreative and LUGGit were asked about the estimated cost and manufacture and delivery times, respectively, within the city of Aveiro, for the same type of "Plastic Toy" used in the Alibaba search.

BeeVeryCreative has 400 USD printers that could produce it in half of day with an average total cost of 20 USD considering labor, materials and other costs; LUGGit has drivers which could perform the service from any location in the city to the delivery destination in real-time for an average price of 15 USD.

Moreover, Figure 15.4 compares the previous empirical example obtained from the Alibaba platform and the solution provided by the combination of the mentioned entities.

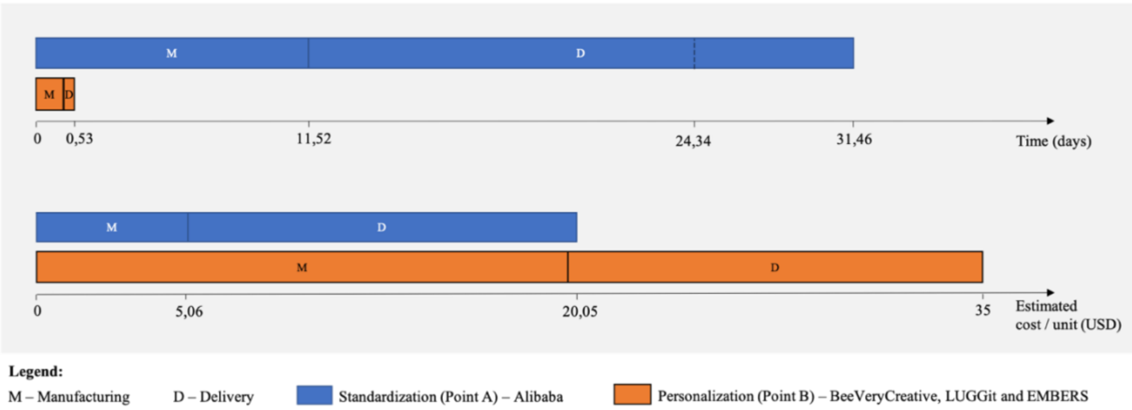


Figure 15:4 Simulation results for the associated time and estimated cost of standardization (sub-section A) and personalization (sub-section B)

As it is demonstrated in Figure 15.4, the overall lead time of the traditional supply chain was decreased by 98% considering the proposed collaboration of the three entities in this sub-section.

From the interviews, it is clear that there will be no limits to what can be achieved by combining 3D printing with real-time logistical capacity and the integration of all stakeholders. However, it was also possible to note that personalized manufacturing is still not competitive for those who do not mind waiting several days to receive their purchases. Moreover, the estimated cost is approximately 74% higher in the proposed model.

Nevertheless, 3D printing evolution is expected to decrease manufacturing costs and reduce the lead time. Furthermore, only the designed solution allows the personalization of the product and real-time delivery.

The combination of the entities of the case study would allow same-day production and delivery of one of the products that based the sample for sub-section A, requiring only a BeeVeryCreative 3D printer and one LUGGit operator to respectively manufacture and deliver it according to the requirements. Furthermore, all this could be integrated into a single platform and charged as a service depending on the resources used, as well as the distance travelled from the manufacturing facilities to the delivery location, as well as time spent.

Based on the findings from the combination of the entities from a small Portuguese city, Aveiro, it is recommended that further efforts are put into place to scale and globally adopt this model.

15.4. Proposed Framework

The main results of this study, described in this section, are presented and discussed according to the steps of the methodology previously outlined. In sub-section A, the results from the simulation of the problem to highlight the existing gap of the traditional supply chain are presented. Following this, on sub-section B, a study from the empirical search and the performed interviews to base a local collaboration to ultimately compare and discuss the standard and personalized supply chain results will be developed. Lastly, this section presents the concept of Last-Mile-as-a-Service (LMaaS).

From the comparing results and the generalization of the designed local combined solution in sub-section B, reflection about the future of the supply chain setup and fulfillment emerges. The relocation of the manufacturing process to the last-mile may eliminate a significant part of the traditional supply chain. The combination of all entities and individuals throughout the globe would allow a new industrial paradigm where the location of the clients would be the input to combine the local entities to manufacture and delivery the product quickly and sustainably. Moreover, any entity could resort to the last-mile created by the combination of the three mentioned entities to provide a product to be delivered to a client in the city of Aveiro. However, others could assure the fulfillment of the last-mile for purchases of clients located in different Portuguese city. Thus, this could be extended to any region. In general terms, this model will allow endless combinations between entities and individuals to meet the personalized requirements of any client anywhere in the globe.

Therefore, a Last-Mile-as-a-Service (LMaaS) should emerge, where stakeholders with delivery, storage and manufacturing capabilities are integrated to perform an end-to-end service within the last-mile. The empirical case study of the previous section can ground this global model that promotes and makes available an open resource-sharing platform based on a marketplace of last-mile collaborations that enables any company to allow their products and services to be personalized and delivered to any location through the cooperation of local stakeholders (Figure 15.5 below). This model suits the interests of the clients by allowing them to choose the exact requirements for product and delivery service.

The marketplace shall contemplate the transparent and open collaboration between stakeholders, fostered by a single platform to find the best combination of means to perform the last-mile for a specific request.

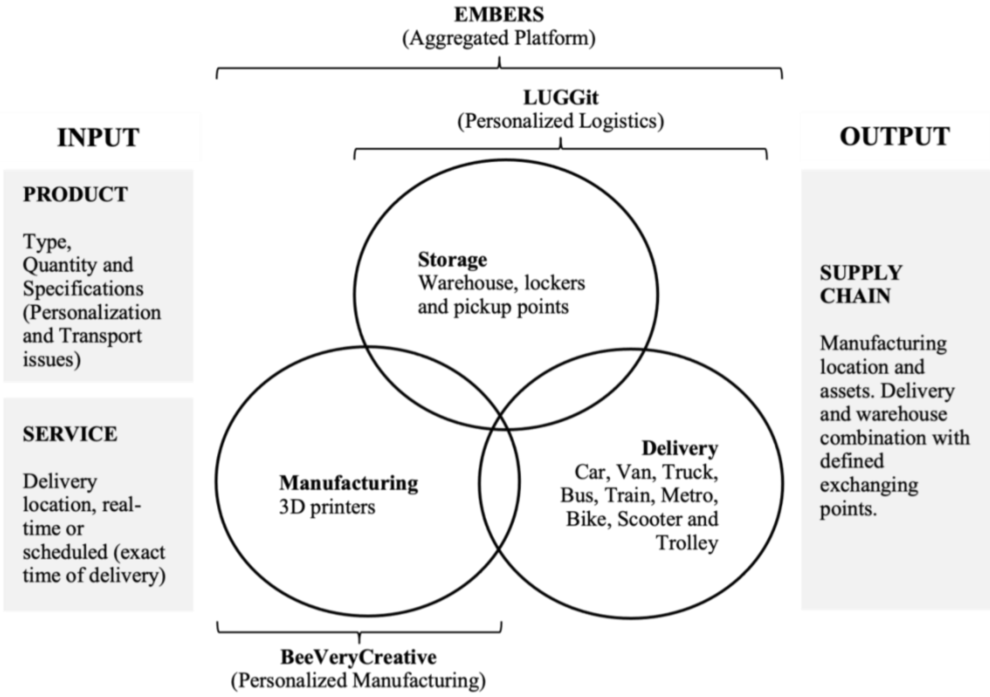


Figure 15:5 Last-Mile-as-a-Service (LMaaS) marketplace

Table 15.2 (below) highlights and compares the relevant features of BeeVeryCreative, LUGGit, EMBERS to ultimately aggregat them,thus forming the foundations of the LMaaS. The indicated features in Table 15.2 were based on the relationship between each of the entities' most significant attributes, and the mentioned gap in the Introduction and the Theoretical Background about the lack of an open and end-to-end integrated and personalized supply chain based on the dynamic collaboration of multiple and local stakeholders.

Table 15:2 BeeVeryCreative (BVC), LUGGit (L), EMBERS (E), and LMaaS features comparison

Features	BVC	L	E	**LMaaS**
Non-proprietary Solution			X	**X**
Open Source	X		X	**X**
Integration of Third-Party Services			X	**X**
Revenue Share Model		X	X	**X**
Multiple Transportation Modes			X	**X**
End-to-end Service		X	X	**X**
Real-time Service		X		**X**
Prediction Analytics		X	X	**X**
Goods Transportation		X		**X**
Passenger Transportation Modes			X	**X**
Tracking (GPS)		X	X	**X**
Storage Warehouses		X		**X**
Stock Control and Management		X		**X**
(Personalized) Manufacturing	X			**X**

Last-mile collaborations will dynamically change, since this concept (LMaaS) is based on a marketplace where individuals or entities can provide their assets so they can be made available to any company that wants to sell (manufacture) their products in a given location. The specific collaboration to each purchase will consist of the best available options capable of responding to the client's requirements of the product and service. Different people can perform the collection of the manufactured goods and the delivery to the client; however, the supply chain needs to be created prior to the manufacturing order. The LMaaS starting point will be dependent on the manufacturing capacity close to the client. A new request will go through the decision journey represented in Figure 15.6 (below), where manufacturing only starts after the algorithm has determined that delivery will also be fulfilled based on the requirements of the client.

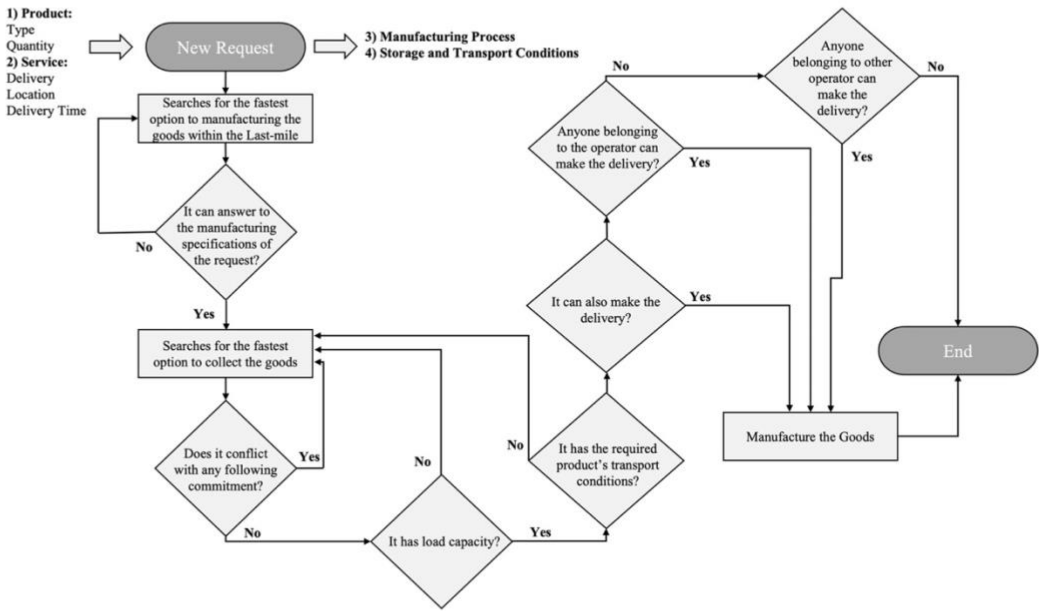


Figure 15:6 Last-mile-as-a-Service (LMaaS) flow chart diagram

Personalization is characterized by producing what the client wants and delivering it at the desired place and time. To ultimately achieve that and be at all times capable of providing an immediate response is necessary to integrate additive manufacturing techniques with logistics, merging the physical and the cyber layer, enhancing the exchanging of information throughout the value chain from the prediction of the order to manufacturing and its delivery (Correia, Teixeira, & Marques, 2021).

Moreover, taking the product specifications, the marketplace will return the most suitable option to manufacturing it (considering the manufacturing process), and combine it with the logistics best options to deliver (and store if needed) the product at the place and time the client chooses. Multiple scenarios and combinations of last-mile fulfillment can be found in Figure 15.7 (below).

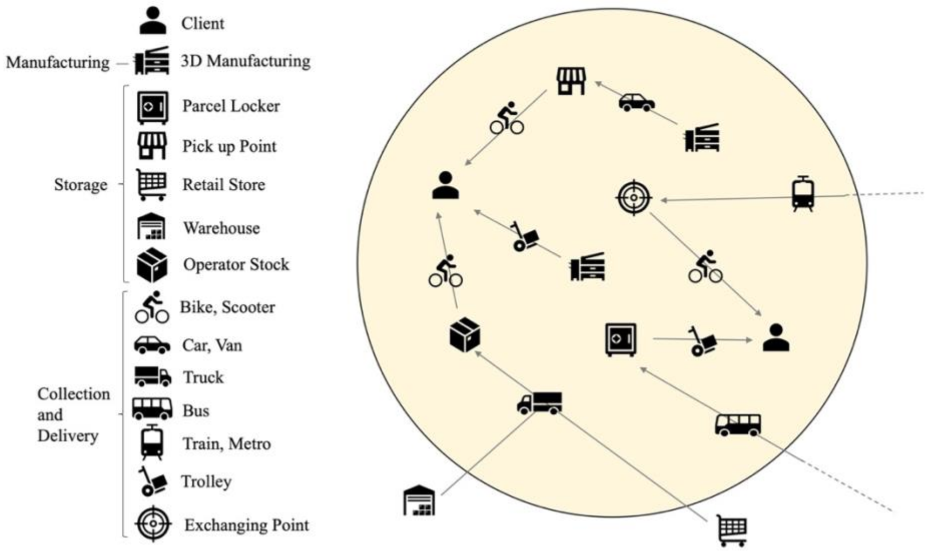


Figure 15:7 Last-mile scenarios examples

Figure 15.7 also acknowledges that standardization and personalization manufacturing processes will continue to coexist. Therefore, the last-mile fulfillment must consider the ability to perform real-time deliveries and enhance the collaboration between stakeholders and modes of transportation, even if it follows the manufacturing of a standard product.

In summary, unlike the existing mass production paradigm that has reasonably justified moving the manufacturing process to other countries, with the LMaaS model the collaboration between stakeholders and the associated technologies can represent a significant decrease on emissions and help combat climate change. At the manufacturing level, the needed raw materials can be considerably reduced, up to 100% of the existing waste, and, at the transport level, fewer vehicles will be needed to perform the deliveries and traveled distances will be shortened. Replacing private vehicles with smooth modes of transportation will leverage cities' footprint towards zero. Thus, this model responds unequivocally to the initial question of this research.

15.5. Conclusions and Future Work

Industry 4.0 is striving to allow clients to purchase personalized products in terms of their requirements and the associated delivery service. Personalization brings several challenges that can only be overtaken with the integration and sharing of resources among organizations. This paradigm can lead manufacturing in the destination country to be easier and cheaper. Moreover, 3D printers can produce personalized components for the open network and relocate the manufacturing process closer to the client, reducing lead time, transport costs and customs fees, with significant impact on economy, environment and society.

Nowadays, if a company wanted to provide an end-to-end personalized service at any location, it would struggle to do it. Based on an empirical study of Alibaba, it was noted that standard supply chains do not present a solution to the research question. After simulating the problem, companies who could provide personalized (and immediate) deliveries and manufacturing were looked for within the local ecosystem. The rationale of the methodology was to choose a small-sized city to study if the collaboration of local companies could be more competitive than the standard mass production supply chain. The corroboration of the theory for the local example would allow a global model to overcome the existing gap and respond to the research question.

From the combination of the manufacture assets of BeeVeryCreative, the operational aspect of LUGGit and the open integration promoted by EMBERS it was possible to reduce the overall lead time by 98%.

Considering the findings of this empirical study and the technological potential of Industry 4.0, this article proposed an innovative concept for the disruption of the Supply Chain — Last-Mile-as-a-Service (LMaaS), where different modes of transportation, storage, and manufacturing resources can be integrated and managed to allow immediate deliveries and summarize the supply chain to the Last-mile fulfillment. LMaaS aims to provide to any entity the chance of allowing the personalization of their products and delivery at any location. The standard supply chain, where manufacturing is performed 10,000 kilometers away from the consumer's location, would cease to exist.

The proposal of this disruptive concept to bring the supply chain to the last-mile will allow the breakdown of the traditional supply chain and help combat greenhouse gas emissions in cities caused by urbanization and logistics activities. The number of circulating vehicles and their travelled distances will reduce at the same time that they will be replaced by last-mile smooth modes of transportation.

However, this new proximity model, due to its complexity and disruptive nature, can bring some challenges. On the one hand, there is the short-term transition challenge for the reality because the concept is grounded in the culture of sharing and cooperation of enterprises. On the other hand, the associated overall estimated cost is still quite high when compared with the traditional supply chain for the consumer. Additionally, this concept may not be applied to all products. Mass production for various sectors and realities will not cease to be present since it will continue to be more competitive for standard products. Moreover, in the future, there may be a close relationship between additive and subtractive manufacturing, in a hybrid model, to the point where the second serves only as support for the production and maintenance of the first.

As future work, the proposed model shall be validated in practice to measure its impact on the macro and micro economy and provide information about the challenges encountered in the process. In addition, this paper can lead to further conceptual and empirical studies while developing connections with local stakeholders in different regions of the globe to realize the concept in a proof-of-concept prototype.

The role of the city can be also further studied. The city can play a catalyst role in the adoption of this concept by putting at the community's disposal the needed resources and materials. The role of society shall be further studied, as well as the impact this concept will have in its organization and labor needs.

The supply of the raw materials and equipment components as well as the assembly of larger products must be further studied. Autonomous vehicles (in their various forms) may also bring new challenges and opportunities.

Evolving into a system where there is the chance of individuals producing everything at any location, it will also be important to study what will be the role of brands and how they will differentiate themselves.

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Appendix 15.1 – Alibaba collected data

Product	MOQ	Price (USD)	Delivery Price (USD)	Transaction Fee (USD)	Execution Time	Delivery Time
1	1000	$1,210.00	$1,068.72	$80.74	15	16-44
2	12	$84.00	$78.02	$5.35	12	18-23
3	20	$220.00	$58.55	$11.46	15	16-44
4	1	$13.00	$56.15	$2.04	15	18-23
5	2	$18.76	$262.10	$8.29	15	7-15
6	2	$70.00	$51.47	$3.59	7	6-10
7	600	$90.00	$53.03	$4.22	25	18-23
8	2	$26.74	$56.15	$2.45	12	20-35
9	4	$16.80	$85.90	$3.03	10	3-10
10	1000	$120.00	$72.57	$5.69	3	6-10
11	1	$4.60	$26.82	$0.93	7	5-10
12	100	$10.00	$46.60	$1.67	7	25-30
13	200	$12.00	$37.89	$1.48	7	5-10
14	200	$40.00	$29.84	$2.30	7	5-10
15	288	$187.20	$232.57	$12.36	7	5-8
16	1	$24.63	$55.92	$2.38	7	25-30
17	200	$40.00	$46.39	$2.55	5	5-10
18	2	$3.82	$21.58	$1.05	7	25-30
19	1200	$2,232.00	$209.81	$72.04	15	9-12
20	10000	$1,600.00	$321.31	$62.72	15	18-23
21	500	$2,995.00	$4,597.00	NA	15	4-15
22	1	$27.50	$82.00	$3.24	10	6-10
23	1	$15.50	$37.16	$1.56	10	6-10
24	50	$110.50	$55.92	$4.91	10	25-30
25	2	$17.90	$26.58	$1.32	7	9-12
26	2	$37.70	$118.00	$4.60	15	3-7
27	2	$7.28	$52.10	$1.76	7	25-30
28	15000	$900.00	$742.80	NA	10	7-15
29	500	$115.00	$213.08	$9.68	5	5-8
30	1	$10.00	$32.00	$1.30	15	6-10
31	1500	$1,350.00	$5,589.44	NA	15	16-44
32	120	$51.60	$53.59	$3.11	3	25-30
33	10	$8.50	$54.00	$1.85	10	5-10
34	300	$1,377.00	$1,140.40	$74.27	15	16-44
35	500	$450.00	$627.22	$31.78	15	25-30
36	10	$2.50	$40.10	$60.00	60	5-10
37	100	$80.00	$148.87	$6.76	15	5-10
38	500	$2,500.00	$1,140.40	$107.40	7	25-30
39	10	$5.50	$39.64	$1.34	15	4-7
40	1	$8.00	$51.26	$1.75	15	25-30
41	20	$16.60	$37.77	$1.61	15	25-30
42	100	$17.00	$55.92	$2.16	5	18-23
43	200	$30.00	$14.00	$1.30	15	09-25
44	100	$198.00	$297.68	$14.63	15	25-30
45	50	$16.50	$62.88	$2.35	4	5-8
46	10	$2.70	$7.04	$0.29	5	20-35
47	50	$60.00	$72.23	$3.91	5	3-7
48	50	$115.00	$93.44	$6.15	7	5-10
49	24	$36.00	$763.74	$23.60	3	9-12
50	2000	$200.00	$322.00	$15.40	15	10-15

Legend:
MOQ – Minimum Order Quantity
N/A – Not Available

Part V

Conclusion

Chapter 16. Conclusion, limitations, and further studies

16.1. Final Conclusion

The research question that inspired this thesis was "How can Smart cities contribute to increase territories' sustainability and the inclusion and quality of life of local communities?". Therefore, this doctoral thesis aimed to provide policymakers with frameworks to support decision-making through the Design Science Research methodology. Moreover, the design guidelines promote the participation of citizens in decision-making by acknowledging dedicated methodologies and bridge their isolation by proposing innovative urban logistics models. This contemplates meeting citizens needs in real-time while reducing circulating vehicles and their travelled distances.

Furthermore, this thesis aimed to raise the discussion on how current urban planning jeopardizes cities' sustainability and citizens' inclusion to propose a reference model to help support policymakers' decisions. With this work, it is expected that cities can benefit from more assertive decision-making to implement a Smart city strategy.

16.1.1. Findings of Strategic Planning and Urban Development

The post-war period acknowledged an emerging information society on the urban scope. As a result, several concepts emerged as "wired cities" and "digital cities". Recently, in the 90s an urban-tech phenomenon led to the understanding that the application of technologies to urban furniture could enhance inhabitants' quality of life.

These ground the emergence of Smart Cities. Moreover, the Smart City concept passed three stages, from Smart City 1.0 to Smart City 3.0, with different focuses: (i) technology, (ii) people and sustainability, and (iii) co-creation and co-design. More than 35 existing variations of the Smart City concept were found within the literature. Despite the different understandings and variations, it was vital to promote a standard Smart City concept to guide cities throughout implementation, following up, and regulation. Therefore, Smart Cities can be defined as cities supported by ICT, co-designed with citizens, to promote social, environmental, and economic sustainability and improve citizens' quality of life.

Portugal served as a case study to understand the state-of-the-art of Smart Cities. Moreover, a significant discrepancy within the country was noticed between cities with financial support and the others, which is directly associated with their dimension. This fact puts the continuity of the projects at risk and may explain the lack of medium and long-term strategies. Furthermore, access to funds has been one of the main drivers of Smart City initiatives in Portugal. This may have led cities to adapt their strategies to meet the scope and requirements of each funding opportunity. Thus, losing the overall logic that was at its origin.

Smart City 1.0 is not assumed in Portugal by implementing technologically disruptive solutions but isolated initiatives, largely pilots, without an apparent holistic strategy. While smaller cities focus on implementing specific verticals to address existing gaps with a quick payback, larger cities, on the other hand, have associated a holistic vision for the territory (Smart City 2.0). More than doing small projects or pilots, the cities are committed to urban digital transformation. Through an integrated management platform, they aim to centralize data to support decisions. On a superior layer, few cities are focused on engaging citizens through participatory methodologies promoting their collaboration and co-creation with citizens (Smart City 3.0).

To understand the lack of Smart City implementations, the barriers that could be hampering the process were studied. Moreover, were obtained 15 critical barriers (characterized by having high impact and are on policymakers' hands), mainly from the areas of Governance, Project, and Organization. Besides these, there was only one additional barrier ("Lack of citizens' inclusion") from the Socio-cultural area. Technology was the only area that was not represented either on the critical or on the endogenous barriers. Therefore, technological challenges are not within the control of policymakers. In addition, there were only two exogenous barriers classified with significant impact.

In summary, the endogenous barriers, with high impact, ordered by priority were: (i) poor data availability and analytics; (ii) unclear vision/ lack of strategy; (iii) lack of alignment of strategic goals and projects definition; (iv) resistance to change; (v) lack of citizens' inclusion; (vi) deficient of unreal planning; (vii) policymakers' attitude; (viii) lack of execution capacity skills; (ix) lack of a project leader; (x) lack of public-private partnerships; (xi) lack of long-term commitment; (xii) lack of dedicated Smart City team; (xiii) multiple or conflicting goals; (xiv) lack of cooperation and coordination between departments; and (xv) lack of performance measurement tools.

Although cities are increasingly seen as data-driven governance projects, thus enabling third parties to develop new applications. Strategic planning remains rather subjective. Empirically, was notorious the lack of a reference framework to guide their strategic planning. Unanimously, the cities do not contemplate methods nor follow specific guidelines. Moreover, the structure of the organization and the methods used to design their strategies are different. Therefore, data were aggregated to highlight the similarities between the interviewees' answers on the existing strategic planning and distinguish them accordingly to their organizations' structure and methods. Moreover, three cases were found among the cities: (i) cities had no strategy; (ii) each department defines a strategy; and/or (iii) the city recurs to an external dedicated team on this subject.

Interview with the secretary of state revealed their understanding that the city strategy is the competence of local authorities. The government is responsible only for influencing and making available the necessary financial resources. Although, a national Smart City strategy that is being drawn based on three principles: (i) integrated planning (implementation of Smart Cities and efficiency of public spending); (ii) scalability (extension of pilot projects); and (iii) interoperability (common principles that are cross-border), there is no formally defined framework for cities to adopt, nor to involve participatory guidelines.

Besides, to evaluate and monitor Smart City, this investigation unveiled three axes: Quality of Life, Sustainability, and Innovation. These were corroborated by policymakers since there is an evident pattern of the understanding of the concept, with its association with technology to improve public services and increase the city's efficiency and sustainability.

Furthermore, each axis needed concrete standard KPIs. Moreover, the literature's comparison of existing rankings and indexes was performed to conclude about the KPIs to apply to each axis. Moreover, the KPIs from ISO 37120 were focused on Sustainability, the ITU 4902 had a purely ICT-enabled indicator orientation, and Mercer's survey focused on the quality of life.

Furthermore, the top-down approach considering the objective statistical analysis of political guidelines explained in strategic planning documents and public policy programs, should be combined with a bottom-up approach, giving particular emphasis to the citizen, on the development of composite indicators and in the definition of initiatives towards the improvement of people's living conditions.

Thus, it allows, on the one hand, measuring of the standard Smart City performance through a set of indicators, comparable between cities, and, on the other hand, comparable in different moments, according to territory's priorities to personalize the understanding of the Smart City action plan in each context. The goal was to provide policymakers with an understanding of their citizens' preferences, allowing better planning, and resource allocation.

16.1.2. Findings of Participation and Inclusion

Bottom-up approaches are only feasible if it is not biased by citizens not knowing the initiatives or policymakers do not consider them in the process. Furthermore, the need to include citizens in Smart Cities policymaking was unanimous among policymakers. However, what was also unanimous is the many problems associated with this, such as the inability of citizens to have a holistic view and strategical thinking required to bring added value.

Through interviews with policymakers, these stressed that it is essential to involve citizens in the policymaking process at an early stage to evaluate pros and cons and post-implementation and understand the satisfaction with a specific solution. Moreover, it was also observed a wide range of citizens involvement methods across cities.

The challenges about participation pointed by policymakers were: (i) the citizens lack motivation – not supported by citizens evidence since the majority said they had never been contacted by local authorities to give their opinion and they would like to participate; (ii) citizens do not have the necessary knowledge – supported by citizens evidence since most of them never heard about the term, and only a few knew the concept; (iii) citizens often represent their interests rather than the collective interest – citizens contradict this since most of them would like to give their opinion on how the city could be improved for all the population; (iv) citizens focus only on a few topics and neglect the holistic vision – citizens perspective about variety of subjects and the will to participate in short and medium-term goals do not corroborate this argument; and (v) current modes of participation are not adequate - citizens disagreed, the most preferred ways to give their opinions are email and online questionnaires.

It was also noted a significant heterogeneity of preferences across different groups. The findings suggest that policymakers need to have open and dedicated methodologies to allow for participation to take place in different ways. Otherwise, they risk leaving out certain groups of the population and biasing their data. If this is not possible, careful attention should be paid to the groups with lower preferences for the deployed methods to ensure their appropriate participation.

16.1.3. Findings of Industry and Urban Logistics

Covid-19 pandemic brought the necessity to reflect on cities adaptability towards extreme events to meet citizens’ needs. Few policymakers answered positively according to the consideration of the occurrence of extreme events in urban planning. In addition, although they demonstrated confidence to organize urban logistics, to meet citizens' needs, they would struggle to operate autonomously since they would depend on private entities. Mainly, on the supporting Human Resources and the ability to coordinate logistics. The challenges raised were mainly due to the lack of logistical planning and coordination and the inexistence of dedicated resources. Nevertheless, there were also challenges regarding data, human resources, organization, process, territory, means, and tools challenges.

Older people and policymakers from cities with less than 25.000 inhabitants are less familiar with the Smart City concept. Smaller dimension cities are less confident about their willingness to organize urban logistics. The policymakers of the biggest cities mentioned they have only data about a few citizens. On the contrary, policymakers from cities with less than 25.000 inhabitants were the ones to point they have detailed information about all citizens.

Nevertheless, they were almost unanimous about the need of having tools that enable real-time visualization. Also, the study of scenarios to place provisional means (delivery and storage) for the supply of goods.

Thus, an algorithm was designed based on considering collaborative logistics and contemplating micro logistics operators, flexible and multi-modal modes of transportation and stock storage within the last-mile, considering the territory's geography, and having the capacity to forecast citizens' needs.

A relationship between Cities and the Industry was also noticed since cities are increasingly co-created with the citizens. Simultaneously, Industry is arranged from consumer (citizens) specifications. Their connection points of Smart Cities and Industry 4.0 can be summarized as Technology, Process, People and Planning. On top of this, sustainable planning and the efficiency of processes are mutual goals. Results showed Smart Cities are influenced by Industry 4.0. The evidence of the Smart City influence in Industry 4.0 does not exist separately from the Industry 4.0 on Smart Cities. Based on this fact, further research was performed about the industry development.

It was noticed by empirical evidence that there is still a general shortage in the possibility of citizens purchasing personalized products with a convenient delivery service. Furthermore, Industry 4.0 paradigm is still in its early days.

Of the empirical research to Portuguese e-commerce companies, it was noted that many businesses that allow the delivery in one or two days require the purchase to be made by a specific time in the previous day and charge an extra fee. All companies safeguard immediate delivery with the existing stock. They also warn that after the delivery carrier's first attempt, the delivery will be left at the nearest pickup point.

Therefore, the introduction of 3D printing will enhance products personalization which combined with last-mile delivery fulfillment will disrupt the supply chain. The real-time supply chain must be based on leveraging production close to the client and breaking down traditional supply chains. Moreover, as noted with the comparison with the Alibaba platform, the traditional supply chain will not keep with future demand. From the local case study that combined the manufacturing assets of BeeVeryCreative, the operations of LUGGit and the open integration promoted by EMBERS, it was possible to reduce the overall lead time by 98%.

Supply chain planning will be set up from adapting the 5W1H methodology (What, Why, Who, Where, When and How) and the proactive forecast of citizens' needs according to their historical information. It must be considered the product specifications (What), to understand the manufacturing process (How), to allocate the order for a specific manufacturer (Who), of a specific location (Where), at the right time (When), to meet the citizen's requirements.

Therefore, it will be searched within the marketplace for the best combination of collaboration, open to all stakeholders. Depending on the product specifications, the most suitable option to manufacture it (considering the manufacturing process) combined with the logistic and delivery combination of assets to deliver the product at the chosen place and time.

16.1.4. Framework to Increase City's Inclusion and Sustainability

As mentioned in Part I – Introduction - when detailing the Design Science Research methodology, an artefact shall be returned, which may be suitable for application in the current environment and considered by literature to inspire further investigation. Moreover, the goal of DSR is to produce prescriptive knowledge by designing an artefact capable of helping to solve a current issue. This artefact is developed based on the results obtained in the scientific works included in the thesis, which provides guidelines to implement a sustainable and inclusive Smart City. This summarizes a framework of best practices to guide the co-creation, implementation and monitor of Smart Cities.

The guidelines aim to promote a unified view between city departments, which shall be supported by a standard architecture and infrastructure, whose costs may be shared with other territories. Members shall constitute a dedicated team with expertise in the different city areas to guarantee initiatives are aligned with the designed strategic plan. These shall enhance sustainability and inclusion (north star metrics). A local council of experts and community representatives shall scrutinize the execution. This plan shall combine top-down and bottom-up approaches by considering the importance and preferences of citizens to the areas of action with the priorities of the executive and policies agenda. The communication of the results and the knowledge sharing with academia and third parties, and the community will base an open data culture that will strive to create an innovative surrounding environment. Thus, the community must be educated regarding the topic to be prepared to participate. Moreover, a co-creation process shall be considered by defining specific methodologies to increase participation, defining the individuals' characteristics. External funding opportunities shall support the designed strategy and not define it. The stimulation of clusters by the transparent share of the roadmap plan of initiatives and solutions acquisition shall promote the involvement of the community and stakeholders. The design of a Smart City strategy shall also consider the occurrence of extreme events. This way, cities will always be prepared to meet citizens' needs and personalized demands. Moreover, urban logistics optimization by promoting the collaboration between private companies and the placement of shared mobile storage infrastructure owned by the city shall reduce the number of vehicles in the city center and their traveled distances, promoting cities sustainability. This way, deliveries can be performed by non-pollutant means of transportation. Besides, it will enhance the inclusion of isolated populations by disposal essentials on the last-mile.

Previous sections clarified the need to develop software tools based on these findings to help policymakers involve citizens in decision-making and adjust urban logistics resources to meet citizens' needs.

Furthermore, these tools intend to evaluate the maturity level of the city, analyze the data collected through participatory methodologies that evaluate the given importance to KPIs and the preferences of citizens. This shall base the implementation process grounded on the combination of top-down and bottom-up approaches. Finally, the goal is to support the design of the strategic plan. It shall be considered specific goals and concrete actions, allowing the parameterization of the city's resources and existing relationships between stakeholders, allowing the development of scenarios to assist real-time decision-making, combating extreme events, and promoting inclusion.

It is expected that, on the one hand, cities that have a Smart City motivation may reflect on their strategy's foundations and premises, and that cities that do not have it yet shall use defined guidelines to co-create a Smart City strategy.

Figure 16.1 summarizes the findings, starting from the historical evolution of Smart Cities to the premises that shall base the development of Smart Cities' development regarding architecture and infrastructure, participation, and the fourth industrial revolution paradigm acknowledgement. Moreover, the discrepancies between the territories and the lack of capacity to fulfil citizens' real-time needs, associated with the results obtained to help explaining those phenomena inspired the creation of frameworks to assist policymakers answering each of the identified issues.

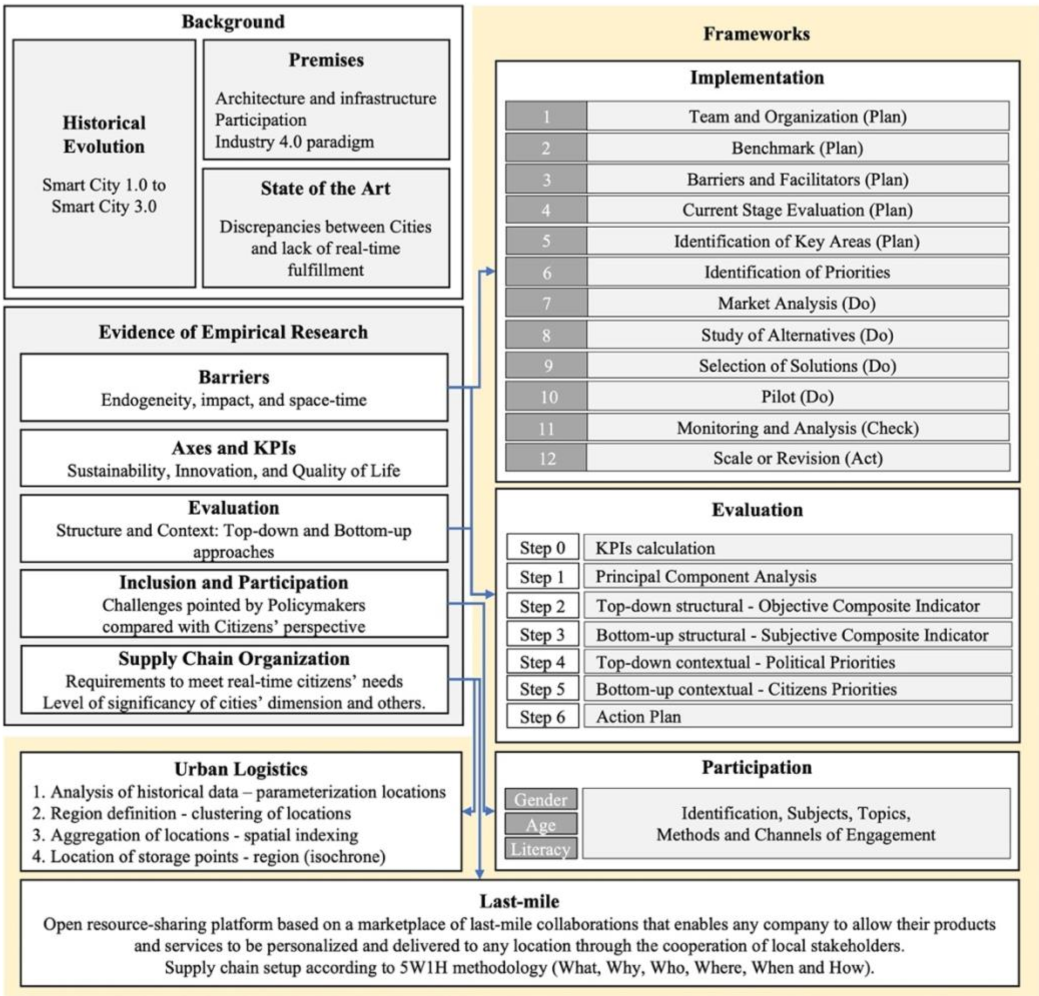

Figure 16:1 Framework to increase cities' inclusion and sustainability (Artefact)

Moreover, detailed information about the empirical research evidence and the frameworks created from the findings can be found in Figure 16.2.

On the one hand, the frameworks here aim to provide academia with new literature and findings to support further studies. On the other hand, to assist cities with detailed guidelines to help them define a strategic action plan. Furthermore, this research can support the definition of requirements to prototyping a technological tool capable of making a portrait of its current situation and guide it throughout the process.

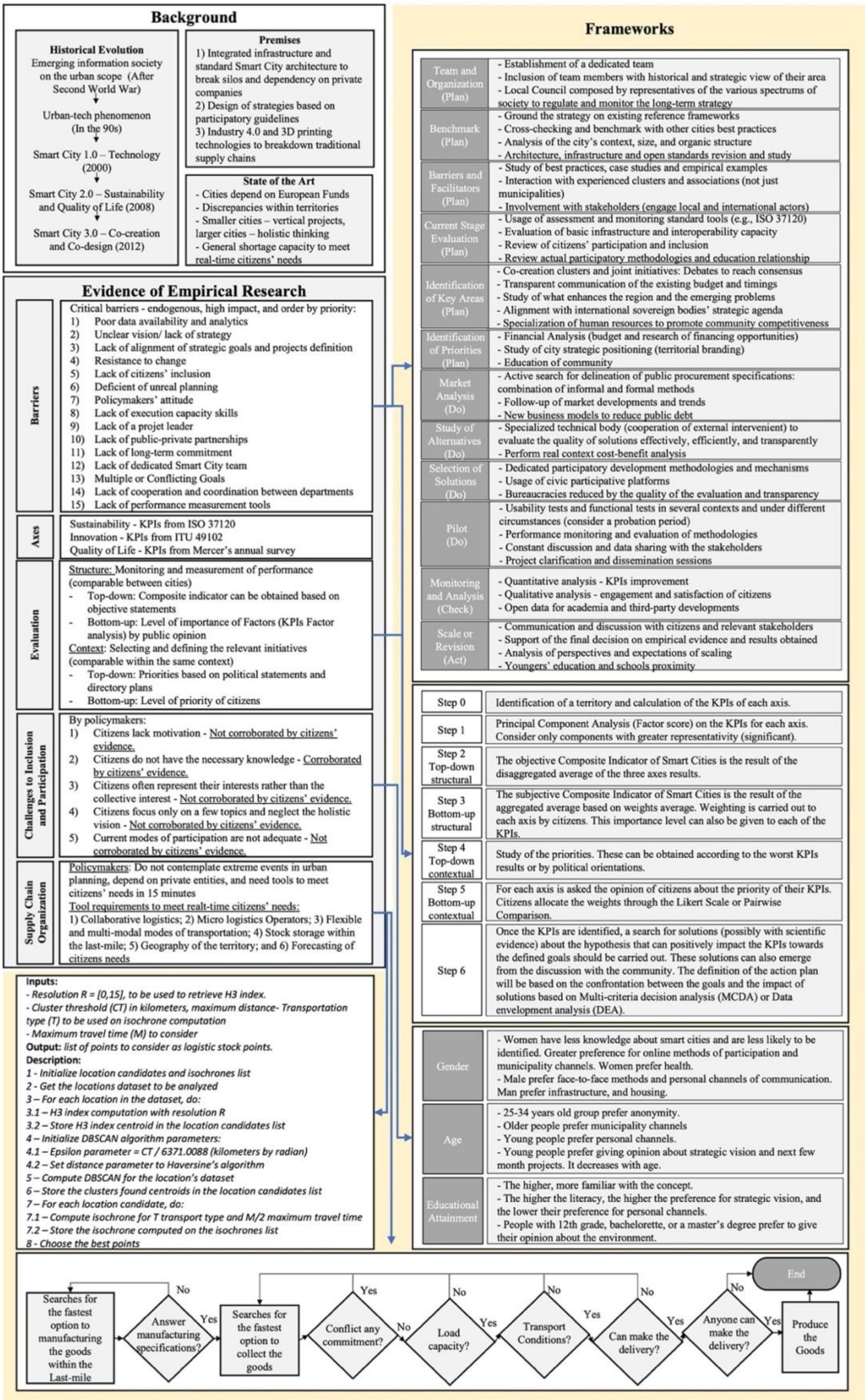

Figure 16:2 Detailed explanation of the framework to increase cities' inclusion and sustainability (Artefact)

16.2. Final Considerations

Final remarks pass through the need to reflect on the course of Smart Cities and how governments shall promote a standard approach and combined strategy. The implementation of participatory methodologies to co-create cities with the community will ensure the adaptation of the strategy to a specific context. The Covid-19 pandemic positively impacted this thesis. Moreover, it brought a new perspective about the need to consider the impact of Industry. The fourth industrial revolution inspires cities to organize urban logistics (the resources and stakeholders) to combat extreme events and reduce circulating vehicles by breaking down the supply chain and resuming it to the last-mile.

This research's moments of discussion and debate raised meaningful discussions of relevant issues in the Smart Cities and urban planning scope. Different stakeholders were joined, and their perspectives compared allowed them to reflect on the future path and need for dedicated debates.

Moreover, the significant take-offs that emerge from the findings of the research journey performed can be summarized as follows:

1) Definition of a strategic plan for the country;
2) Promotion of the relationships and strategies between cities and regions;
3) Proposal of standard architecture and optimize public investment on infrastructure;
4) The need to reduce bureaucracy and optimize public procurement processes (Academia peer-to-peer review models can have a critical role);
5) Catalogue and digitize of cities' resources with attributes to base real-time models;
6) Train human resources and educate citizens on the topic;
7) Discussion of the city organization and logistics role to combat extreme events;
8) Ensure the representativity of different community groups and their participation;

16.3. Impact

The contribution of this thesis can be measured by further implementation of Smart City strategies grounded on the defined guidelines. These shall promote the inclusion of citizens and different approaches according to the different groups of the population.

Since through questionnaire performed to policymakers, 96.47% showed interest in having a tool that could help them organize urban logistics. Use cases could be designed on top of these premises to simulate operational aspects and build case studies.

Moreover, the proposed frameworks shall be validated in a real environment to measure their impact on the macro and micro economy and provide information about the challenges encountered in the process. Furthermore, these guidelines shall be extended with usability tests to realize the proper User Interface and User Experience (UI/UX) to base a next-stage solution. Therefore, this research work may support the requirements of dedicated software to support the strategic planning of Smart Cities.

The impact measurement can be calculated by the number of cities interested in the research findings and want to move forward with discussions and reflections on their territory. Nevertheless, several KPIs can be considered:

1) Number of cities that adopt the frameworks;
2) Number of cities that design a Smart City strategy based on the knowledge obtained through this thesis;
3) Number of cities that implement participatory methodologies;
4) Increase of the percentage of participation and the representation of the different community groups;
5) Decrease of greenhouse gas emissions based on last-mile collaborative models proposed;
6) Decrease of public expenses on solutions without a long-term strategy;
7) Increase in the acquisition and development of open-data and open-source technologies.

Another KPI that can help to evaluate the impact of the present thesis, in this case, in the scientific field, is the number of citations of the papers that constitute this work.

The results and findings will be disseminated directly to policymakers and community involvement to increase awareness. In summary, the willingness to discuss new projects and policies will dictate the success of the present investigation.

16.4 Limitations

As limitation of the present thesis can be pointed the fact that empirical evidence was obtained always recurring to Portuguese stakeholders. Although it is a research with global impact ambitions, it was considered a Portuguese target audience to give a specific context of analysis. Some of the conclusions could not be drawn if considered minor groups of other territories, since it would lack representativity, Therefore, the actors either by focus group, interviews or questionnaires were in their unanimity Portuguese.

In addition, some of the empirical research methods may lack generality since they only considered a small subset of the population and, in some cases, did not perform in-depth analysis about the significant differences. However, these can be points of departure for future research.

The fact that there is no unlimited time to allow experts to reflect on the topics may also present a limitation. Because of Covid-19 pandemics, data was collected through online channels. Although the digital exercise format favors the experts' attendance, it may also represent a limitation because of the lack of physical contact for greater openness.

16.5. Further Studies

Based on the contribution of this thesis, it is crucial to look at the cities' strategic plans for their approach to the topic to initiate a more structured and integrated debate about how shall implement the proposed guidelines.

In addition, through the evidence of the Portuguese territory, the lack of partnerships and current projects between cities was also noted. Therefore, the constitution of partnerships between cities could enable investments in IoT networks, sensitization, data platforms and data analytics services, among others. Furthermore, infrastructure and architecture should be standard among the territories to support the development of applications and combat the high level of initial investment and knowledge, which is scarce in smaller cities. These aspects deserve further discussion.

Existing clusters shall not just be national-wide and must conceptualize transparent methodologies to develop the knowledge and consider their solutions by international cities and ecosystems. A deeper understanding shall be undertaken of implemented projects, their status, and the reasons for their success or unsuccess. The inherent role of European funds or others have, and if they helped cities strive in the process or misaligned their strategies. This should also ground further reflections about the variables and indicators that define the success or failure of a Smart City strategy.

The empirical research performed suggested that there will be no limits to 3D printing and additive manufacturing. The introduction of 3D Printing technologies and data analysis techniques to communities can also be the subject of further discussions. Moreover, it is necessary to understand how cities can assist with the knowledge and means. Thus, allowing the co-creation and learning of innovative manufacturing processes towards the paradigm raised by this research. The city's role can also be further studied since they can play a catalyst role in adopting new models by putting at the community's disposal the needed resources and materials. Evolving into a system where individuals can produce everything at every location, it is also vital to study the brands' future role and how they will differentiate themselves. Privacy and legal work barriers deserve further attention be studied.

Besides 3D printing, autonomous vehicles (in their various forms) may also bring new challenges and opportunities to enhance cities inclusion and sustainability. Shall be discussed the role of the city of owning or not these urban elements.

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