Knowledge and Technology Transfer: Focus on Vietnam

Universities are considered to be important instruments to stimulate regional and national innovation. As such, knowledge and technology transfer from universities to society is the third mission of universities, next to education and research. In a rapidly developing country such as Vietnam, universities are ready engage in these services towards society and to act as an engine of economic development. This book introduces KTT concepts, practices, and contexts to an audience of policy makers, university managers, KTT professionals, researchers and students. We explore the role of KTT in the Research Lifecycle, relevant processes and the stakeholders involved. We particularly highlight the role of education, policy instruments, funding opportunities, governance and infrastructure in the development of a Vietnamese KTT ecosystem. The book combines lessons from Vietnam and Europe considered to be relevant to the Vietnamese KTT community with practical cases from different Vietnamese regions.

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Handbook on Knowledge and Technology Transfer

VETEC

VETEC
Vietnamese European Knowledge and Technology Transfer Education Consortium

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Handbook

on Knowledge and Technology Transfer: Focus on Vietnam

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HANDBOOK on Knowledge and Technology Transfer: Focus on Vietnam

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Introduction

Dear Reader,

If you are reading these lines, chances are high that you have a keen interest in the topic of *Knowledge and Technology Transfer (KTT)*. In short, KTT is defined as the flowback of knowledge and discoveries to the general public or society. This handbook therefore addresses how university knowledge can have an impact on society and how this process could be managed. More specifically, in this book we investigate how KTT is or can be structured in the context of Vietnam.

This handbook is one of the main deliverables of the Erasmus+ Project *Vietnamese European Knowledge and Technology Transfer Education Consortium.* During the period 2016-2019, three European and three Vietnamese Universities engaged in a very intense collaboration to enhance Knowledge and Technology Transfer (KTT) Practices in Vietnam. The main goal of the project was to build KTT capacities at the Vietnamese partner universities – Hanoi University of Science and Technology, Can Tho University and Hué University – by training university leaders, staff members, researchers and students.

This book provides a summary of the KTT teaching materials developed in the framework of VETEC as well as the information on the Vietnamese KTT scene that was compiled over the course of the project. The book can be used to teach students the basics of KTT, as a reference handbook for KTT professionals or scholars and as a useful source of ideas and reflections for university leaders.

This book is divided in six main parts: The Research Lifecycle; Knowledge and Technology Transfer; The KTT Process and its stakeholders; The Researcher; Policy and Government; and Funding KTT. Each part consists of a number of self-contained chapters, which are accompanied by a reference list for further reading.

The editorial board of this book hopes you enjoy this handbook during your journey to become more knowledgeable about KTT. It is the board's express intent to educate all stakeholders in the KTT process and to make sure that the efficiency and effectiveness with which university research finds its way to society – in Vietnam but also outside of Vietnam – increases.

Last but not least, the editorial board wishes to thank all the contributors to this book for their efforts!

Have fun!

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VETEC
Vietnamese - European Knowledge and Technology Transfer Education Consortium

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Table of Contents

List of abbreviations

3F's - Friends, Family and Fools
4Ps - Public-Private-People Partnerships
AE – Academic Entrepreneurship
BA – Business Angel
BOD - Board of Directors
BTP – Best Transfer Practice
CPU- Central Processing Unit
CTTS - The Center for Technology Transfer and Services
CTU - Can Tho University
E-education - Entrepreneurial-Education
ERS – Early Career Researcher
FDI - Foreign Direct Investments
GF - Group of Facilitators
GP – General Partners
HEI -Higher Education Institution
HU – Hue University
HUST – Hanoi University of Science and Technology
ICT - Information and Communications Technology
IKTT – International Knowledge and Technology Transfer
IP – Intellectual Property
IPO - Initial Public Offer
IPR – Intellectual Property Rights
ISO - International Organization for Standardization
KPI - Key Performance Indicators
KT – Knowledge Transfer
KTT – Knowledge and Technology Transfer
LP -Limited Partners
MD – Mekong Delta
MNF - Multi National Firms
MOET – Ministry of Education and Training
MOOC - Massive Open Online Courses
MVP - Minimum Viable Product
NATIF - National Technology Innovation Fund
OA - Open Access
OECD - Organization for Economic Cooperation and Development
PRO - Publicly-Financed Research Organization
R&D – Research and Development
S&T – Science and Technology
SEEM - Student Entrepreneurship Encouragement Model
SME – Small and Medium Sized Enterprise
TRL -Technology Readiness Level
TT – Technology Transfer
TTO – Technology Transfer Office
TUD – Technical University Dresden

U-I – University-Industry
UA – University of Aveiro
UATEC - Technology Transfer Unit of University of Aveiro
UIC – University-Industry Collaboration
UK – United Kingdom
UVC – University Venture Capital Funds
VC – Venture Capital
VETEC – Vietnamese European Knowledge and Technology Transfer Education Consortium
VND – Vietnamese Dong
VoD - “Valley of Death”
VUB – Vrije Universiteit Brussel
WIPO - The World Intellectual Property Organization

Vietnamese - European Knowledge and Technology Transfer Education Consortium

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1. The Research Lifecycle

1.1 From fundamental research to application

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In order to position Knowledge and Technology Transfer (KTT) in the research lifecycle, it is important to understand the spectrum of research activities and types that exist within universities. Since research at universities generates new knowledge and research results that forms the basis of innovations, we therefore explore how and why this new knowledge is generated and where these activities are positioned vis a vis innovation.

But what exactly is innovation? The definitions of innovation are manyfold and are constantly debated, see also Baregheh et al. (2009) for an elaborate discussion on the matter. However, there are a number of aspects or concepts that always return in any definition of innovation. We consider innovation to be the useful application of new inventions and discoveries or, even more broadly, the useful application of new knowledge. Importantly, this means that we do not consider a mere invention or discovery to be an innovation, indeed the invention or observation should be applied and have "real world" impact in order to qualify as an innovation.

In this chapter, we look at the first step of innovation, namely the generation of new inventions, discoveries or knowledge as they form the start of the technology transfer process.

An invention is "any useful process, machine, composition of matter, or any improvement of the same" (VUB Tech Transfer, 2019, p.7). Interesting to highlight here is the fact that usefulness is already a crucial element which distinguishes an invention from, for instance a discovery which is a mere observation of a phenomenon.

In many cases, university-born inventions form the basis of new products & processes (innovations); by transferring university research results to society & industry, the university plays an essential role in the development of the economy and society as a whole. For an overview and discussion on the historical evolution of the role of universities in society, please refer to Audretsch (2014).

1.1.1 The role of research activities at universities

Although this book focuses on the so called 'Third Mission' of universities, this mission can not be seen in isolation of the other two missions of a university. The three missions of a university are:

- First Mission: Education, building human capital
- Second Mission: Research, production of new knowledge
- Third Mission: Knowledge Transfer, connect the university to its socio-economic context

Knowledge and technology transfer forms an integral part of the third mission[1], it refers to the transfer and dissemination of university-generated knowledge into society, for the benefit of society. That means that we first need to investigate how this new knowledge is generated within the university. We distinguish a number of research activities that lead to new knowledge: (1)

[1] For a full discussion and fine grained overview of the third mission of universities, we refer the reader to Perkmann et al. (2013).

fundamental or basic research; (2) strategic basic research; and 'applied research'. In the remainder of this chapter, we define these types of research and position them on the famous 'Technology Readiness Level' scale.

1.1.2 Types of research activities

Fundamental or Basic Research

Fundamental or basic research activities aim to develop (new) scientific theories in order to improve our understanding of the fundamental principles underlying our natural world. This type of research activities is often curiosity-driven and the researchers engaging in these activities often have no clear application or sub sequent innovation in mind. As such, the main aim of this kind of research is not to create or invent something but to understand. In many cases, the end results have no direct application or immediate commercial benefits. However, the research results can form the basis for applications or innovations in the long term. A text-book example of this type of research is for instance the development of 'the theory of electronic semi-conductors' by, a.o., Alan Wilson during the 1930s. Later on, this theory formed the basis for the development of transistors, micro-chips and the whole digital revolution.

Strategic Basic Research

Strategic Basic research refers to high-level basic research with an emphasis on risk, inventiveness and innovation. Typical for this type of research activities is the fact that they are considered to be 'strategic' (it is in the name of course) and hold a promise on valorization, i.e. transfer to society, on the mid to long term (3 to 10 years). So the researchers are looking to the future and trying to devise technologies, knowledge… that will have a large impact on the long term. Strategic basic research is still generic; it does not focus on one single industrial sector but has clear possible applications that are of interest to a consortium of possible end users. This kind of research is often carried out by large consortia of research groups (VUB Tech Transfer, 2019). As an example, we turn to the Nanobodies technology, developed at VUB by Prof. Hamers and his team. After the discovery that camelids possessed a special type of antibodies (fundamental research), a whole team of scientists went to work to try and produce, isolate, select, modify… these biomolecules since it was considered an important technology with applications in the domain of health care, food and industrial processes. This research was the 'strategic basic research' that took place.

Applied research

The primary purpose or applied research activities is "to discover, to interpret and to develop methods & systems for the advancement of human knowledge on a wide variety of scientific matters" (VUB Tech Transfer, 2019, p. 10). As the name already indicates, researchers are developing knowledge with a clear application in mind. Typically, the end user is already identified and steers the type of research. Universities use there knowledge to solve specific issues or develop specific products. In this kind of research, collaboration with industry is common. To turn back to the example of the nanobodies, after scientists figured out how to work with the technology, they tried to generate drug candidates against specific indications based on the nanobody technology.

1.1.3 Technology Readiness Levels

Now, does this mean we are ready to transfer knowledge or technologies to society when we have applied research results. No, the Technology Readiness Level (TRL) scale helps us to conceptualize the long road between idea and fully commercial production and to position a university's research activities in the broader context. In Table 1, we give an overview of the different TRL levels, their definition and context. We illustrate that research institutes, including universities, are active in the early stages of research and development. *Knowledge and Technology*

Transfer is, then, concerned on bringing technologies to a higher TRL, closer to commercialization and society.

Table 1
Technology Readiness Levels

TRL	Definition	Research Activities	Dominant Players
1	Basic Principles Observed	**Basic Research**	
2	Technology Concept Formulated	**Strategic Basic Research**	**Research institutes**
3	Experimental Proof of Concept	**Applied Research**	
4	Technology validated in the lab	Technology Demonstrators	
5	Technology validated in relevant environment	Technology Development and Prototypes	University-Industry Collaboration
6	Technology demonstrated in relevant environment	From Prototype to Pilot	
7	System Prototype Demonstration in Operational Environment	Pilot Plants and Upscaling	
8	System complete and qualified	Early commercialization	Industry
9	System proven in operational environment	Full Commercialization	

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1.2 Collaborative Research and Platforms

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Exerting collective effort when undertaking research is of increasing importance, because rarely are discoveries or inventions made by individuals nowadays. The body of knowledge and technological development have evolved very far and are so refined that skills and competencies required for new breakthroughs are distributed across several persons. Moreover, scientific communities are global communities, because research is either capital intensive (and therefore not easily reproducible) and/or segmented into very fine-grained partitions with only a few researchers being experts for very distinct parts of knowledge. This distribution (also in terms of "more basic" or "more applied") necessitates collaboration in research including a fair amount of coordination. In the following motivations and rationales for collaborative effort in research are outlined. Further, university-industry collaboration in research is singled out as particularly important for KTT. Last but not least, the significance of platform technologies and technology platforms are highlighted.

1.2.1 Collaborative effort and research results

Collaborative effort within the same field

A motive for collaboration may be the concentration of forces in a sense that there are reductions in fixed costs and probably speed advantages if experts within the same field work on the same problem. This is especially relevant in scientific fields with high capital investments (e. g. particle physics). This effect is currently over-shadowed by an emphasis on multi-/inter-disciplinarity (see below). Nevertheless, collaboration of researchers within the same field is still important, especially if they come from different backgrounds (academia vs. industry, see below). Moreover, it has distributional effects and accelerates the diffusion of knowledge (see also 1.3 "International Collaboration").

Multi-disciplinarity, inter-disciplinarity

New research results and breakthroughs are currently thought to stem from the collective effort of researchers coming from different fields. One line of reasoning is the ongoing erosion of established scientific "fields" dating back to the 19th century and the replacement/ complementation with new ones at their boundaries (e. g., Biotech, Quantum physics, Mechatronics, Biochemistry, etc.). Another insight is that current and presumably future challenges of mankind constitute a complex bundle of issues that needs to be targeted from different perspectives. "Challenge-driven research" or the definition of "Millennium Goals" are manifestations of this view (Kuhlmann & Rip, 2014, Hicks, 2016). Multi-/Inter-disciplinarity is also more interesting from a KTT perspective, because there are language as well as methodical barriers and frictions between different fields that pre-determine a rather high necessity for coordination.

International Collaboration

From a KTT perspective, international collaboration has essentially three dimensions: specialization, distribution/diffusion effects and diversity aspects. The first one refers to the possibility to involve the best experts needed for a research project that are typically not to be found in one country (or at least not all of them). The distribution/diffusion perspective emphasizes that international collaboration can lead to a better common understanding of research subjects. It is also important for developing countries, because they can catch up to the research frontier more easily. Another aspect of international collaboration is diversity, because it provides opportunities for learning. Countries are usually characterized by different geographies, resource endowments, institutions, but also historic developments. Together with differences in research traditions and, e. g., publication behavior, international collaboration promises to add variety in questions that are asked, attributed relevance, interpretation of results, but also access to untapped reservoirs of knowledge (in some instances). However, differences in cultures, modes of conduct, financial endowments, language and others also determine higher coordination costs that are not always taken into account.

1.2.2 University-Industry research collaboration

University-Industry collaboration can take various forms, all of which have in common that they need to bridge a gap between two "systems" that follow different logics, have different incentive schemes and attract different people. The focus in the following is on research collaborations, as most of the other topics are covered in separate sections.

Absorptive Capacity

Absorptive Capacity (Cohen & Levinthal, 1990.) is a well-established concept in the scientific literature that emphasizes the need to invest into own capabilities by the receiving party, in order to make any kind of knowledge transfer successful. The concept is often referred to in University-Industry transfer, especially when SMEs are involved. Cutting-edge technology and research results are hard to understand/interpret if one does not possess specialized knowledge in the respective field. Therefore, it may be important for firms (as a receiver of transfer) to invest into (human) capital that is not directly needed for production, but to secure the ability to "absorb" (technological) knowledge resulting from spill-over and collaboration.

Asset Complementarity

Asset complementarity is often an incentive to engage in (University-Industry) collaboration, whereas "assets" have a rather broad meaning. Universities usually contribute cutting-edge research equipment, qualified human capital, but also social capital (networks, contacts to international researchers) and reputation/legitimacy to a collaborative project. Industry brings "hands-on" experience, industrial researchers, industry-grade equipment (e. g., for testing theoretical results in the field) and financial resources to the table. The ability to tap into the others resource pool is actually one of the biggest incentives to engage in University-Industry collaboration (see Rothaermel (2001) on the topic for inter-firm alliances).

Market-Pull vs. Technology-Push

The need for University-Industry collaboration (sometimes also arguments for supporting it) can be justified/described from two different viewpoints, which are also linked to the motivation for collaboration and who initiates the contact (see Fig. 1). The "Market-Pull" view has the initiative mostly with firms who perceive a (technical) problem or a general challenge in the market, which they cannot address on their own. In order to solve the problem, firms engage in collaboration with universities, specify their needs as best as possible and "pull" new technologies from the "basic research status", across "applied research" and "development" all the way through to "industrial-scale application". The advantage is usually a good applicability of the results and a high motivation by industrial partners, because research is oriented towards market needs rather than technological feasibility. The downside is usually less variety, because results tend to fall into the category "more of the same".

The "Technology-Push" view locates the initiative mostly with universities, who believe they have found a promising new technology, which they want to "push" through "applied research" and "development" into the market. Technology-Push is often the basic logic for government support, because it increases technological variety. However, it is not always easy to find industrial partners for collaboration, because industrial-scale feasibility is more uncertain, technical solutions may compete with existing ones and initial market-orientation is general low.

Coordination costs

As promising as it may be, any form of collaboration does entail coordination cost, especially in University-Industry collaboration, where different logics of work, incentive schemes, time-horizons and cultures have to be bridged. Whereas industry is usually well aware of the need for professional "Project Management" (especially in large projects), academic researchers have little experience in this regard and view highly-formalized administrative structures with distrust (cit.?). Moreover, public funding (both "basic" and project-based) does usually provide for managerial costs only to a very limited extend. Thus, coordination needs (and costs) are very often a source of frustration in University-Industry collaboration.

Informal collaboration/transfer

The previous subsections focused largely on formalized collaboration. However, scientific literature posits that informal transfer/collaboration is of equal importance (Kreiner & Schultz, 1993). Informal collaboration is often based on social ties/networks that facilitate trust and/or accompany formal University-Industry collaboration. Advantages of informal collaboration are diffusion speed and often the transfer of tacit knowledge. Disadvantages are less control, possibilities of (negative) spill-overs/leakage of trade secrets and often inferiority with regard to the number of people knowledge is shared with.

1.2.3 Collaboration and Platforms

There is currently much talk on "platforms" and terms like "platform economy", "platform technology", but also "technology platform" occur regularly in KTT discussions. The focus here is on the latter two.

Technology platforms

Collaboration in general and University-Industry collaboration in particular can be enhanced by the usage of state-of-the-art communication technology. Many universities have established "technology platforms" that collect and showcase available equipment and skills. These serve at least two purposes: From an "inward" and more governance-oriented viewpoint they allow university leadership and individual researchers to gain an overview on available (human and physical) capital, which is otherwise hard to get, because of the self-governance ideal of traditional universities. From an "outward" perspective, technology platforms showcase the competencies and equipment to potential industry partners making universities more attractive as collaboration partners. The value of a technology platform for both purposes depends on regular updating of information (which is often based on self-reporting of the different structural units) and the ability to reduce its complexity for the presentation to different stakeholder groups. This requires an adequate design of the platform and incentive schemes to keep information up-to-date.

Collaboration on platform technologies

Platform technologies are usually a bundle of technologies, which build the basis for a broad range of applications. They are usually guaranteeing versatility, but also define boundaries of future developments. The term is often referred to in programming (CPU architecture and design is a platform technology because it defines the (binary) code that can be run on it) and biotechnology/pharmaceuticals. The appeal for University-Industry collaboration in platform technologies comes from the ability to facilitate transfer in the future. If academic and industrial realm would use different platforms (say in computer programming) exchange is hampered a lot, because an additional step is needed to "translate" problems and solutions alike.

Learning Questions and Discussion:

1. What is the main driver of increased multi-/inter-disciplinarity in research?
2. How may your university/institution benefit from increased international collaboration? What may be the cost/disadvantages in this regard?
3. What is the difference between "Market-Pull" and "Technology-Push" in KTT? Which one is probably more likely to succeed? Which one is easier to control/incentivice from a government perspective?
4. Does your university/institution own or develop a particular platform technology? What kind of collaboration partners would you like to attract for this kind of development?

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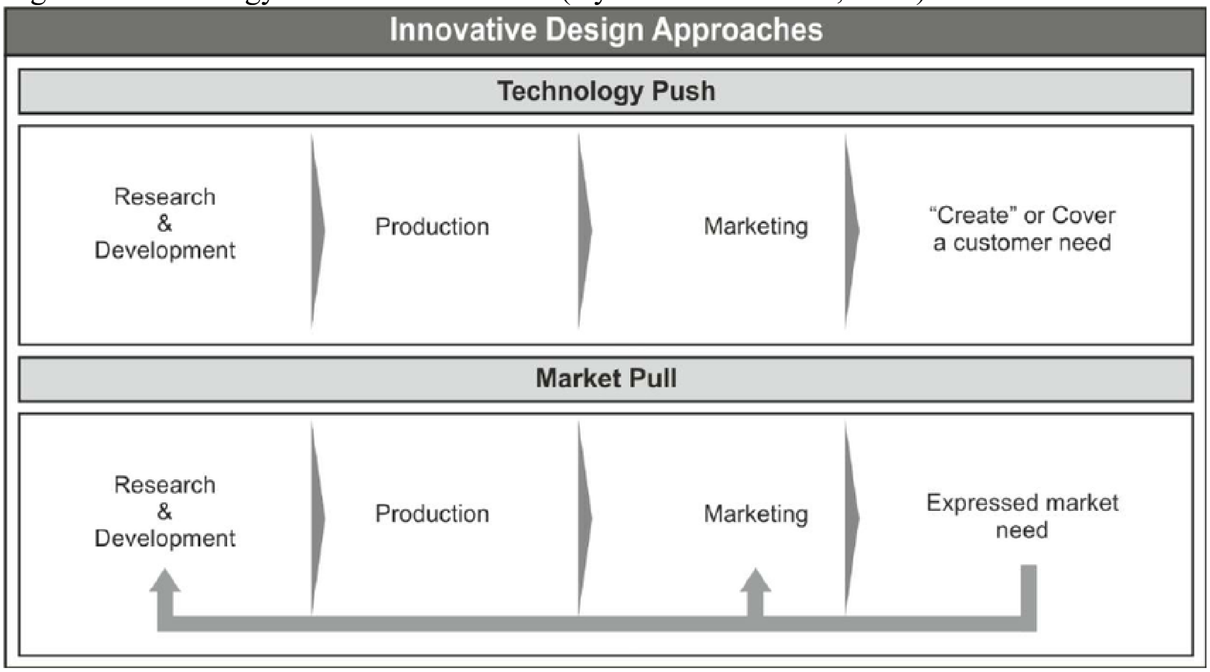
Figure 1. Technology Push vs. Market Pull (Kyratsis & Efkolidis, 2013)



1.3 From “exclusive” to “open to all”: a paradigm shift to more openness

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1.3.1 The Open Science movement

The idea that science should be “open” is not new and dates back at least to the 19th century. In fact, the birth of the current model of essay writing and circulation among peers is essentially a result of the idea of openly exchanging research results. However, it is scientific consensus that knowledge is not a “public good”, but shares characteristics of a “club good”. Essentially stakeholder groups can be excluded from its usage, for example, through limiting access to scientific journals. Recently, the term “Open Science” is therefore used as an umbrella term for a variety of actions undertaken to achieve easy and free access to research results, but also participation in the research process for everyone interested (Simon, Kuhlmann, Stamm, & Canzler, 2019). In other words, “outsiders” have the chance to participate during the typically exclusive phases of research by: gathering or reusing data, using open source programs for scientific methods, attending open educational formats or reading open access publications (see figure 1). This movement can be seen as democratization of scientific practices as old hierarchies are broken down (Simon et al., 2019). The movement has gained momentum in lieu of developments in digital communication technologies that lower costs of production, storage and distribution of knowledge.

1.3.2 Open Access

Distribution of scientific essays is typically via specialized journals issued by publishers like Springer or John Wiley & Sons, Inc. These organize the peer review process as a central element in scientific quality control and used to organize physical distribution as well. For this service publishers demanded license fees (usually from university libraries). With the advent of the digital age, distribution and reproduction costs have decreased significantly and the “closed access” model was increasingly criticized. The call was for a more open model that would ensure publication of research results to be accessible by anyone interested in the topic (anyone with an internet connection and a .pdf-reader at least). Open Access (OA) is currently distinguished into “green”, “gold” and “black” OA. Green OA refers to publication of research results without the use of a specialized publisher (e. g., on researchers’ websites or on “Researchgate”), often without a peer-review process. Gold OA is publication via a publisher, but without the reader having to pay licensing fees. Gold OA usually works with schemes that have the authors pay instead and does usually encompass a formal peer-review process. Black OA is (unauthorized) access to closed access publications by pirating or hacking an account that has access (e. g., a student’s library account).

1.3.3 Open Source

Similarly to Open Access and perhaps even slightly pre-dating it, Open Source aims at the disclosure of code and whole programs in the realm of software development, usually with the explicit right to alter it for personal and/or commercial use. A famous example is the operating system Linux.

1.3.4 Open Education

Open Education aims at improving the general education status of citizens by lowering barriers of entry and provide better access to educational material, especially in higher education. Two slightly different elements are of specific practical relevance in this regard. The first element is more akin to Open Access or Open Source and encompasses the provision of standardized and free-to-use materials (overviews, instructions, work sheets, books, etc.). It is more targeted at "instructors" within the education system (teachers, lecturers,…) and allows them to use instruments and materials that are up-to-date in terms of content and pedagogy. The second element is the development of new forms of education by making use of communication technologies. A prime example are "MOOCs" (Massive Open Online Courses) that allow to teach thousands of people simultaneously. Many of these new concepts do include interactive elements.

1.3.5 Citizen Science

European and American Model

What is commonly understood by Citizen Science is the involvement of non-professional researchers in the (academic) research process. The idea that anyone can be a researcher has a long tradition in European scientific history and is most evident in examples of non-professional researchers (Isaac Newton, Albert Einstein) or polymath/renaissance (wo)men (Gottfried W. Leibniz) that have had a great influence on scientific discoveries. The recent understanding ("American Model") of Citizen Science sees it as a part of Open Science, which enriches scientific knowledge production through the involvement of the public, especially for scientific data gathering (Bonney et al., 2009). This approach, described by Bonney et al. (2009) (see figure 2), preserves a certain asymmetry between professional researcher and (non-professional) public by allocating responsibilities and planning for a research project to the researcher(s). After volunteers have been trained, they gather data, which is typically stored in a central database. In the spirit of Open Science, raw data is usually openly disclosed and available to anyone interested. For scientific validity as well as educational effects on the involved citizens, good planning is fundamental (Bonney et al., 2009). Therefore, the realization of a Citizen Science project usually demand researcher capacity as well as financial support for training volunteers and the development of a database.

Community Science

A second approach, which is referred to as Community Science, addresses questions relevant for a (geographically bounded) subgroup of citizens and does not always involve researchers or research institutions. Instead, the whole research process can be driven by the community itself (Dosemagen & Parker, 2019) and is often motivated by its current or prospective needs (e. g., air pollution in metropolitan areas, soil degradation, solitude in old age). However, inexperience with scientific methods, coordination problems and other methodical weaknesses can cause faulty data. Therefore, professional researchers can support Community Science projects, for example, by offering technical support, skill building and setting standards. Lending legitimacy to the Community Science projects, it also enhances the anchorage of universities in their local community and increases the spectrum of engagement between general public and universities (Dosemagen & Parker, 2019). A potential drawback is a lack of acceptance of Citizen Science in general and Community Science in particular, among the professional research communities. Involvement of "amateurs" in the scientific process is often viewed with suspicion, because of lack of control and concerns regarding validity and generalizability of the results.

1.3.6 Practical Implications and Perspectives

The Open Science movement has two straightforward implications for developing countries: first and foremost as a receiver/beneficiary and second as a contributor. In the first role, it increases the potential to participate in global, cutting-edge discussions for local researchers and should also increase KTT from developed countries to less developed ones. Open Access in particular promises to mitigate resource disadvantages of less developed countries, when seeking access to research results. Provided the necessary capabilities to understand and interpret the results, it may also lead to faster application research, because the “basic” part of research is undertaken by others. Open Education resources can significantly lower barriers to (higher) education, especially for people living in rural areas (and disadvantaged groups). It may also be a cost-efficient way to teach rather high numbers of students, which should free capacities for research. Translating existing and “free” (open) material into one’s own language may be another promising undertaking. In the role of beneficiary of the Open Science movement investments should primarily be undertaken into capabilities to understand, absorb and transform existing knowledge and technology rather than to compete with more developed countries in cutting-edge basic research.

In the role of a contributor, Open Science bears the possibility to increase visibility of particular countries within global research communities. During the last decades the focus of research in many fields was mainly on western countries. One reason is unavailability of data. Publishing data via Open Access could strengthen the local research landscape by allowing foreign researchers to validate/generalize established concepts in previously inaccessible frameworks. Although this may limit the potential for “indigenous” researchers to come up with cutting-edge results, it may be a viable strategy if financial resources are limited. Even more promising are schemes that encourage international research collaboration with local researchers.

Another possibility for developing countries are Citizen Science projects, which are a rather young concept. Citizen Science projects encourage people to be an active part of science by observing and gathering data. Thereby the volunteers learn scientific methods and by studying the research objective, they are additionally sensitized for it. Especially the involvement in environmental projects can enable the complementation of the traditional work in environment protection (Dosemagen & Parker, 2019). By opening towards the society, science can become more inclusive and is likely to focus more on societal needs. However, the participation in Citizen Science projects requires “free-time” and interest on the side of participants. Moreover, its support is partly a policy decision, because researchers have to devote effort towards the development of suitable projects.

Learning Questions and Discussion:

1. What is the basic gist of the “Open Science Movement”?
2. In which realms do you see potential for Open Education in your university/institution?
3. What is the difference between the European and American Model of Citizen Science?
4. Do you know of any researchers at your university/organization that have are using Open Data? Do you know of any that contribute to Open Source/Open Data projects?

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Figure1: The participatory science cube with two prototypical manifestations of scientific projects on the opposite edges of the cube: traditional, closed, institutionalized science and open hacker or maker projects (Schrögel & Kolleck, 2019).

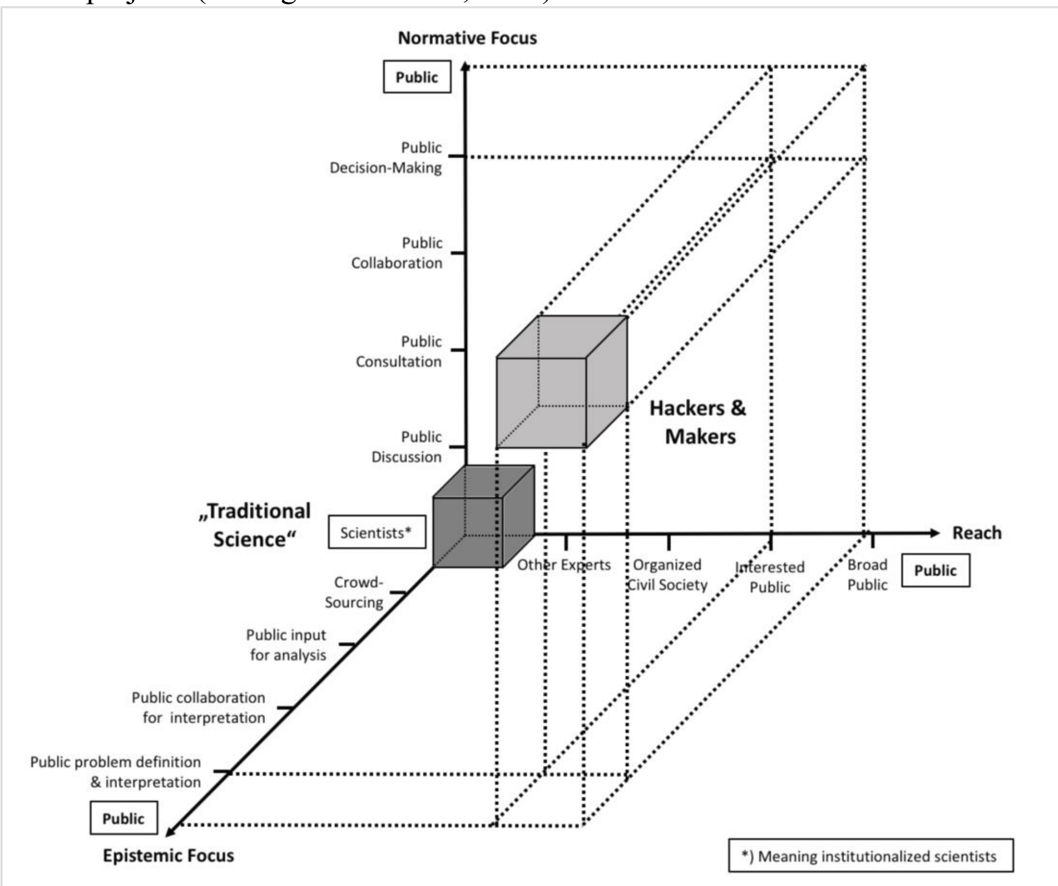

Figure 2: Model for developing a citizen science project (Bonney et al., 2009).

Box 1. Model for developing a citizen science project.

1. Choose a scientific question.
2. Form a scientist/educator/technologist/evaluator team.
3. Develop, test, and refine protocols, data forms, and educational support materials.
4. Recruit participants.
5. Train participants.
6. Accept, edit, and display data.
7. Analyze and interpret data.
8. Disseminate results.
9. Measure outcomes.

1.4 From Research to Technology Transfer (Case): Neccesity for an increase in intellectual property registration in the university

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Registration of intellectual property for research results brings many practical benefits for scientists. It will create favorable conditions in the process of transferring research results to businesses. However, the percentage of research results registered for intellectual property is still low in universities in Vietnam. Procedures and process difficulties are the main barriers to registration of intellectual property. On the other hand, implications of research themselves also contribute to limiting the development of patents. The establishment of technology transfer centers or the organization of seminars and technology transfer consultancy for scientists at universities is essential to stimulate and develop IP registration activities. In addition, cooperating on the basis of sharing benefits among partners who are scientists and international universities with much experience in international patents application is also a necessary direction for intellectual property registration.

1.4.1 Reasons for choosing research topics and current situation of science and technology transfer activities at organizations

Vietnam has diverse natural resources and medicine knowledge from ancient traditional medicine. The study of extracting natural substances from Vietnamese resources has been having new promising results.

Vietnamese scientists, as well as at Hue University, have many studies on active ingredients with good biological activity from medicinal sources. However, most results are not registered for intellectual property or utility solutions, nor are they copyrighted. Fundings for research are mainly from the state budget (very little comes from businesses). The fact is that Vietnamese scientists have little experience in patent registration in Vietnam . The percentage of intellectual property/research works is very little. The registration procedures are known to be quite complicated, discouraging scientists, without any effective support from organizations.

Vietnam also has many businesses, factories producing medicines and/or supplementary foods from herbs. However, the connection of transferring research results between scientists, universities and businesses is currently very loose, limited. There is no market or focal point to evaluate research results. In my case, when my research results are available, I directly have to go to meet the enterprises to introduce my research results. However, it is difficult for scientists to have copyright on hand before transaction with businesess. therefore, exchanges often fall into two directions: research results are revealed but they are likely to be lost if transactions are not made with the enterprises;or scientists do not reveal all of their research results that means all of the advantages of the research are not provided to the enterprises and therefore, the enterprises cannot assess the potential of products for commercialization, leading to failure in transactions. With such difficulties, many researches are very commercially potential but cannot be developed and transferred to the enterprises. The rate of studies funded by enterprises is low and the rate of research results from universities to market through enterprises is even lower.

1.4.2 Necessity and initial steps for registration of intellectual property from personal experience

In such a reality, I believe that registering intellectual property as a patent is very necessary. It protects research results, being a safe basis for exchanging and dealing with the enterprises. The same research result, if not registered for intellectual property, is very difficult to trade and often be paid at low prices. If the patent is obtained, the research result will be paid at higher prices and transaction process is are also easier. In 2017, I learned about patent registration, but I was confused about where to start and how to overcome complicated administrative procedures in Vietnam. Fortunately, after that I attended training on technology transfer at Aveiro University - Portugal in VETEC project. During the training process, I realized and clarified a lot of things, that the connection between scientists, universities and businesses is very necessary and practical to have fundings for research. The research ordered from the enterprises is also closer to reality and the ability to apply it into practice is also higher. I saw the patent registration process according to ISO standards in Europe that is operated properly and the patent registration process is very clear. Scientists can easily learn about this process, understand the rights, duties and roles if involved in the process. When registering, the scientists have the main task of writing presentations on their research while the later work is done and supported by the technology transfer department (TTO) of the universities and companies specializing in legal affairs and patent registration. I saw reports of huge fundings from businesses pouring into universities (like research orders), as well as huge revenues from universities from activities of technology transfer to businesses. This activity is also very important as the assessment index of the position of universities inceases and the personal reputation of scientists is better..

In the research direction, I have learned a lot of patent claims related to the work I have been doing. I have learned research methodologies and research orienation to achieve new and acceptable results when applying for patents. I also understand that the pursuit of patents is quite time consuming as well as costly. I also take into account the feasibility if the product is commercialized. These two factors play a decisive role in whether I should pursue patent registration or not.

Until now, many universities have established technology transfer centers to support scientists to register ownership of research results. If scientists have had foerign research collobarations, , and foreign partnersshould consider cooperating to apply for patents on the basis of jointly contributing responsibilities and sharing benefits after obtaining patents and commercializing their products. Cooperation with international organizations that have a lot of experience in patent registration will bring many advantages. These international organizations have a quick and convenient process for submitting applications, as well as have a good team of consultants in assessing the risk or future commercialization of research results. By cooperating with them, you will have more experience in the patent application process. In my experience, the division of responsibilities and benefits often has a clear set of rules (although usually proposed from the partner's side); thus, you do not have to worry too much about it. It is important to have a reliable partner to develop cooperation, and your research results/orientations are strong enough for them to accept cooperation with you.

With the registration of domestic intellectual property, although there are many complicated procedures but as a scientist, you need to learn how to apply it, to add more value for your research. This is the key to promoting safe trading and cooperation with businesses.

2. Knowledge and Technology Transfer (KTT)

2.1 Introduction to Technology Transfer and Knowledge Transfer

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2.1.1 Defining Knowledge and Technology Transfer

Knowledge and technology transfer (KTT) is broadly defined as the flowback of knowledge and discoveries to the general public. Often this is from a university context to non-academic environments. Today, KTT is regarded as the third mission of a university, next to teaching and research, as the university takes a role in the socio-economic development of its region and country. The big question is of course how we operationalize this definition. According to the European Commission, knowledge transfer "involves the processes for capturing, collecting and sharing explicit & tacit knowledge, including skills & competences. It includes both commercial & non-commercial activities such as research collaborations, consultancy, licensing, spin off creation, researcher mobility, publication, etc." (EU, 2007, P. 6)

In this chapter, we clearly define the interrelated concepts of knowledge and technology transfer and we focus on the role of academic entrepreneurs in this process.

Knowledge vs. technology transfer

In order to understand what KTT is about, we make a clear distinction between what we consider to be *knowledge* transfer and what we consider to be *technology* transfer (Gopalakrishnan & Santoro, 2004). Technology is about knowing *how* things are done and is more explicit then knowledge. Technologies are usually embedded in documents, blueprints or some other tangible form. For example, the ability to control temperatures and pressures to align grains of silicon and form silicon steel consist of specific steps and procedures that can be written down in a document. As a result, the document can easily be transferred to other members within a company. In a university context, technology transfer usually occurs in the form of publications, contract research, patents, licensing agreements, or the creation of spin-off companies. As these consist of rather "official" ways to transfer technologies to society, these forms are also regarded to as *formal* transfer modes. These formal modes are more closely linked to the *commercialization* of knowledge and technology transfer, in which the transfer to the market involves a monetary aspect or an intention towards financial gain.

Knowledge, on the other hand, is about knowing *why* things occur. It is less explicit, more tacit, which means it usually resides in the minds of people. Referring to our previous example, understanding the underlying chemical and physical process that produces the alignment of the silicon grains is less tangible. Such knowledge can less easily be written down or passed on to third parties. In a university context, knowledge transfer usually occurs through science communication events, internships, trainings, personal interactions, student or staff mobility, or exchanges at conferences. These modes are also referred to as *informal* transfer modes.

So, whereas technology transfer refers to flows of technologies, knowledge transfer refers to flows of knowledge. In this work, we choose to make the distinction explicit. However, we should note that some scholars pose that technology and knowledge activities are interrelated, others pose that the one encapsulates the other.

Academic Entrepreneurship

In previous chapter, we already discussed that, next to education and research, universities engage in the commercialization of knowledge and technologies to the benefit of society (Etzkowitz, Webster, Gebhardt, & Terra, 2000; Molas-Gallart & Sinclair, 1999). Supported by governmental initiatives, such as the establishment of the Bayh-Dohl Act, entrepreneurial activities have expanded greatly at universities in developed and developing economies. We observe worldwide growth in patenting and licensing activity, the establishment of incubators, science parks, and of university spin-offs. These activities have a positive and significant impact to the economy and society (Guerrero, Cunningham, & Urbano, 2015).

Academic entrepreneurship refers to the efforts undertaken by universities to promote commercialization on campus and in surrounding regions of the university (Siegel & Wright, 2015). Scholars have examined academic entrepreneurship by methodological diversity (qualitative and quantitative methods), by different units of analysis (e.g. the individual academic, university department, technology transfer office) and in many different countries and institutional contexts (Kalar & Antoncic, 2015; Balven, Fenters, Siegel, & Waldman, 2017).

In the 1990s, the term academic entrepreneur was used mostly in the context of academics forming companies. The past decade, the activities of the academic entrepreneur concern a broader and more indirect spectrum, including external teaching, working in industry, initiating the development of new degree programs, and contributing to the establishment of incubators or science parks (De Silva, Uyarra, & Oakey, 2012). These different entrepreneurial activities are interrelated (D'Este & Perkmann, 2011). Not only the activities of the academic entrepreneur broadened over the years. Siegel and Wright (2015) point out that a broader range of actors are involved in academic entrepreneurship: where before only faculty and post-docs were involved, it now involves students, alumni, returnee academics, on-campus industry collaborations, and surrogate entrepreneurs.

Technology Transfer: towards existing firms vs. towards spin-offs

As indicated above, technology transfer boils down to transferring formal(ized) knowhow from universities towards external parties. Often this knowhow is made explicit in the form of Intellectual Property, mostly patents. A patent gives the patent owner the right to exclude others from making, using, offering for sale, selling, or importing (…) the invention claimed in the patent (United States Patents and Trademark Office, 2015)

The patent owner is free to decide how to provide access to the IP i.e. how to license the IP. There are several dimensions along which licensing strategies can differ:

- Free vs. paying licenses
- Exclusive vs. non-exclusive licenses
- Licensing the IP solely for a specific usage/application area or not
- Licensing the IP for usage in specific geographics regions or worldwide
- Licensing the IP for a limited period or unlimited in time
- Licensing or selling the IP
- Licensing (or selling) the IP to an existing entity or to an entity specifically created for the purpose of valorizing this IP, i.e. to a spin-off company

The difference between licensing and spin-off creation resides in this last point. A spin-off is a legal entity specifically formed in order to valorize university IP. Generally, a completely new organization is created: sales and marketing organization, manufacting and distribution, human resources, legal department… In some cases however, for example in biotech, a separate legal entity in founded for the commercialization of an IP asset, but the entity has no or very limited own assets and employees, as it subcontracts all activities to third parties.

Typical for the creation of a spin-off is that this organization is owned by the shareholders of the spin-off and that therefore the subsequent evolution of the company is owned by them. In contrast, in the case of licensing the IP to an existing organization the licensee's organization brings the innovation to market. The value captured by the licensor is limited to the income generated from the license; all other value remains in the hands of the licensee.

To translate it in biological terms: licensing to an existing company is like a virus: the 'genetic code' is brought to expression inside an existing organism, while in the case of a spin-off a completely new organism is created, with all functions required for survival and growth.

As a consequence, spin-off creation is substantially more complex, as a completey new organization must be built from the ground up and marketed towards its potential customers. But on the other hand, the created value can be orders of magnitude larger than the case of a license.

Finally, the patent owner is free to negotiate the form of the renumeration and the way this renumeration is calculated. Many schemes can be used; to name a few

- renumeration under the form of shareholdership in the licensee (especially in case of spin-off) or through financial payments
- a one-off payment vs. milestone payments vs. periodical payments vs. volume-related payments (royalties)
- calculation of the payments: fixed rates vs. evolving rates. Moreover, the variables that define the rates, the maximum amount and/or the duration of payments can vary strongly
- postponement of initial payments: for an agreed upon period, an initial royalty-free sales volume…

These licensing agreements are the result of complex negotiations; it is therefore adviseable to involve seasoned professionals that have experience with such negotations.

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2.2 Knowledge and Technology Transfer in Developing vs. Developed Countries

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KTT as the third mission is implemented in many universities. The prerequisites differ though when it comes to developing countries. Universities' focus lies predominantly on the training of skilled graduates, firms lack own innovative activities and governments need to prioritize due to limited funds. The economic situation, the higher education system and the governmental set up are crucial factors determining the success of KTT. The triple helix approach illustrates the necessary interplay between academia, industry and government. Concerning developing countries, the single elements need to raise commitment and set the right conditions for a successful interplay.

2.2.1 KTT, Economic Growth and Economic Development Level

According to the theoretical framework of Solow (1956), long term economic growth is driven by an increase in efficiency over time, which can be achieved through technological progress. Levels of efficiency in developing countries are characterized by significant variation, with some countries probably even lacking firms able to replicate and/or change already existing technologies (Bell & Pavitt, 1997). Unlike most developed ones, developing countries also experience lower levels of inter-firm migration by skilled workers, hampering diffusion of knowledge (Bell & Pavitt, 1997). Nikoueghbal & Valibeigi (2005) cite political instability and poorly-designed or implemented state interference policies as further obstacles to growth.

Innovation activities, which are a significant driver of economic growth in developed countries, are characterized by complex interactions of a number of stakeholders (see Triple Helix Concept by Etzkowitz & Leydesdorff (2000) or Quadruple Helix Model including public values and demands (e. g., Bozeman et al., 2015)). In contrast, the fields of academia, state, industry, and public seem to be more separated in developing countries. Moreover, KTT between universities and industry in these countries have different characteristics, because development levels of universities (typically the KT supplier) and firms (usually the KT receiver) are lower on average. Focusing on the elements of the Triple Helix model (Firms, Universities, Government) some differences between developed and developing countries are considered in the following. General contingency factors like illiteracy rate or growth dynamics are not considered.

2.2.2 Firms

Multi-National Firms

Multi National Firms (MNF) are often present in developing countries through Foreign Direct Investments (FDI). FDI is usually desired by governments, because it is a source of forex, promises local employment and often comes with other development investments (general infrastructure, local schools, hospitals,…). Although MNF activity in developing countries is in production only (sometimes including smaller units for developing/adapting existing technology to local needs), they are often seen as a source of KTT between countries, because they are thought to import state-of-the-art production technologies. However, because of the limited activities they are no suitable partners for within-country KTT. Moreover, managerial and research capacities of universities in developing countries are often not on par with the research activities of MNFs (see also "Types of Universities" below). Accordingly, demand of MNFs for KTT with local universities is rather low and the latter are often exclusively seen as a source for trained workers.

Domestic Firms

Demand for KTT with local universities from domestic firms is also lower in developing countries. First, because in-house development and formal R&D is often beyond the capabilities of domestic firms and buying components from MNFs is much easier. Sometimes lack of skilled workers dampens competitiveness and innovative capacity of firms as well. Second, because limited capacities for research on the side of universities make them comparatively unattractive as research partners. However, domestic firms in developing countries may be more open to less formal and less commercial oriented KTT activities, like consulting or Community Science projects, especially when in close proximity to universities. As in developed countries, local identity, common heritage and shared "fate" (for example with regard to regional government policies) can be a strong diver of collaboration between universities and industry, even if direct results are hard to measure. Another aim of universities could be the improvement of the quality of university graduates for domestic firms by fostering a stronger (informal) collaboration of universities with industry. One possibility would be to establish consultative processes with local firms, for example in curriculum development.

2.2.3 Universities

Types of Universities

Gibbons et al. (1994) distinguish universities into Mode 1 and Mode 2. Mode 1 universities set the knowledge creation objective into strict disciplinary, hierarchical and homogenous frameworks. They see their primary mission in the creation of new knowledge without further application in mind and usually operate rather disconnected from industry, state, and the general public. In Mode 2 universities, on the other hand, knowledge is created through interaction and negotiation between different fields and stakeholders, akin to the Quadruple Helix concept. A stylized fact seems to be the tendency of developing countries to organize knowledge creation in a Mode 1 framework, whereas most developed countries' research systems are better classified into Mode 2.

Mission statements of Universities

Additional to the model of knowledge creation, the missions of universities differ within and between countries. The university missions have given rise to distinct concepts of the teaching university, the research university and the entrepreneurial university (see Table 1). University KTT may take place under all of these regimes, although foci vary between training, R&D and technology commercialization and spin-offs, respectively.

Attributed roles of Universities

Priorities and scope of universities differ between developed and developing countries, but also the role that is ascribed to them by governments. In many developing countries a major concern is the quality of education, while simultaneously lacking financial resources. This results in an insufficient capacity to conduct research or join industry in innovation-related projects. Universities therefore have little experience in industry collaboration and limited (managerial) capacity in research. Building linkages in this context takes time and sustained effort. Collaboration in developing countries is rather informal. The predominant role of universities for industry is provision of university graduates for staffing, alongside consulting activities. Augmenting the classification into Teaching, Research and Entrepreneurial University (Guimon, 2013, see table 1), Brundenius et al. (2009) propose a model of Developmental Universities. Leveraging universities' abilities to tap into (global) knowledge pools and to educate highly-skilled workers, the authors suggest to developing countries to foster collaboration between universities and external agents in order to contribute to social and economic development rather than focusing on direct commercialization and spin-offs.

Support and Awareness for KTT within Universities

In their investigation of two Brazilian TTOs Aparecido Dias & Silveira Porto (2018) cite lack of support from the university leadership and a protective patenting behavior towards the industry as obstacles for successful technology transfer. Kumar & Kharazmi (2010) identify the focus on theoretical issues by university members as main barrier to university-industry collaboration in their analysis of Iranians industry-science relationships. Although these findings are relevant as KTT obstacles in developed countries as well, they are amplified by the emphasis on education and training as the key role of universities in most developing countries.

2.2.4 Role of Government

Direct financing

Government usually plays multiple roles in the realm of KTT activities. First, a direct role in providing funds to universities' R&D projects, which form the basis of KTT. Some policy instruments have been developed to flank these project funds. As an incentive for KTT, the innovation voucher, for example, constitutes an instrument to promote collaboration, which has been successfully tested in several developed countries (OECD, 2010). Small lines of credit are provided by governments to firms to purchase service from universities with a view on introducing innovations in firm's business operations. Its simplicity makes the measure easily adoptable in developing countries as well.

Framework setting, IP legislation, infrastructure

Second, government plays an indirect role by passing laws and regulations that also effect other parts of economy and society (e. g., patent law, funding for schools, funding for telecommunication networks, etc.). Moreover, infrastructure and the setting up of intermediate organizations such as TTOs, science parks and business incubators can be facilitated by government decisions. Although not always having direct effects, governments should try to take as many consequences into account. Moreover, setting up of intermediary organizations should be in accordance with a realistic assessment of the impact they can achieve in a given context.

Regulatory framework for universities

In addition to effects from more general regulatory frameworks, governments can influence KTT environments through policies that are targeted at universities directly. For example, Zuninga (2011) points out that employment rules at universities and limits to the creation of spin-off from public organizations may limit the scope of KTT in developing countries. Moreover, traditional performance measurement of universities is often geared towards teaching and research output (e. g., number of students, PhD graduates, scientific publications). To stimulate KTT other criteria can be introduced, such as the number of patents, the volume of consulting or R&D contracts with industry, income from patent licensing, etc. In the UK, Canada, India and Singapore governments started to offer universities supplementary funding for research conditional on number of contracts with industry, spin-offs or start-ups (Yusuf, 2007). Such criteria can also be included in tenure track systems to incentivize the engagement with industry and to foster KTT.

2.2.5 Concluding remarks

When building up new structures for KTT the economic, geographic and social environment has to be taken into account. Concepts that have been developed and proved in developed countries are not always directly transferable because they function under certain conditions as the legal framework, the research landscape and economic wealth. For developing countries, it is therefore essential to take into account the national differences and develop own ideas and action plans on how to integrate KTT into the existing structures and settings. Hence, the involvement of all actors regarding universities, governments and industry becomes even more indispensable when scare resources are to be utilized most efficiently.

Learning Questions and Discussion:

1. What are advantages and disadvantages of Foreign Direct Investment with regard to KTT? Do you feel that your country benefits from FDI with regard to Transfer?
2. Do you believe your university/organization to be more Mode 1 or Mode 2? What is the role your government/policies attribute to universities in general?
3. What are the specific conditions at your university/institution to engage in KTT (e. g., spin-offs) within the regulatory framework of your country? Are you, for example, allowed to found/own/lead a firm as a professor?

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Table 1: University types in developed and developing countries based on Guimon (2013)

	Teaching University	Research University	Entrepreneurial University
developed countries	Private participation in graduate programs Joint supervision of PhD students	Research consortia and long term research partnerships to conduct frontier research	Spin-off companies, patent licensing Entrepreneurship education
developing countries	Curricula development to improve undergraduate and graduate studies Student internships	Building absorptive capacity to adopt and diffuse already existing technologies Focus on appropriate technologies to respond to local needs	Business incubation services Entrepreneurship education

2.3 International Knowledge & Technology Transfer: a University Perspective

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International knowledge and technology transfer represents a new phenomenon and opportunity for internationally-oriented universities. We position the phenomenon next to existing knowledge and technology transfer modes. We discuss the need for international knowledge and technology transfer and formulate some barriers to overcome.

2.3.1 Knowledge and technology transfer

The university's third mission

Knowledge and technology transfer (KTT) is broadly defined as the flowback of knowledge and discoveries to the general public. Often this is from a university context to non-academic environments. Today, KTT is regarded as the third mission of a university, next to teaching and research, as the university takes a role in the socio-economic development of its region and country.

Knowledge vs. technology transfer

In order to understand what KTT is about, we should distinguish between what we consider to be *knowledge* transfer and *technology* transfer (Gopalakrishnan & Santoro, 2004). Technology is about knowing *how* things are done. It is more explicit then knowledge and is usually embedded in documents, blueprints or some other tangible form. For example, the ability to control temperatures and pressures to align grains of silicon and form silicon steel consist of specific steps and procedures that can be written down in a document. As a result, the document can easily be transferred to other members within a company. In a university context, technology transfer usually occurs in the form of publications, contract research, patents, licensing agreements, or the creation of spin-off companies. As these consist of rather "official" ways to transfer technologies to society, there forms are also regarded to as *formal* transfer modes. These formal modes are more closely linked to *commercialization,* in which the transfer to the market involves a monetary aspect or an intention towards financial gain.

Knowledge, on the other hand, is about knowing *why* things occur. It is less explicit, more tacit, and usually resides in the minds of people. Referring to our previous example, understanding the underlying chemical and physical process that produces the alignment of the silicon grains is less tangible. Such knowledge can less easily be written down or passed on to other members of the company. At a university context, knowledge transfer usually occurs through science communication events, internships, trainings, personal interactions, student or staff mobility, or exchanges at conferences. These modes are also referred to as *informal* transfer modes.

So, whereas technology transfer refers to flows of technologies, knowledge transfer refers to flows of knowledge. In this work, we choose to make the distinction explicit. However, we should note that some scholars pose that technology and knowledge activities are interrelated, others pose that the one encapsulates the other.

2.3.2 International knowledge and technology transfer

When knowledge and technology transfer crosses national boundaries, we talk about *international* knowledge and technology transfer (IKTT) (Rostan & Höhle, 2014). Generally, universities who have an international scope or international ambitions, have established some forms of IKTT. Typically, staff or student mobility has an international dimension, publications hold co-authorship with scholar from abroad, researchers engage in international joint research project, students have internships or trade missions abroad, or academics go to conferences or workshops abroad (Knight, 2004). Interestingly, the majority of these existing activities concern the more informal KTT modes, while the more formal KTT modes, related to commercialization, are underrepresented. As a result, practices and guidelines to deal university spin-offs, co-patenting, licensing activities, or contract research with an international dimension remain underdeveloped. The rest of this paper is directed towards dealing with these underdeveloped modes and guidelines.

2.3.3 The need for international knowledge and technology transfer

We identify three reasons why more attention should be devoted towards international university knowledge and technology transfer.

1. Complementarity to existing university missions. An international dimension to knowledge and technology transfer is a logical extension for any university where internationalization is already embedded within its first and second mission. For example, what would happen to inventions coming forth from an international joint research lab or to European project outcomes with commercialization potential? Such opportunities should be structurally approached for them not be lost of discontinued.
2. Missing KTT model. From a university perspective, regional/national KTT is generally accepted as common practice (see Figure 1). This translates in universities collaborating closely with regional industry surrounding the university. From an industry perspective, international KTT is actually well established with knowledge and technologies being transferred through subsidiaries and foreign direct investments. Looking at these two existing models, it becomes apparent that internal KTT from university to academia or industry abroad is missing (De Moortel & Crispeels, 2018)
3. From a commercial perspective, globalization and the interconnectedness of markets leaves start-ups and spin-offs to have an international mindset from the start of their existence. This is not surprising. With new countries and regions dominating some scientific fields (e.g. artificial intelligence and big data in China), technologies and knowledge usually reside in foreign countries, leaving start-ups to find technological or research partners, specific data, investors, manufacturers, or other complementary partners abroad. In addition, companies and investors are increasingly aware of market opportunities beyond national boundaries resulting in fast growth potential. Increasingly some countries also offer favorable conditions to start-ups to move abroad for a certain period, which connects these start-ups with foreign ecosystems (e.g. science parks and incubators), and thereby attracting talents, technologies and knowledge to their countries and regions.

2.3.4 Barriers to international knowledge and technology transfer

The reason that IKTT is not well embedded within universities might be due to the set of hurdles that IKTT brings along for individual academics, technology transfer offices, university management, and government. We list below some examples.

- IKTT might be difficult - if not impossible - to take place when traditional (university-industry) KTT is not well established yet within the university. For example, due to KTT being a very recent phenomenon in Vietnam, regulations and laws are still being developed and implemented. As a result, priority should be devoted towards developing these activities first. IKTT may only come in play in a later stage, when the university ecosystem has gained experience with traditional KTT and is ready to leverage these activities to an international level.

- For its implementation, IKTT requires reallocation and/or addition of resources. On an individual academic level, researchers usually deal with time constraints to commercialize a technology as research and educational activities get priority. A high willingness and commitment are needed on a personal level to engage in IKTT. From a technology transfer office perspective, funding may be targeted towards regional KTT, due to the origin of the subsidies, and the staff may be faced with limited knowledge on intellectual property rights and legal systems of other countries and with different KTT organizational structures and procedures.
- IKTT adds a layer of complexity to communication (e.g. language) and understanding a counterpart as cultural differences translate into different habits, interpretations, management styles, administrative procedures, values, routines and so on. Coordination of IKTT activities also becomes more difficult due to geographical distances and decreases in personal face-to-face meetings.

In order to overcome these barriers university management and government should devote commitment and resource towards the development of IKTT practices. Taking into account existing KTT activities, universities should develop roadmaps toward integration of the international dimension.

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Figures

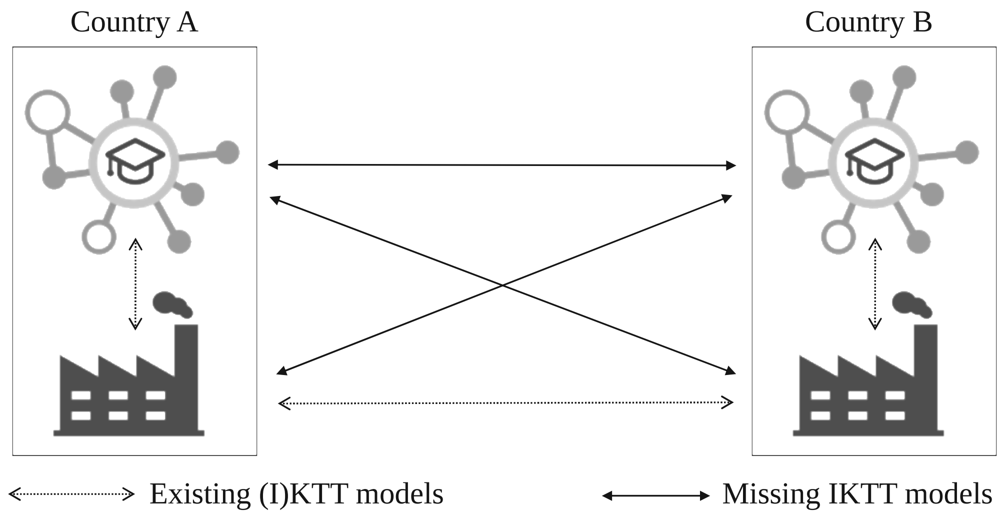

Figure 1. Existing and missing international knowledge and technology transfer models.

2.4 University-Industry Collaborations in Vietnam specific context (CTU case on social impact of university on farmers)

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The Mekong Delta (MD), with a natural area of about 4 million hectares and over 18.4 million people, is the biggest agricultural production area in the entire country and is considered the rice basket of Vietnam. Besides rice production, the MD is also rich in fruits and fish for export. Can Tho University (CTU), an important state higher education institution, is the cultural, scientific and technical center of the MD. Since its founding in 1966, now CTU has an enrollment of about 54.000 undergraduate students; around 3.000 students have been following Master programs; and around 300 students are Ph.D candidates. CTU has got over 2.000 staff members, including nearly 1.200 teaching staff. From a university with a few fields of study at the beginning, it has developed into a multidisciplinary university. Currently, CTU has 93 undergraduates, 34 Masters and 13 Doctoral training programs (Can Tho university, 2016). CTU's main missions are training, conducting scientific research, and transferring technology to serve the regional and national socioeconomic development. In addition to its training responsibilities, CTU has actively taken part in scientific research projects, applying the advances in scientific and technological knowledge to solving problems related to science, technology, economics, culture and society in the region. From achievements in its scientific research and international cooperation projects, CTU has developed a variety of products and technological production processes that benefit people's lives and promote export, thus helping CTU to gain prestige in national and international markets. CTU has established scientific and technological cooperation with many international organizations, universities, and research institutes. As a result of these cooperative projects, the staff's administrative capabilities and specializations have been upgraded. The facilities, experimental equipment, and scientific materials have also been added. CTU targets to be one of the leading higher education institutions in Vietnam and recognized as one of the top universities in Asia-Pacific in training and research in 2022. CTU operates its resources to be the leading national institution for education, research and technology transfer (TT), making significant contributions to the development of high quality human resources, fostering the talents and the advancement of science and technology to cater for the regional and national socioeconomic development. CTU is the crucial driving force for the development of the MD region with the core values are consensus, devotion, quality, and innovation (CTU, 2019).

2.4.1 Scientific research and TT activities of CTU

Besides training, CTU has focused on implementing scientific research programs, applying scientific and technical achievements to solve scientific, technological, economic, cultural and social issues of the MD. From the results of scientific research, the CTU has created many products and technological processes for production, life and export, creating prestige in the domestic and international markets. Scientific research activities of the CTU contribute to the cause of industrialization and modernization, improve the physical and spiritual life for people in the MD during the period of international integration and adaptation to climate change. There are 5 priority fields of science and technology that CTU plans to implement including (i) Application of high technology in agriculture, fisheries, and environment; (ii) Management and sustainable use of natural resources; (iii) Technological and ICT technology; (iv) Education, law and humanities science; and (v) Economic development and market. The potential technology products, technology processes, and services for TT mainly from research fields as soil science, crop production, crop protection, animal production, aquaculture, biotechnology, food processing, ICT, engineering technology, natural science, and sustainable environment. In the period of 2012-2016, CTU had 1,269 science and technology tasks at all levels implemented. Funds for investment in scientific research from many sources included allocated state budget, CTU budget, local authorities, businesses, and international cooperation. The total funding for the scientific research project was VND 342.2 billion (US$ 1,468,635.2), reaching an annual average of VND 68.4 billion (US$ 2,935,622/year). The total number of articles published in specialized journals was 3,772 articles, in which there were 2,883 articles in the national journals and 889 articles in the international journals (ISI). Besides, there were 2,268 articles published in the domestic conferences and workshops, and international proceedings. The ratio of total articles to the number of lecturers reached about 5.2 times (6,040 articles/1,161 lecturers). During the period from 2014 to 2019, there were 73 TT contracts were held between CTU and enterprises with a total value of US$ 576,230. In addition, from 2006 to 2017 CTU has achieved some results on IPR such as 1 CTU Trademark (since 2007), 14 copyrights, 3 patents, 12 licenses and 10 protection of rice varieties.

2.4.2 Process for performing a TT project of CTU

This process is established, performed and maintained aiming to get a coordination between CTU's units in order to conduct TT to local agents, enterprises as well as individual households that have a real need in receiving TT services for their business-production activities. There are 4 main steps as follows:

Step 1: Receiving information on the progress of science and technology

The Center for Technology Transfer and services (CTTS) updates information on the progress of science and technology from DSRA's information management system as well as from scientists belonging to CTU's colleges, institutes, and research centers. These informations are monthly updated through CTU's email system, seminars, workshops, conferences, exhibitions and fairs. Receiving information on the scientific research by accessing: https://qldiem.ctu.edu.vn/STMCTU/tracuutt

Step 2: Promoting CTU's science and technology products and receiving client's needs of TT

Promoting and looking for clients who have needs of receiving CTU's TT through: (i) Linking TT programs between CTU and localities, especially Department of Science and Technology, Department of Agriculture and Rural Development, Department of Environment and Natural Resources; (ii) Linking TT programs between CTU and small and medium enterprises (SMEs); and (iii) Means of TT communication are Email, seminars, workshops, conferences, exhibitions, and fairs.

Step 3: TT information from production and negotiation, and TT performance

This step is performed by the contents such as: (i) Directly approaching target clients that are determined at the *Step 2*: Leaders and staff of CTTS and Department of Scientific Research Affairs hold field surveys at places where clients are working and having a need of TT in order to determine in detail what clients need to be transferred; (ii) Based on the surveyed results, CTTS discuss with CTU's scientists about a person/group who will undertake the TT project. CTTS will send a draft TT project to client for referencing and deciding; (iii) CTTS negotiates with clients about the contracts through telephone/Skype/email, official documents or face to face discussion; (iv) The undertaking person/group makes a detail plan for implementation of the TT and send it to the clients. After agreement, CTTS drafts a TT contract for signing. Based on the implementation plan, the undertaking person/group will carry out the TT contents. CTTS is responsible for supervising the undertaking person/group's progress plan; and (v) CTTS is responsible for consulting and guiding the undertaking person/group to finish the payment documents that are suitable to the current regulations and in time. After finishing all contents mentioned in the TT contract and been accepted by clients, CTTS is responsible for consulting and guiding the undertaking person/group to complete the balance documents and TT contract liquidation documents.

Step 4: Feedbacks and innovation

Receiving feedback from the clients: CTTS is responsible for receiving and sending feedback from clients to undertaking person/group if there are any problems in using transferred technology that are still under warranty. When clients want to innovate the transferred technology CTTS will ask for another TT contract. Feedback from the clients is also premise of research for scientists of CTU.

2.4.3 Impacts of TT activities in agriculture in the MD

From 2008 to 2017, export turnover of agricultural products of Vietnam reached USD261.2 billion, an average increase of 9.24% per year. Particularly in 2017, export turnover reached USD36.6 billion, up by USD20.05 billion compared to 2008. Income of rural households increased from VND75.8 million (in 2012) to VND130 million (in 2017). Up to now, Vietnam has 10 agricultural products with a turnover of over USD1 billion, among the 15 countries exporting the largest agricultural and food products in the world with products in 180 countries and territories. According to the research results of the Ministry of Science and Technology, after nearly 30 years of implementing the renovation policy, agriculture, farmers, and rural areas of Vietnam has achieved many great achievements and quite comprehensive. Agriculture continues to boom in the direction of commodity production, improving productivity, quality, and efficiency, ensuring national food security. From a country that has to import food so far we have become one of 15 largest agricultural exporter in the world. The strong development of Vietnamese agriculture in the last 10 years is one of the typical proofs of the impact of science and technology with new development steps to increase output, contributing over 30% of the added value of agricultural production, models of high-tech applications in cultivation, animal husbandry, and aquaculture have helped increase economic efficiency by 10-30% The Ministry of Science and Technology affirmed in that success, science and technology have really been one of the important solutions that have contributed effectively, creating breakthrough changes in agricultural production development, such as improving productivity, quality, competitiveness of agricultural products and goods on domestic and international markets, solving extreme climate change problems, etc., serving restructuring agriculture, improving the lives of farmers. With the great contribution of the community of scientists, the participation of enterprises and science and technology has effectively contributed to the development of agricultural production, ensuring productivity, quality and competitiveness of agricultural products and goods, and services for domestic and international markets. Many scientific research results have been transferred and applied to agricultural production such as new varieties, technological processes, and new technological advances, which have contributed to reducing investment costs, increasing profits and bringing high economic efficiency in agricultural production (Nguyễn Hùng, 2018).

With a natural area of 3.96 million hectares, agricultural production of the MD region accounts for 50% of rice production, 65% of aquatic production, and 70% of fruit production of all kinds. Along with that the cultivation and aquaculture industry has many opportunities to develop. Currently, agricultural resources (rice, shrimp, and Pangasius) in the MD are contributing significantly to national exports with over USD1 billion per year. From these advantages, the MD agriculture has received much attention from scientists, experts, and many large enterprises and corporations involved in the investment. Investment of technology in production is considered the most effective way to help the MD to promote agricultural restructuring and sustainable development, especially in the context of climate change taking place faster than forecast.

In TT activities, CTU paid attention to specific socioeconomic development needs from the district level, therefore, many research and TT contracts between CTU and districts in the MD were signed in the past years. Most science and technology projects and research topics in the region focus on agriculture, aquaculture and fishery processing industry. Typically in rice cultivation, many promising varieties are used in large scale production with high yield, good quality, pest resistance that have been studied and selected. The research program on rice farming systems has contributed to increasing productivity, output, product quality, hunger eradication and poverty reduction and increasing production rice exports in the MD. Technological advances in farming are transferred to farmers effectively in paddy fields and orchards as an integrated pest management program, application of techniques of three reductions, three increases, and four correct in rice production; techniques of off-season flowering stimulation, vegetable growing with drip irrigation system to save water in Hau Giang, Vinh Long, Dong Thap, Tien Giang, Ben Tre, Tra Vinh Provinces, etc. Besides, CTU has collaborated on research and TT with many enterprises, e.g. Bayer Vietnam Limited Company on salinity tolerance of rice varieties to transfer to farmers, cooperating with Southwestern Fertilizer Joint Stock Company and Petroleum Chemicals to build maps of soil-crop-fertilizer to help localities and farmers improve the crop cultivation, cooperating with Loc Troi Group to evaluate the validity of fertilizers used for cops, etc.

The research results on livestock are also applied bringing efficiency such as leaning pigs, biochemical cows towards meat, improvement of goat stocks and waterfowl in the direction of collecting milk, eggs. In the fishery sector researches have been conducted to test farming models of tiger prawns, giant freshwater prawns, Pangasius, process of artificial sea crab breeding, artificial breeding, etc. and disseminate technical procedures for farmers. Research and TT programs in aquaculture contribute positively and effectively to the development of aquaculture that have brought many effects, contributing to help the MD stand top of the country on fish food export.

In the field of industry, the TT activities of CTU contributed to the improvement of processing products from coconut (Ben Tre and Tra Vinh Provinces), rice polishing technology (Dong Thap and Tien Giang Provinces), processing sugar (Soc Trang, Can Tho, and Tra Vinh Provinces), processing aquatic products and seafood (Bac Lieu, Ca Mau, and Soc Trang Provinces) that helped the SMEs to innovate equipment and technology for raising high productivity and product quality. Beside TT activities CTU has also contributed many decisive ideas to localities in orienting long-term development strategies, regional and sub-regional development projects, and criticism for many major projects of state in exploiting the potential of the MD.

Implementation of the Government's guideline that is universities are not training institutions and research but also application bases of science and technology, in recent years CTU has promoted scientific research activities, applying research results in training, production, and life so TT activity is a very important task to be further promoted in the future. However, the implementation of TT still faces many obstacles due to the following shortcomings (Table 1):

Table 1
Evaluation of disadvantages of TT activities in the MD

No.	Contents	Ratio % (*)				
		1	2	3	4	5
1	No systematic in TT management	7.7	48.7	25.6	10.3	7.7
2	Restrictions on the method of organizing TT management	12.8	35.9	35.9	15.4	0.0
3	Lack of initiative in developing TT activity plans	38.5	41.0	12.8	7.7	0.0
4	Lack of human resource for TT management	7.7	17.9	56.4	15.4	2.6
5	Restrictions on qualifications and capacity of TT managers	7.7	46.2	33.3	10.3	2.6
6	Complex financial payment procedures	10.3	43.6	25.6	17.9	2.6
7	Poor diversification of TT activities	7.7	35.9	46.2	2.6	7.7
8	Ask-Give mechanism in research and TT activities	12.8	46.2	30.8	5.1	5.1
9	Restrictions of awareness of enterprises on TT activities	0.0	23.1	53.8	20.5	2.6

(*): 1: Do not agree; 2: Partially agree; 3: Agree; 4: Fairly agree; 5: Strongly agree

(Source: survey result of CTU in 2019)

In general, the above contents focused on two major issues such as the organization and management of TT, and the perception of TT of enterprises. This showed that the State management was crucial to TT activities and relationships with enterprises to help them to be well aware of the necessity of TT for improving production that was very important. TT management activities in the MD as well as in Vietnam so far had not regularly ensured the transfer of good technologies, modern and suitable technologies as well as limited outdated technologies that could affect the environment. Therefore, between State management and enterprises it is necessary to innovate thinking about TT to absorb foreign advanced technologies, but it must avoid technologies at risk to the environment and security, and national defense. Last year the connection point of technology supply and demand in the MD (TechDemo 2018) had officially opened at Can Tho City and put into operation. The operation of the TechDemo 2018 expected to support effectively enterprises in the MD to implement technological innovations, connecting scientists and enterprises to quickly bring about scientific and technological results and products into production and business.

2.4.4 Issues for TT activities of CTU in the MD in the future

TT in agricultural production with the participation of enterprises is a factor to ensure the success of the transfer process: In order to successfully transfer technical skills, especially those with high scientific content into agricultural production, creating products of high value for goods requires the participation of businesses, because businesses have the financial advantage to invest in the development of technical infrastructure, meeting the requirements of receiving new and advanced technologies. On the other hand, the support of enterprises in market development and product consumption will be the driving force for the development of production, improving the efficiency of the technical transfer process. Agriculture is the foundation of industry and service, the main occupation of farmers. Agriculture has its own characteristics, especially the production process is governed by many natural factors: land, climate, hydrology, etc. Therefore, it is necessary to master the characteristics of agricultural poduction, rural, and appreciate the achievements and shortcomings in the rural areas to select suitable techniques, select the right location, objects to receive, transfer units, plan and methods of appropriate TT to promote the effectiveness of technical expertise, creating a driving force for agricultural development and new rural construction. It is very important in the value chain to link businesses with scientific research agencies to research, transfer, production and distribution of profits according to the law (Lê Tất Khương, 2011). To continue good impact on agricultural production in the MD the TT activities of CTU in the future needs to consider the main following issues: Aquaculture production and value chain; rice production and value chain; selection of adaptive crops, livestocks to mitigate effects of climate change; adaptation technologies for water and land use; industrial food processing and preservation; mechanization of agriculture, information technology application in agriculture; and logistic technology of commodity chains.

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3. The KTT Process and its stakeholders

3.1 The KTT Process

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As indicated before, knowledge and technology transfer (KTT) is transfer and dissemination of university-generated knowledge into society, for the benefit of society. KTT runs in parallel with and is the continuation of the research timeline described in chapter 2.1 'From fundamental research to application'.

3.1.1 Protecting Intellectual Property

The Technology Transfer process adds new dimensions to the task of the researchers. Researchers should extend the scope of their literature study beyond scientific publications and include patent databases as sources, allowing them to identify the current state-of-the art inventions. Lab notebooks should be used to document the research work, establish the date of invention and identifying the inventors.

Once an invention is made both the invention and inventors should be described in an Invention Disclosure Form. The IP team of the institution will study the prior art: all information that has been made available to the public in any form before a given date that might be relevant to a patent's claims of originality (Wikipedia, 2020)

It cannot be stressed enough: once an invention has been made public it becomes impossible to protect it; all too often the person creating the prior art is the researcher him/herself. It is therefore important to involve the Tech Transfer Officer before publishing anything relevant for the IP.

Precisely formulating the subject of the invention is the work of specialists. Patent attorneys, who represent their customers in all matters related to patents, will translate the inventions in a number of claims. Claims describe in technical terms what is protected under the patent. Patent applicants target the widest possible application field for their claims, but are limited by what was previously published and protected.

Universities must make a judgement call on the opportunity of patenting the invention: is the inherent value of the innovation enough to warrant the cost and efforts related to patenting? Many elements come to play in this analysis; to name a few: how much better is the invention compared to the state-of-the-art? What is the economic potential of the invention? Will it be possible to identify infringements to the patent? Are potential partners and/or an entrepreneurial team identified? Are there other strategic reasons for patenting?

The filing of the initial patent application is the beginning of a long and costly process which can take three years or more and results in the granting of a patent by a number of national authorities. Generally, an International Phase is included in the patent procedure, in which international actors such as the Patent Cooperation Treaty (PCT) play a role in examining the patent. But in the end it are national authorities that grant the patents. Many decisions need to be taken during this patenting process, including geographical reach of the patent.

An alternative form of IP protection is secrecy, whereby essential knowledge required to perform a certain task is kept hidden from the public. Trade secrets are a frequently used form of IP in business life, but secrecy is very hard to reconcile with the role of academic researcher.

3.1.2 Valorising Intellectual Property

The other important activity is added downstream of the research process: valorising the research results; putting these results to concrete societal use.

A number of choices have to be made regarding valorisation paths: open source access, licensing, spin-off creation… Each valorisation path has its own requirements in terms of expertise, resource and time allocation.

In the case of spin-offs, we can identify four large activity groups, each with their own sets of deliverables (source: Knowledge and Technology Transfer - Finding your way through the jungle, VUB , 2019)

- Identification and evaluation of the opportunity and the IP position of the spin-off idea
- Proof of viability: proof of concept and of market, commitment by team
- Development phase: validating a market; market positioning; development of product and Business Plan, team formation
- Spin-off generation: formalizing the agreements, company formation, funding, start of activities

The steps have a major impact on the whole ecosystem and its actors. Following elements undergo significant change when we proceed with valorisation.

Stakeholders and ecosystem actors

Fundamental research is driven by scientific curiosity; as research gradually turns into valorization, new stakeholders become involved in the process: investors and users, but also regulators and policy makers. This subject is covered in chapter 3.2.

Skillset of researchers

As activities evolve from fundamental research towards valorization, the required skillsets evolve too. This subject is covered in chapter 4.3.

KTT regulation: IP regulation & ownership

Lawmakers and regulators need to adapt as well: clear rules and guidelines are needed regarding ownership of IP developed at universities, fair renumeration of the different parties involved, the freedom to operate of universities regarding economic activities etc. This subject covered in chapter 5.

Funding schemes

New funding schemes are needed to close the gap between fundamental research and profitable economic activities: strategic, applied and industrial research, funding of the development of prototypes and proof-of-concept… Decision making criteria need to be adapted to these new realities, including other criteria than purely scientific relevance. Private investment funds too need to adapt to the properties of research-based ventures. This subject is covered in chapter 6.

University Governance and administration skillset

New academic entities need to be installed, especially tech transfer organizations, in charge of the valorization process. Internal regulations are needed, creating a clear regulatory framework for tech transfer activities. This subject is covered in chapter 7.

Infrastructure: incubators, science parks …

And finally, the infrastructural needs evolve as the project matures. Incubators -often with with lab space and equipment- facilitate the starting phase of the venture, as the company can limit the investments it needs to make in infrastructure. Later on, science parks located near to the university may facilitate the interaction with the research community.

3.2 The stakeholders of KTT

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Framing KTT as a process that has many stakeholders, not just the researcher, the TTO and the investors. This document therefore offers an overview of how the stakeholder concept came to be, how it was developed in KTT literature and what its implications are.

3.2.1 The stakeholder concept

The classic definition of a stakeholder is ' any group or individual who can affect or is affected by the achievement of the organization's objectives (Freeman, 1984). Friedman and Miles (2006) in their seminal work on stakeholders were able to find more than 70 conceptual definitions that were at that time being used to conceptually describe the term stakeholder. What is most striking is the fact that these definitions range from very broad to very narrow in terms of the types of actors that are involved and offer either normative or strategic reasons as to narrow down those that are affected by or are able to affect the objectives of an organization (Aerts et al, 2015). Stakeholders are crucial in terms of the organization's long-term success and survival (Freeman, 1984; Hillman and Keim, 2001; Perrini and Tencati, 2006; Crilly and Sloan, 2012). However, according to certain authors, the stakeholder concept is still an essentially contested idea, meaning that its denotation is dependent on the context, circumstances, or situation in which it is used (Friedman and Miles, 2006; Miles, 2012). As a result, before we introduce stakeholder management as a practice, we must first understand the stakeholder as a concept, whilst also coming to terms with the notion that the conceptual stakeholder definition differs depending on the actor and/or context. Secondly, based on the concept and context, stakeholders must be identified, and classified in terms of their attributes or potential impact on the organization. Finally, the management of these stakeholders can be analyzed (Mitchell et al., 1997).

3.2.2 Identifying stakeholders

The stakeholder concept can be viewed either from the organization's perspective or from the stakeholder's perspective. Organization centric models and theories focus on stakeholder identification and stakeholder salience. Authors such as Mitchell, Agle and Wood (1997) developed models that allowed organizations to define stakeholder salience through the application of three attributes, i.e. power, legitimacy and urgency. Each of these attributes function in relation to the other attributes, subsequently they interact and overlap. A stakeholder is at its most salient when it is powerful, legitimate, and presents an urgent claim simultaneously. The attributes are therefore dependent on the belief system, i.e., the institutional system or environment wherein the relation is situated. Based on the attributes and their possible permutations, the authors provide a model for stakeholder classification (Aerts et al, 2015).

Other models for stakeholder identification include those by Freeman (1984) and Rowley (1997). Freeman's (1984) theory provides easy to use elements, aimed at furthering insights into stakeholder identification, issue salience, and stakeholder influence. The latter element is of importance since influence works in several ways. Freeman (1984) addresses the organization vis-à-vis stakeholder, as well as the stakeholder vis-à-vis organization influence. Influencing is analyzed by knowing who carries which claim, combined with knowledge about the way in which one party can influence the other. When these elements have been established, it allows organizations to map their stakeholders in a stakeholder network (Aerts et al, 2015).

Rowley (1997) utilizes this network theory of stakeholder influence in order to position the organization within its network and in order to assess what the network is made up of. Rowley's (1997) theory is an extension of Freeman's (1984) theory, in the sense that Rowley adds the notion of relations existing simultaneously; both theories consequently overlap, as the map or network that is represented by Rowley, is somewhat more complex than the map presented by Freeman (1984). The importance of the network is uplifted, since it acts as a coordination mechanism, encouraging joint action, and deterring individual opportunism, such as free riding. Network related information is indicative of the position of an organization within the network, revealing the influence it is exposed to. Concurrently, the coordination strategy an organization can have is impacted by its position, also indicating how powerful the organization can be within the network (Aerts et al, 2015).

3.2.3 Stakeholder strategy

An inclusive stakeholder management definition would embrace several crucial elements. The first element is the necessity for an organization to manage its relationships with its stakeholder groups in an action-oriented way (Freeman, 1984), whilst, secondly, emphasizing the development and implementation of organizational policies and practices that, thirdly, take the goals and concerns of relevant stakeholders into account (Post et al., 2002). The important functions of stakeholder management are therefore to describe, analyze, understand and, finally manage in a risk-remedying fashion (Friedman and Miles, 2006; Carroll and Buchholtz, 2009).

Strategizing for stakeholder management can be done in several ways. One of the leading models however was presented by Savage et al (1991) in which they envision stakeholder strategy being made on two axes. One is the potential for cooperation, and one is the potential for harm or threat to the organization. Based on these two dimensions these authors establish 4 generic stakeholder types for which different stakeholder strategies can be employed.

- Stakeholder type 1: This type holds a low threat level and a high potential for cooperation. The strategy is to involve these stakeholders in the objectives of the organization.
- Stakeholder type 2: The second type has a low threat potential and a low potential for cooperation. The strategy is to monitor these stakeholders, yet not to actively pursue their involvement.
- Stakeholder type 3: This type of stakeholder has a high threat potential and a low potential for cooperation. The strategy here is to defend against these stakeholders in order to safeguard the organization's objectives.
- Stakeholder type 4: The final type of stakeholders has both a high threat potential as well as a high cooperation potential. The strategy here is to collaborate with these stakeholders in order to ensure that the organization's objectives are met.

3.2.4 The KTT stakeholder: Empirical findings

In recent and forthcoming empirical research performed by Aerts and Crispeels (2019) technology transfer actors, involved in technology transfer in Brussels Belgium, were asked to identify the key stakeholders that are part of the technology transfer ecosystem. From their results it is clear that these ecosystem participants identify the stakeholder listed in the table below. What is striking, is that these respondents did not explicitly mention civil society as a stakeholder, nor that they mention very broad stakeholder type conceptualizations such as future generations, the environment or others. The focus of these respondents is on the practical value of stakeholders in

KTT ecosystems and therefore attributes most meaning to the stakeholders that appear in day to day interactions (Aerts and Crispeels, 2019).

Table 1. Identified KTT ecosystem stakeholders from Aerts and Crispeels (2019)

#	***Stakeholders***
1	Universities
2	University colleges
3	Research centers
4	Federations
5	Governmental bodies: Government
6	Governmental bodies: Administration
7	Governmental bodies: Agencies
8	Incubators
9	Venture capital funds
10	Private equity funds
11	Business angels
12	Local companies

3.2.5 Concluding remarks

The KTT ecosystem stakeholders are very much reliant on the organizational contextual definition and situational reality within which the conceptualization, identification and strategy making around stakeholders needs to happen. As such, it is very hard to develop exhaustive lists of stakeholder types that are particular for KTT ecosystems. It is clear however that in order to frame KT and in order for KT to be effective and efficient, it needs to address the correct interlocutors. Hence, from an organization-centric point of view KTT ecosystem participants stand to benefit from business unit, organization and even ecosystem wide conceptualization, identification and strategy definition for the stakeholders that are active in their context, given that these actors stand to affect or be affected by the objectives of the participant's organization.

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3.3 KTT Ecosystems

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The follow paragraphs provide a discussion of key sources of literature that address the key components and the make-up of knowledge and technology transfer ecosystems.

3.3.1 On ecosystems & technology transfer ecosystems

Building on systems analysis and denoting a managerial concept, the term ecosystem was first mentioned by Rothschild in 1990 and then further develop by Moore in 1993 (Rothschild, 1990; Moore, 1993). Since then the conceptualization of all sorts of ecosystems proliferated in management and economics research. Business (Moore, 1993), innovation (Adner, 2006), knowledge (Clarysse, Wright, Bruneel, & Mahajan, 2014) and entrepreneurial (Prahalad, 2009) ecosystems popped up and as such have been the object of much scrutiny as the ecosystem concept emerged from various streams of literature and has remained underdeveloped as a core concept.

Several authors attempted to distill the common components of the ecosystem literature in order to properly define and establish the ecosystem concept (Pilinkienė & Mačiulis, 2014; Scaringella & Radziwon, 2018). From their analyses, a framework arises which in essence provides a more detailed and more organizational view of what Champenois and Etzkowitz (2018) define as the boundary space within the triple helix (Champenois & Etzkowitz, 2018).

In parallel to these conceptual ecosystem definitions, literature on technology transfer ecosystems recently also emerged and several authors attempted to fit the concepts derived from business or innovation ecosystem literature directly on technology transfer where the actors in the system are heterogeneous.

Heinzl et al. (2013) define the TT ecosystem as the "interrelated cognitive, cultural and structural embeddedness of the innovation commercialization infrastructure at universities" (Heinzl, Kor, Orange, & Kaufmann, 2013).

Good et al. (2019) define the TT Ecosystem as "the set of industry affiliated intermediary organizations that are connected by directly supporting TT activities" (Good, Knockaert, Soppe, & Wright, 2019).

Hayter (2016) defines the entrepreneurial university ecosystem as: "the strategic and collective actions of various organizational components – what we term knowledge intermediaries – in order to maximize both the entrepreneurial and innovative contributions of universities" (Hayter, 2016).

Most of these technology transfer ecosystem definitions are complementary to the conceptual definitions put forwards by Scaringella et al (2018) and others, yet one of the main issues lies in the fact that all these definitions revolve around a specific value proposition.

Another issue is that these systems seem to emanate from a specific institution (the universities or the companies). TT systems lack a clear shared value proposition towards specific customers - as made clear by the definition of Heinzl et al. (2013) - which makes us question whether the ecosystem concept can be applied to technology transfer, decoupled from the broader triple helix boundary space.

On top of that, approaching the TT systems from the university side leads to an unbalanced or too narrow approach of the system, as in Good et al. (2018) where the TT ecosystem is confined to four components: Technology Transfer Offices, Science Parks, Incubators and University Venture funds.

As the TT system resides at the heart of the Triple Helix model, a more balanced and multi-perspective yet directed approach to the study of TT ecosystems, as defined by Hayter (2016) and as conceptualized by Scaringella and Radziwon (2018) becomes necessary.

3.3.2 Early contributions by Moore (1993)

In predators and prey: a new ecology of competition Moore (1993) suggests that a company should be viewed not as a member of a single industry but as part of a business ecosystem that crosses a variety of industries. In a business ecosystem, companies co- evolve capabilities around a new innovation: they work cooperatively and competitively to support new products, satisfy customer needs, and eventually incorporate the next round of innovations.

A business ecosystem, like its biological counterpart, gradually moves from a random collection of elements to a more structured community. Business eco- systems condense out of the original swirl of capital, customer interest, and talent generated by a new innovation, just as successful species spring from the natural resources of sunlight, water, and soil nutrients.

Every business ecosystem develops in four distinct stages: birth, expansion, leadership, and self-renewal or, if not self-renewal, death. These evolutionary stages blur, and the managerial challenges of one stage often crop up in another.

During Stage 1 of a business ecosystem, entrepreneurs focus on defining what customers want, that is, the value of a proposed new product or service and the best form for delivering it. Victory at the birth stage, in the short term, often goes to those who best define and implement this customer value proposition. Moreover, during Stage 1 of a business ecosystem, it often pays to cooperate. From the leader's standpoint, in particular, business partners help fill out the full package of value for customers. And by attracting important "follower" companies, leaders may stop them from helping other emerging ecosystems.

In Stage 2, business ecosystems expand to conquer broad new territories. Just as grasses and weeds rapidly cover the bare, scorched ground left after a forest fire, some business expansions meet little resistance. But in other cases, rival ecosystems may be closely matched and choose to attack the same territory. Direct battles for market share break out. Fighting can get ugly as each ecosystem tries to exert pressure on suppliers and customers to join up. In the end, one business ecosystem may triumph, or rival ecosystems may reach semi-stable accommodations.

In general, two conditions are necessary for Stage 2 expansion: (1) a business concept that a large number of customers will value; and (2) the potential to scale up the concept to reach this broad market. During the expansion stage, established companies can exercise enormous power in marketing and sales, as well as in the management of large-scale production and distribution, literally crushing smaller ecosystems in the process.

In stage 3, the ecosystem must have strong enough growth and profitability to be considered worth fighting over. Second, the structure of the value-adding components and processes that are central to the business ecosystem must become reasonably stable. This stability allows suppliers to target particular elements of value and to compete in contributing them. It encourages members of the ecosystem to consider expanding by taking over activities from those closest to them in the value chain. Most of all, it diminishes the dependence of the whole ecosystem on the original leader. It's in Stage 3 that companies become preoccupied with standards, interfaces, "the modular organization," and customer- supplier relations.

Stage 4 of a business ecosystem occurs when mature business communities are threatened by rising new ecosystems and innovations. Alternatively, a community might undergo the equivalent of an earthquake: sudden new environmental conditions that include changes in government regulations, customer buying patterns, or macroeconomic conditions. Moreover, these two factors reinforce each other. An altered environment is often more hospitable to new or formerly marginal business ecosystems (Moore, 1993). Companies can respond in several ways; one is working with the innovators and or disruptors that bring new ideas to the existing ecosystem. Another is the creation of high barriers to entry to prevent innovators from building alternative ecosystems. The latter can also be achieved via high customer switching costs in order to buy time to incorporate new ideas into new products and services. Alternatively, if self-renewal does not work, the company will eventually become uncompetitive and disappear from the ecosystem.

3.3.3 The proliferation of ecosystem models

Business ecosystems, as defined by Moore (1993, 1996), Iansiti and Levien (2004) and or Zhand and Liang (2011) refer to loose networks – of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organizations – affect, and are affected by, the creation and delivery of a company's own offerings. Like an individual species in a biological ecosystem, each member of a business ecosystem ultimately shares the fate of the network as a whole, regardless of that member's apparent strength.

Innovation ecosystems, as defined by Adner (2006) refer to the collaborative arrangements through which firms combine their individual offerings into a coherent, customer-facing solution. Enabled by information technologies that have drastically reduced the costs of coordination, innovation ecosystems have become a core element in the growth strategies of firms in a wide range of industries.

Entrepreneurial ecosystems, as conceptualized by Prahalad (2005) refer to the market-based ecosystem allows private sector and social actors, often with different traditions and motivations, ad of different sizes and areas of influence, to act together and create wealth in symbiotic relationship. Such an ecosystem consists of wide variety of institutions coexisting and complementing each other.

Knowledge ecosystems finally, as conceptualized by Clarysse et al (2014) refer to the flow of tacit knowledge between companies and the mobility of personnel have been advanced as the main advantages of geographic colocation which characterize these hotspots. Such hotspots have been characterized as knowledge ecosystems where local universities and public research organizations play a central role in advancing technological innovation within the system.

3.3.4 The ecosystem model by Scaringella and Radziwon (2018)

Scaringella and Radziwon (2018) explore and present the terminology that management scholars use when referring to the various streams of research dedicated to ecosystems by systematically reviewing a wide range of papers from business, management, and economics; to list the invariants that appear unchanged despite the timing and framing of a literature stream; to link the ecosystems' growing stream of literature to the well-established and mature literature dealing with the territorial approach; and to build the framework that will be a base for further research.

In order to reach these objectives, they address the following research question: What are the conceptualizations of the ecosystem approach, its invariants, and its links with the territorial approach? In ten searches the authors identified 35 primary, 30 secondary, 117 peripheral, and 172 non-relevant records. Based on this analysis they created a conceptual model of the ecosystem, based on the invariants that were retrieved during their analysis. The authors provide a list of the elements that all theories on ecosystems have in common. Overall the authors identify 7 common elements. 1. a given territory with a unique atmosphere, the anchoring of an industry, and varying sizes; 2. a set of common values, such as trust, belonging to a community, a mutual understanding built over time through common history, culture, and routine; 3. a set of various stakeholders, such as firms of different sizes, research institutes, universities, and policymakers, all positioned at different stages of the value chain; 4. a strong economics foundation based on localization economies, agglomeration economies, transaction cost theory, localized spillovers, and economies of scale; 5. a strong social foundation based on the coexistence of collaboration and competition, which focuses on the increasing importance of both social and human capital; 6. a central position of knowledge of a different nature (tacit versus explicit), which circulates well through transfer, is well-absorbed through intensive learning, and offers synergies; and 7. important outcomes, which are the catalysts of innovation, entrepreneurial initiatives, and competitiveness and lead to economic growth, long-term development, performance, and success.

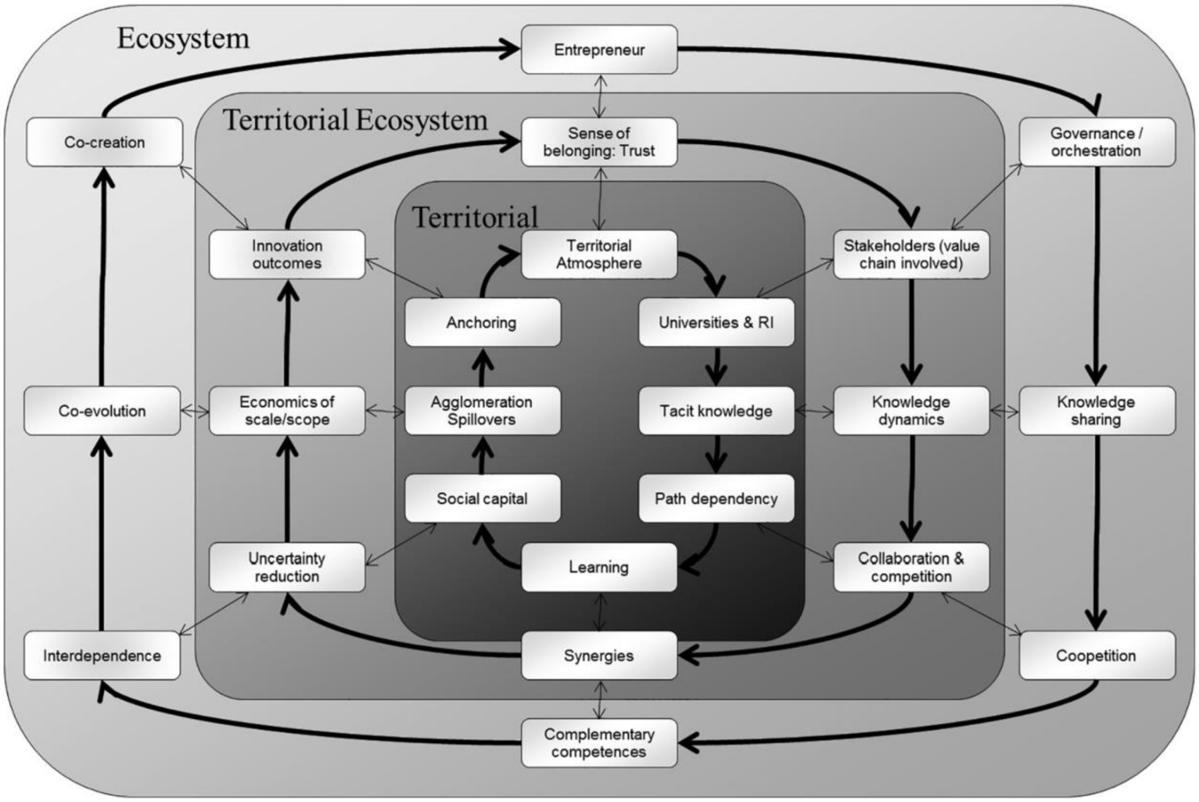
The model shown in figure 1 shows the conceptual model that these authors developed on the basis of the invariants uncovered through their research. The framework highlights the interconnection of the three complementary layers: ecosystem, territorial ecosystem, and territorial. The external layer (ecosystem) offers a broader view, the internal layer (territorial) offers an inner view, and the intermediate layer (territorial ecosystem) is the point of friction between the two complementary streams of literature. The authors believe that (a) there is a causality between the invariants at each layer, (b) there are virtuous circles at each layer where an interaction strengthens the next iteration, and (c) there is a high degree of porosity among the three layers and a certain influence between invariants: from the ecosystem to the territorial approaches (broad-inner dynamics) or from the territorial to the ecosystem approaches (inner broad dynamics).

Regarding the external layer (light grey color), entrepreneurial activities clustered in an entrepreneurial ecosystem offer the possibility for large firms to play the role of orchestration, which shapes knowledge sharing between the members, involves a form of coopetition, complementarity, and interdependence, determines the joint evolution and the co-creation of value, and finally, reinforces the entrepreneurial activities.

The internal layer, the territorial atmosphere supports the development of research centers and universities and the exchange of tacit knowledge, which consequently creates a certain path dependency; it shapes the collective learning, the development of a social capital, and the agglomeration of firms benefiting from localized knowledge spillovers, which strengthens the anchoring of knowledge; and finally, it reinforces the territorial atmosphere.

As for the intermediate layer (grey color), the interconnections and interdependencies between ecosystem stakeholders create a trusting atmosphere and a sense of belonging, which encourages various stakeholders to become involved in the value chain. Consequently, the stakeholders also engage in knowledge dynamics as purposive inflows and outflows of knowledge, and this creates an environment where there is a dual existence of collaboration and competition, which is needed to create synergies between closely connected actors and reduce initiative, interdependence, and integration risks, benefit from economies of scale/scope, and offer innovation as a social and iterative process, reinforcing the sense of belonging.

Figure 1. Ecosystem model by Scaringella & Radziwon (2018)



3.3.5 Concluding remarks on KTT ecosystems

Contemporary literature on KTT ecosystems can be summed by stating that KTT ecosystems are complex, multi-layered systems anchored in geographically delimited spaces. Within these surroundings these systems exhibit and require the existence of a number of constructs, heavily drawing from the triple helix knowledge base and integrating the knowledge, business and policy communities, thereby generating interaction between its actors through which relationships are purposefully oriented towards several objectives, of which the primary are: the strengthening of companies, the reduction of uncertainty, the generation of innovation and the fostering of learning. Future research on the matter will need to address these ecosystems in a holistic, comparative and encompassing manner in order for researchers to distill lessons learned and best practices towards the design, development, implementation and improvement of these systems.

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3.4 Business Development and Commercialization in a University Context: scouting and screening research results

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Technology transfer activities in higher education require the capacity to analyse research taking a business perspective in order to devise what are the market needs (Bennetzen & Møller, 2013). Accordingly, success in business development and commercialization based on university research results implies, first and foremost, the deployment of efficient methods to access, store and process generally large volumes of a basic ingredient that is information. Accordingly, technology transfer, in its various forms, require a first and basic step, which is the collection of information concerning what kind of knowledge and where in the university is it being generated, as well as who is responsible for its generation. This approximates the overall searching process for new knowledge described by Laursen and Salter (2004). However, when taking a business development and /or commercialization of research perspective, the simple searching process needs further qualification, or, in other words, a more critical and insightful approach to collected information. This qualifying process assumes the nature of what is generally referred to as a scouting mechanism, which identifies and critically assesses information under the light of an interpretation of signals indicating technology change trends (Rohrbeck, 2010). A further decisive step consists of selecting the best, i.e., the ideas/results that are more likely to give rise to effective knowledge valorisation. This approximates what is commonly designated by a screening process. Scouting and screening processes are, thus, crucial preliminary steps in the endeavour to foster business development based on and commercialisation of academic research results. As such, they contribute to face the challenges of university-industry links, namely the high level of transaction costs stemming from the uncertain and non-codifiable character of scientific results (Debackere, 2012).

3.4.1 About technology scouting

Taking it simply, scouting activities can be regarded as stemming from three major actions: to observe, to explore and to find (e.g., Merriam & Webster dictionary). In overall terms, scouting in higher education institutions aims to gather intelligence concerning, on the one hand, the knowledge and/or technology being generated by academic research, and, on the other hand, the technological needs and state of the art, as well as the emerging trends taking place in the market. This twofold perspective on scouting gives ground to a most relevant match, which, in the end, establishes the science and technology opportunities that deserve to be subjected to a subsequent selective endeavour.

A direct consequence concerns the need to draw on a variety of information sources, both internal and external to the academic organization, and of a tacit or codified nature Greitemann et al. (2014). The authors provide some examples of this variety of information sources, as in Table 1.

Table 1. Scouting information sources

	Tacit	Codified
Internal	• Face to face contacts • Gatekeepers	• Internal documents • Internal databases

	• Workshops	• Reports
External	• Conferences • Trade fairs • Networks	• Journals • Patents • Think tanks

Source: Based on Greitemann et al. (2014)

Accordingly, those agents who act as technology scouts in higher education institutions should have a full understanding of what is going on in terms of research within the walls of different departments, schools or faculties, cultivating personal relationships with research staff and actively participating in academic relevant events, and accessing a wide range of internal documental sources. At the same time, they should be skilled in interacting with the external world, making use of personal and/or institutional networks and taking part in purposeful events, as well as be knowledgeable of a wide range of external documentation that can provide valuable intelligence on technology needs and changing trends. Franzoni (2007) suggests that a TTO, while scouting, performs a task she terms as ‘opportunity recognition’, “*a distinctive entrepreneurial skill, which leads from the research phase to the framing of a business idea*” (id., p. 53).

Obviously, easy access to privileged informants in a context of proximity (be it institutional or personal) is a valuable asset in the context of a scouting process. Taking the example of the University of Aveiro, the scouting process is based on departmental pivots who are responsible for identifying and primarily assess the development potential of the knowledge and, subsequently, for establishing the connection with the university’s technology transfer unit. In turn, the technology transfer unit, drawing on the interpretation of technical change trends and market needs, is able to inform each department about emerging fields of research and white spaces in need of fulfilment. It is worth mentioning that these organizing settings are in process of rearrangement. The emerging model, which is not fully deployed yet, although maintaining the two-way process, places the pivotal role under the framework of external impact areas, rather than departmental scientific expertise.

The potential for generating new knowledge and ideas existing in universities can provide ground to question whether there are risks of reducing the possibility of an innovation breakthrough when in presence of a proliferation of ideas. Hansen and Birkinshaw (2007, p. 122) acknowledge that risk, talking about concepts that “*never flourished, nor did they die*”. They add (id., p. 124): “*Generating lots of good ideas is one thing; how you handle (or mishandle) them once you have them is another matter entirely*”. This argument suggests the need for identifying the most suitable ideas for business development and commercialization of academic research results. This entails what is commonly called technology screening process.

3.4.2 About technology screening

Technology screening encloses a selection process based on the relevant intelligence collected through the scouting phase. The output allows for the identification of knowledge and/or technology that, more likely, can nurture effective business development or technology commercialization and avoid, as mentioned above, the potentially innovation hindering effect of idea proliferation.

As a selection mechanism, screening aims at finding the best matches between new knowledge and/or technology and existing market needs. Moreover, it can provide useful hints for selecting research results that, although not suitable for exploration in the context of current market needs, show higher potential to match expectations stemming from technological change trends inherent to emerging markets.

This selective endeavour, in comparison with the scouting phase, requires, as expected, the TTO to develop a deeper understanding of the technology, and the markets it may be aimed at. Simultaneously, the process sets off a perception on the qualities of the people responsible for the idea (e.g., are they business-prone?). This deeper understanding, all together, gives a first insight on the most adequate solutions for a successful transfer from academia to the world of production. In other words, it contributes to unveil the most suitable transferring process, be it through a start-up or a non-venture type of commercialization. An additional and most relevant issue concerns the role screening plays in the identification of ways of improving ideas in order to make them suitable for commercialization. As such, it can give rise to a 'no-go' situation and the need to recast and enhance the original idea. Obviously, screening has an important role to play in avoiding failures, which can be harmful not only to the failed project but to the overall technology transfer strategy of a higher education institution.

In this context, the early disclosure of the idea is very important. The timely TTO screening intervention, i.e., the prompt evaluation of the idea development potential, can be instrumental to succeed. It allows for an effective management of time-consuming tasks such as the assessment of market opportunities. Furthermore, it can give sufficient time to think about the best ways to ensure intellectual property (IP) protection, as well as to identify potential funding sources and/or prospective customers.

The knowledge about the market, namely in terms of its receptivity in relation to a given product or service, is an essential ingredient to validate the idea and its potential as basis for business development or commercialisation. A structuring query concerns what are the needs the idea is expected to address and the willingness of potential clients to pay for a solution based on that idea. This can be a challenging step, namely because the working basis is the potential rather than any concrete product or service materialised with basis on research results. This query plays no second fiddle when deciding whether the best way to take commercial advantage from academic research results is the setting up of a firm or the adoption of an alternative commercialisation path.

3.4.3 Choosing the path

Business development and licensing can be regarded as major forms of technology and knowledge transfer from academia to industry. Accomplished the scouting and screening tasks, and eventually set out effective IP schemes, the path to be followed is there to be chosen. Basically, the crux of the matter is the selection of the best way to proceed.

The selection effort can be based on criteria that Resende et al. (2013) wrap up under the term 'proximity argument', which, in short, creates a dependent relation between the way to proceed and the degree of closeness of the technology to the market. Drawing on the same authors, if it is very close to the market, the way to go would be the establishment of a licensing agreement with an industrial partner. If the technology is close to the market, but there is the need for maturation, the best way to move forward can be a sponsored research agreement, which provides funding to further research aiming at ensuring that a given technology reaches the conditions set for licensing. Finally, when in presence of a technology that, because of its nature and reach, and, above all, low replication possibilities, brings a competitive edge for a period between 5 and 10 years, setting up a start-up company can be the best solution. Naturally, the stronger or weaker entrepreneurial profile of the researcher responsible for the breakthrough plays a decisive part here.

3.4.4 Business development

There is plenty of evidence in the history of innovation and entrepreneurship showing that many good ideas do not turn into successful businesses. A wide range of challenging situations, requiring sharp and timely decision-making and action, can determine different futures for start-ups. These challenges are seldom passible to be faced by individuals in isolation, independently of their stronger or weaker entrepreneurial abilities. Accordingly, as soon as universities and other higher education institutions started to act as economic development agents and a privileged *locus* for turning academic knowledge into wealth, incubating facilities became a widespread organizational structure within academia. The basic idea was to provide academic entrepreneurs with the capacity to overcome the turbulence affecting the early stages of starting up a business.t support.

What kind of support do start-ups find in an incubator? Firstly, every incubator tends to offer at a low cost, a variety of basic services, such as, for instance, consultancy and support in the process of business-plan making, accounting services, IP protection schemes, communication strategies and support for internationalisation. Furthermore, in early stages, incubator services can help to gather valuable information on the matching between idea/product/process and market conditions, thus improving decision making and subsequent action… even to devise the possibility of a 'no-go' situation, avoiding a probable failure in the short term.

The incubator services help the potential entrepreneur to find the right answers to questions such as the following:

What kind of market is targeted by eventual products/processes stemming from a good idea?

Are there alternatives already in the market?

How different is the product/process from others in the market?

What is the growth potential of the product/process (competitiveness)?

The answers emerge as an essential set of information, allowing for accurate judgements about the feasibility of turning an idea into business. Methods such as the so-called 'lean start-up' (Ries, 2012) are frequently used in incubators. The business potential of an idea is validated the Minimum Viable Product (MVP) process. In short, the MVP implies the development of a simple product/service prototype, which is then presented to potential customers. Their opinion on the solution can be a valuable asset to introduce changes aimed at a better matching with customers' expectations and needs. In the end, it is possible to collect evidence that, although minimal, allows knowing more about whether there are enough customers to make viable the new venture.

New ventures generally find in incubators support to look for and access the funding needed to start operating in the market. The often (institutionally and geographically) far reaching networks of an incubator (business angels, venture and seed capitalists, financial institutions, government organisations, etc.) can play a pervasive role in the effort to find the right funding.

Moreover, in order to avoid or, at least, mitigate errors along the starting-up process, to count on the insights of a mentor can be of great importance for an incubated firm.

3.4.5 Licensing

Licensing is a frequently used means of exploiting IP, including in the process of commercialization of research outcomes produced in universities and publicly financed organizations. Universities can become part of a community of innovators by enabling the licensee to use, manufacture and sell technology they are owners.

Universities should be able to leverage external networks (organizations often rely on their existing networks to identify licensing opportunities) and set up multidisciplinary teams to identify deal opportunities. Rogers et al. (2000) highlight that licensing generates payments for the use of acquired technology (i.e., license royalties), which turn into revenue for universities. Furthermore, IP rights create strong incentives for universities to adopt a perspective of commercializing their research results (Debacker and Veugelers, 2005).

Considering the high degree of customization of licensing processes and the inherent complexity of IP management, learning the basics of licensing is a prerequisite to undertaking any of the more complex means for exploiting IP. The World Intellectual Property Organization (WIPO, 2015, p. 5) set out an introduction to successful technology licensing in which six "*fundamental and simple ideas*" are highlighted:

Technology licensing only occurs when one of the parties owns intangible valuable assets, i.e., meriting the status of intellectual property.

There are different kinds of technology licenses (according to WIPO it is useful to think of them in three categories - for certain IP rights only; for all the IP rights of any kind that are necessary to reproduce, make, use, market, and sell products based on a type of technology; and, for all the IP rights necessary in order to create and market a product that complies with a technical standard or specification);

Technology licensing happens in the context of a business relationship in which other agreements are often important;

As in every negotiation, technology licensing negotiations involve interests that are different, but must coincide in some ways;

Technology licensing involves reaching agreement on a complex set of terms;

Technology licensing is not necessarily a technology transfer activity.

Following WIPO's (2015) guidance, some core components should be checked in order to avoid misunderstanding about the basic objectives and terms of the license and is an important component in technology licensing. The parties should begin thinking about the business reason for the license and the leverage for each one. After that, the period for signing the license agreement, the data and documents, the negotiating team and the negotiating strategy should be set. Finally, it is important to verify the positions on the key issue and if preliminary agreements will be needed.

The terms agreed upon in a license agreement are commonly grouped in four main aspects (WIPO, id.). Firstly, the subject of the license (the parties should agree on the matter; the ownership of the IP; the possibility to see the technology before the commitment; the need of a license to use the trademark; and, if the technology is being licensed complete or not). Secondly the rights given by the license (the scope, the territory and exclusivity). Thirdly, the financial terms (the value for the use of technology; the payment conditions by the licensee; the performance, warranties and indemnities; and, when to use cross licenses and covenants not to sue). Fourthly, and lastly, technology growth and development over time (the parties should verify if the licensee receives rights to future releases, versions and product and if there are services, support and also spare parts included in the license).

Technology transfer to a company is usually done through a licensing agreement, which may or not be exclusive, for one or more applications of the technology and with full or limited geographical scope. All the drivers of the technology commercialization should be discussed with the company in order to obtain a maximum return on investment and to expand universities' capacity and knowledge.

University licensing agreements are similar to commercial licenses. However, they may include additional conditions that reflect university objectives and the stage of technology development. The university and the company agree terms, conditions, and payment. Universities should be aware that aligning interests and define cooperation for technology transfer should be the subject of specific contract clauses.

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3.5 Vietnam Knowledge and Technology Transfer Ecosystem

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The ecosystem of knowledge and technology transfer contributes to promoting cooperation between universities and industries. Collaboration between universities and industries is important for skill development (education and training), creating, acquiring and receiving the knowledge (innovation and technology transfer), and promote entrepreneurship (start-up and spin-off). Collaboration between universities and businesses helps promote commercialization of research results, as well as exchange of labor between the public and private sectors, and helps create new products for society.

3.5.1 Parties in the knowledge and technology transfer ecosystem in Vietnam

The ecosystem of knowledge and technology transfer (Figure 1.1) consists of many participants such as market and society, the investors, incubators, industrial area, government, industries, service providers, research community, KTT centers, and students. These parties interact with each other and help the ecosystem to form and develop. The following content will evaluate the knowledge and technology transfer ecosystem in Vietnam.

Market and society

Markets and society need new and useful products to bring better life. Therefore, consumers want new products that are good, beautiful and have higher quality, with cheaper prices. The business environment of a country is developed to support and encourage the more sophisticated and effective competition. This process is a series of sequential development stages; each stage has its own characteristics and challenges.

- *factors driven economy (resources)*
- *Eficiency based economy*
- *innovation based economy*

Vietnam is currently only an factor based economy . Therefore, the economic growth rate is very low and the society has not strongly developed (Figure 1.2).

Vietnam's products are mainly produced at the processinging level for foreign companies such asor processed agricultural, forestry and seafood products. Thus, the added value is not high.

In Vietnam, new and advanced products are imported, such as Iphones, computers, household appliances, electronics, etc.

Therefore, Vietnam needs to promote innovation and development based on promoting investment to increase labor productivity and then to rely on innovation (based on technology).

Investors

According to the report "innovation start-up" by the National Agency for Science and Technology Information, in Vietnam, investment activities for innovation are expressed as follows:

Innovation start-up investment fund: By the end of 2017, there are about 40 investment funds operating in Vietnam with the majority of foreign investment funds. Among them, only some investment funds have representative offices in Vietnam, such as IDG Ventures, CyberAgent Ventures, DJF-Vina Capital, 500 Startups. In addition, there are private investment funds (Private Equity Fund), which do not focus on investing in startups but can invest in the transition from start-ups to mature businesses such as Mekong Capital Fund, Dragon Capital, VinaCapital.

Angel investors: The number of angel investors is not much, but it starts to increase. Most of these are successful entrepreneurs who want to invest in startups in the next generation. Some overseas Vietnamese people or overseas Vietnamese students have been returning to Vietnam to participate in innovative entrepreneurship investments. Activities of angel investors in Vietnam have started to be more systematic by connecting and forming a number of clubs and investment networks for startups such as VIC Impact, iAngel or VCNetwork.co.

Credit providers: Recently, some banks have started offering interest rate support programs for start-up businesses such as Vietcombank, 40 Vietinbank, VPBank, and BIDV. For example, in March 2018, BIDV announced to spend VND 4,000 billion of preferential credit for start-up businesses. However, banks also share with innovatiion start-up enterprises. The assessment of intellectual property, business models and risks of these units still faces many difficulties.

Participation of corporations: The period from 2016 to 2017 witnessed the participation of many Vietnamese corporations in investing in startups such as FPT Investment Fund (FPTVentures), Viettel Investment Fund (Viettel Ventures), and CMC Creative Fund.

Innovation reative start-up activities have appeared in Vietnam since the year 2000s when the American Venture Capital Fund - IDG Ventures brought $ 100 million to invest in Vietnamese startups, creating the first wave of startups. Since then, this activity has increased both in quantity and quality. Investment funds from Australia, Singapore, and South Korea have come to Vietnam to find investment opportunities in innovative startups.

According to Echelon - one of the leading magazines on startups in Southeast Asia, Vietnam currently has about 3,000 startups. According to the statistics of Topica Founder Institute (TFI) 2017, Vietnam received 92 investment deals with a total capital of USD 291 million - nearly doubling the number of deals and nearly 50% of the total investment capital compared to 2016 (50 deals with USD 205 million). According to Tech in Asia , in 2017, Southeast Asia attracted USD 7.86 billion of investment in start-ups - thus, the amount of Vietnamese investment attracted is very small. However, the investment capital attracted in 2018 is USD 889 million, 3 times higher than 2017. This shows that technology transfer and start-up activities are strongly concerned in Vietnam.

Incubators

The model of enterprise incubation appeared in Vietnam over the past 10 years and has been increasingly paid attention to. It is considered as one of the most effective tools to support businesses in the early stages of development. Vietnam has formed a number of incubation models or a number of organizations that function as incubators, such as: HBI Incubator; Hoa Lac High-Tech Business Incubator of Hoa Lac High-Tech Park; incubator established by Tinh Van Informatics Technology Company; incubator established by FPT company; High-tech business incubator that belongs to High-Tech Park (Saigon HiTech Park), technology business incubation center of Ho Chi Minh City Polytechnic University, Quang Trung software incubator, etc. Most of incubators are concentrated in big centers such as Hanoi and Ho Chi Minh City and mainly state-owned. Recently, many incubators have been put into operation in localities such as Vietnam - Korea Industrial Technology Incubator (in Can Tho), Can Tho University Technology Business Incubator, and many enterprises' incubators such as workspaces Up-Co, Dreamplex, Circo, I.Value(3), etc.

Incubators are established by private companies, state and domestic and foreign organizations to support incubation development.

Science park

Currently governments have established large science parks in different regions such as Hanoi, Da Nang and Ho Chi Minh City with thousands of billions Vietnamese dong. However, the level of attracting companies, the level of infrastructure development, the comprehensiveness, as well as the development of enterprises in science parks is still limited.

High-tech parks have not been completed and developed (2/3 of high-tech parks). Although attracting FDI and domestic enterprises to invest, infrastructure development is limited and far from the center (Hoa Lac). There is no close connection with related parties so that the development is not as expected.

Government

The Government has issued many laws and documents to support intellectual and technological transfer, as well as to establish many relevant agencies such as the National Assembly's Technology Transfer Act 2017, No. 07/2017/QH14; the National Technology Innovation Fund (NATIF) and the Small and Medium Enterprise Development Fund that are being expanded by the Government to target start-up businesses. (https://startup.vnexpress.net/tin-tuc/xu-huong/von-chinh-phu-tu-nhan-thoi-luong-gio-moi-cho-startup-viet-3698050.html); Project 844; Project on supporting women to start a business in the 2017-2025 period in Decision No. 939/QD-TTg dated June 30, 2017 and Project on supporting students to start a business in Decision No. 1665/QD-TTg dated October 30, 2017.

The Government has focused on implementing the following main contents:

- Creating an international environment favorable for innovation start-up development
- Step by step building legal corridors, supporting the formation and development of national entrepreneurial ecosystems
- Gradually improving the capacity to implement innovation start-up activities.
- Organizing activities to connect, communicate and provide S&T information to promote creative entrepreneurial movement
- Efforts of the Ministry of Science and Technology, ministries, branches, localities, social organizations and associations.

Industry

According to the FIRST project, strong and weak industries of Vietnam (based on the level of scientific impact and specialization index compared to the world average level) are shown in Figure 1.3. below. Thereby, Vietnam is strong in the following sectors:

- Group 1: Soil and environmental science, and biomedical research
- Group 2: Mathematics, agriculture, biology, physics and information technology and communication (highly specialized index)
- Group 3: Clinical medicine, and engineering (high in terms of scientific impact)
- Group 4: Chemistry, strategic support technology (low)

Export advantages are only in some sectors such as textiles, clothing, food processing, non-metallic minerals, radio, television and telecommunications, some electrical equipment and rubber products.

Vietnam needs to select a path of innovative labor-based productivity to promote economic development as emphasized in a joint research report between the World Bank and the Organization for Economic Cooperation and Development (OECD).

In summary, innovation activities in Vietnamese enterprises are very low and ineffective. Therefore, it is necessary to speed up technology and innovation activities at the school level, researchers and technology transfer to businesses should be boosted to help businesses improve their competitiveness.

Service providers

Currently, 2017 marked a strong activity of innovative startup support organizations like BK-Holdings, Vietnam Young Start-up Network (VYE), VCCI, Innovatube, etc. The Program named Vietnam Mentors Initiative (VMI) in 2017 organized 03 training courses to connect mentors with the participation of 83 representatives of start-up groups in Hanoi, Ho Chi Minh City and Dong Thap. International organizations from Finland, Israel, United Kingdom, Australia, and some others are also very interested and join hands to support the development of innovation.

In general, there are many organizations that support mentoring activities for start-up groups. However, the approach between the two parties has not been effective because the communication activities, as well as the databases of these companies have not been updated and disseminated to start-up groups.

Center for knowledge and technology transfer

The establishment of a technology transfer office (TTO) in universities has become an extensive institutional mechanism to support researchers's findings and obtaining license fees and royalties (Correa and Zuñiga 2013). TTO offers a range of services to improve technology transfer cycles, such as patent application process, licensing agreement, partner search and funding, and training and support in creating university-based spin-offs.

At present, knowledge and technology transfer centers are only a part of the functions of universities. Therefore, the KTT implementation is still limited and the implementation results are not very satisfactory. Many research marketable results have not been commercialized.

Students

The National Start-up Day for students in 2018 is held on December 15-16, 2018 with the participation of a total of about 80 projects. The contest "Students with start-up ideas - SWIS 2018" is organized on a national scale with the participation of more than 200 universities, colleges, intermediate schools and high schools (200,000 students in total).

Currently, universities also have entrepreneurship/startups competitions to encourage students to participate, especially Hanoi University of Technology, University of Foreign Trade, National Economics University, Ho Chi Minh City Economics University, Lotus University, etc.

The Youth Science Innovation Contest was organized in 2017 and 2018 with the participation of 110 teams. There were 70 teams in 2017 and 40 teams in 2018.

However, entrepreneurship and innovation knowledge for students is limited.

3.5.2 Current status of the knowledge and technology transfer ecosystem at Hanoi University of Science and Technology

So far at the University of Hanoi, there have been the following parties in the KTT ecosystem:

- Research groups from faculties, departments, institutes
- Department of Science Management

- Bkholding
- Students

In terms of potential, Hanoi University of Science and Technology is one of the leading technology schools in Vietnam with a number of high-quality officials to 26 professors, , 237 associate proffesors, and 514 PhDs, with a total of 30000 students per year. Total funding for research is USD 2-3 million/year from various sources. The number of annual ISI/scopus articles is 200 - 250 articles. As of 2017, the school's total number of intellectual property registrations is 119 applications (of which 69 are exclusive applications and mainly at the national level), in the main areas of chemistry, food biotechnology, mechanics, textile, etc. The license contract value is not clear.

Technology transfer activities are mainly technological consultancy, which are carried out at faculties or institutes at a small and individual scale. The TT value is not high. Researchers are not well aware of intellectual property laws as well as the role of technology transfer in research and training at universities. Figure 1.4 shows the transfer values over the years of Hanoi University of Science and Technology.

Many training programs to promote the entrepreneurial spirit of students have been organized by Bkholding and the Department of Science Management, attracting great interest of students. Besides, many programs for researchers are also organized with the sponsorship of projects (E+: NutriSEA, VETEC…; …..) in order to improve general knowledge about starting a business and entrepreneurship .

In the context of university autonomy today, the further promotion of technology transfer activities will enhance the reputation of the University with enterprises and communities, creating opportunities for cooperation and funding from enterprises for applied research activities for Hanoi University of Science and Technology.

Moreover, the establishment of a technology transfer office (TTO) in universities has become an extensive institutional mechanism to support researchers findings to commercialize their products and obtaining license fees and royalties (Correa and Zuñiga 2013). TTO offers a range of services to improve technology transfer cycles, such as patent application process, licensing agreement, partner search and funding, and training and support in creating university-based spin-offs.

The lack of a team specialized in technology transfer at Hanoi University of Science and Technology is a weakness. Thus, the formation of such team to undertake the technology transfer activities is necessary, creating a better connection between Hanoi University of Science and Technology and the community.

3.5.3 Conclusion

Knowledge and technology transfer activities in Vietnam are weak, partly reflected in Figure 1.5. Therefore, the establishment of a technology transfer center will help the connection between universitiesies and businesses become closer. Especially, businesses have a low and ineffective fundings for research and development

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Figure 1.1: Knowledge and technology transfer ecosystem

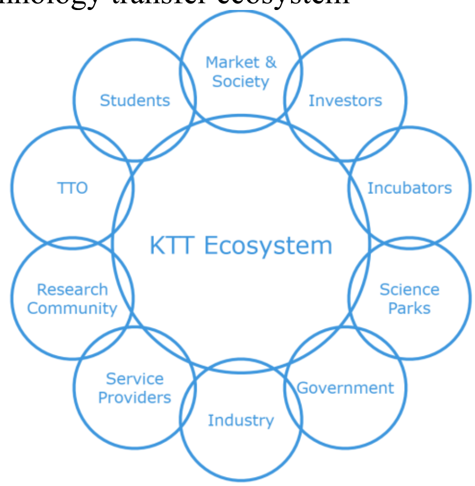

Figure 1.2: Economic development stages of Vietnam

Region	Factor-Driven Economies (Stage I)	Efficiency-Driven Economies (Stage II)	Innovation-Driven Economies (Stage III)
Africa	Botswana, Burkina Faso, Cameroon, Uganda, Egypt, Senegal	Morocco, South Africa, Tunisia	
Asia & Oceania	India, Iran, Philippines, Vietnam	China, Indonesia, Kazakhstan, Lebanon, Malaysia, Thailand	Australia, Israel, Japan, Republic of Korea, Taiwan
Latin America & Caribbean		Argentina, Barbados, Brazil, Chile, Colombia, Ecuador, Guatemala, Mexico, Panama, Peru, Uruguay	Puerto Rico
Europe		Bulgaria, Croatia, Hungary, Latvia, Poland, Romania, Macedonia, Turkey	Belgium, Estonia, Finlanc, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Slovenia, Slovakia, Spain, Switzerland, UK
North America			Canada, United States

Table 1: Economies participating in the 2015 GEM survey, grouped by geographic region and economic development level

Source : Kelleyet al(2015)- GEM 2015/16

Figure 1.3 STI capacity of Vietnam according to FRIST's assessment

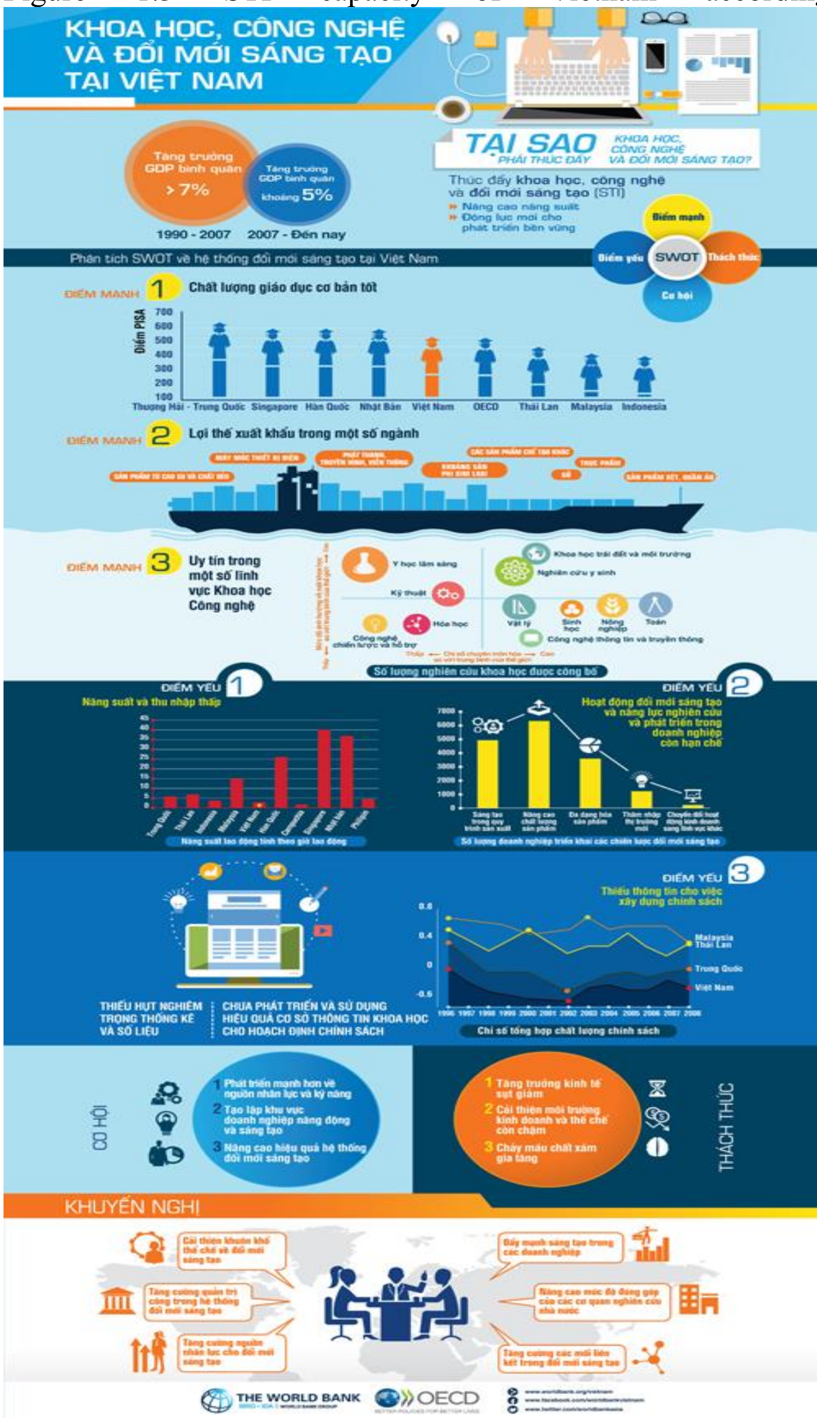

Figure 1.4: Value of technology transfer at Hanoi University of Science and Technology

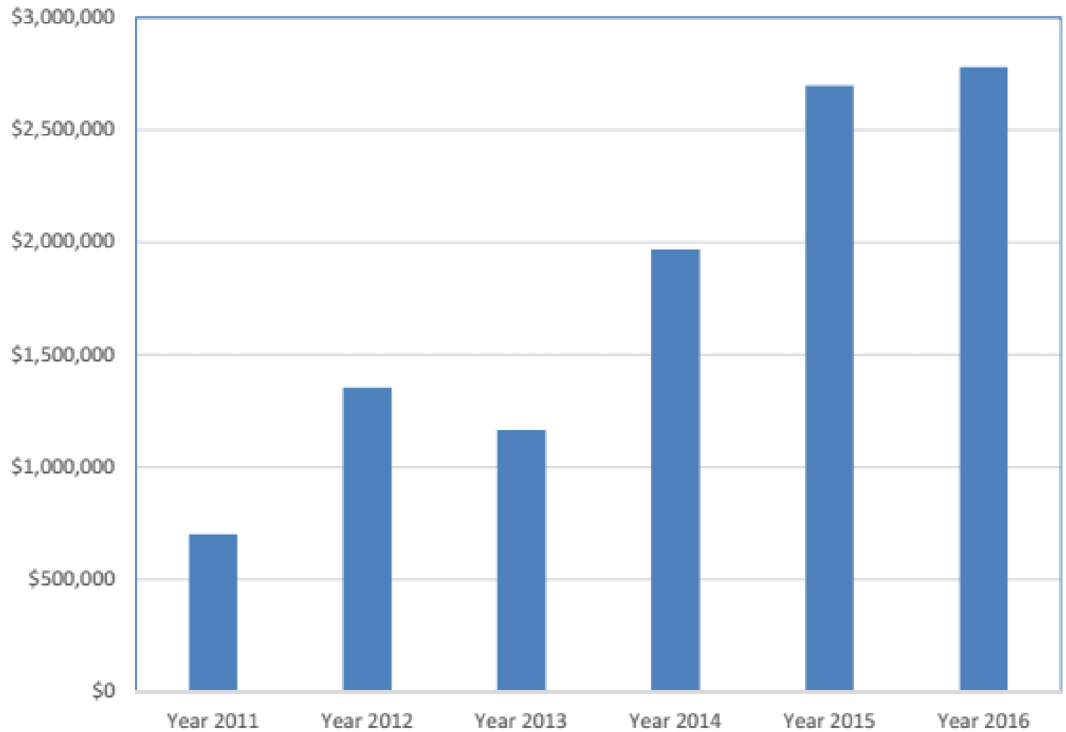

Figure 1.5: Vietnam start-up capacity

Entrpreneurial conditions	2017		2015		2013	
	Score	Ranking /54	Score	Ranking /62	Score	Ranking /69
Internal Market - Dynamics	4.15	5	3.59	11	3.50	15
Cultural and Social Norms	3.62	6	3.23	14	3.10	20
Physical Infrastructure	4.19	10	4.07	17	3.58	43
Internal Market - Openness	2.79	12	2.51	28	2.66	32
National Policy - General Policy	2.40	13	2.78	15	2.89	20
National Policy - Regulation	3.02	25	2.62	25	2.77	13
R&D transfer	2.19	34	2.33	30	2.54	20
Education - Primary & Secondary	1.83	34	1.57	47	1.97	46
Commercial Infrastructure	2.82	36	2.93	42	2.89	45
Tài chính cho kinh doanh	2.27	39	2.12	50	2.40	42
Education - Post-School	2.61	40	2.53	47	2.64	50
Governmental Programs	2.09	43	2.14	50	2.50	38

Ranking of the entrepreneurship ecosystem in Vietnam in 2013-2017 *Unit: Points 1-5*

Source : The Global Expert Survey in the period 2013-2017

Figure 1.6. Vietnam's innovation index

VIET NAM

GII 2018 rank **45**

Output rank	Input rank	Income	Region	Efficiency ratio	Population (mn)	GDP, PPP$	GDP per capita, PPP$	GII 2017 rank
41	65	Lower-middle	SEAO	16 ●	95.5	643.9	6,913.1	47

		Score/Value	Rank	Notes
	Institutions	**56.2**	**78**	
1.1	Political environment	53.1	62	◆
1.1.1	Political stability & safety*	68.5	57	◆
1.1.2	Government effectiveness*	45.4	71	◆
1.2	Regulatory environment	56.8	89	
1.2.1	Regulatory quality*	32.5	99	
1.2.2	Rule of law*	45.2	57	◆
1.2.3	Cost of redundancy dismissal, salary weeks	24.6	97	
1.3	Business environment	58.6	103	
1.3.1	Ease of starting a business*	82.0	95	
1.3.2	Ease of resolving insolvency*	35.2	107	○

		Score/Value	Rank	Notes
	Human capital & research	**30.0**	**66**	
2.1	Education	61.2	[18]	
2.1.1	Expenditure on education, % GDPⓓ	5.7	29	
2.1.2	Government funding/pupil, secondary, % GDP/cap	n/a	n/a	
2.1.3	School life expectancy, years	n/a	n/a	
2.1.4	PISA scales in reading, maths & science	502.0	20	◆
2.1.5	Pupil-teacher ratio, secondary	n/a	n/a	
2.2	Tertiary education	24.4	84	
2.2.1	Tertiary enrolment, % gross	28.3	80	
2.2.2	Graduates in science & engineering, %	22.7	44	
2.2.3	Tertiary inbound mobility, %	0.2	99	○
2.3	Research & development (R&D)	4.5	81	
2.3.1	Researchers, FTE/mn pop.ⓓ	672.1	58	
2.3.2	Gross expenditure on R&D, % GDPⓓ	0.4	66	
2.3.3	Global R&D companies, top 3, mn US$	0.0	40	○◇
2.3.4	QS university ranking, average score top 3*	0.0	78	○◇

		Score/Value	Rank	Notes
	Infrastructure	**40.4**	**78**	
3.1	Information & communication technologies (ICTs)	52.7	76	
3.1.1	ICT access*	47.5	89	
3.1.2	ICT use*	36.5	85	
3.1.3	Government's online service*	57.2	72	
3.1.4	E-participation*	69.5	43	◆
3.2	General infrastructure	38.8	57	
3.2.1	Electricity output, kWh/cap	1,671.4	84	
3.2.2	Logistics performance*	42.2	63	
3.2.3	Gross capital formation, % GDP	26.7	28	
3.3	Ecological sustainability	29.6	94	
3.3.1	GDP/unit of energy use	6.9	85	
3.3.2	Environmental performance*	47.0	103	
3.3.3	ISO 14001 environmental certificates/bn PPP$ GDP	2.3	46	◆

		Score/Value	Rank	Notes
	Market sophistication	**54.3**	**33**	◆
4.1	Credit	64.1	15	●◆
4.1.1	Ease of getting credit*	75.0	26	
4.1.2	Domestic credit to private sector, % GDP	123.8	19	●◆
4.1.3	Microfinance gross loans, % GDP	3.9	11	●◆
4.2	Investment	31.1	109	○
4.2.1	Ease of protecting minority investors*	55.0	78	
4.2.2	Market capitalization, % GDP	28.0	50	
4.2.3	Venture capital deals/bn PPP$ GDP	0.0	62	
4.3	Trade, competition, & market scale	67.7	40	◆
4.3.1	Applied tariff rate, weighted mean, %	2.9	62	
4.3.2	Intensity of local competition†	61.0	101	○
4.3.3	Domestic market scale, bn PPP$	643.9	33	

		Score/Value	Rank	Notes
	Business sophistication	**30.0**	**66**	
5.1	Knowledge workers	25.3	91	
5.1.1	Knowledge-intensive employment, %	11.0	95	
5.1.2	Firms offering formal training, % firms	22.2	69	
5.1.3	GERD performed by business, % GDPⓓ	0.3	48	◆
5.1.4	GERD financed by business, %	58.1	13	●◆
5.1.5	Females employed w/advanced degrees, %	5.8	78	
5.2	Innovation linkages	22.6	88	
5.2.1	University/industry research collaboration†	41.7	59	
5.2.2	State of cluster development†	46.2	64	
5.2.3	GERD financed by abroad, %	2.9	68	
5.2.4	JV–strategic alliance deals/bn PPP$ GDP	0.0	53	
5.2.5	Patent families 2+ offices/bn PPP$ GDP	0.0	98	○
5.3	Knowledge absorption	42.0	25	●◆
5.3.1	Intellectual property payments, % total trade	n/a	n/a	
5.3.2	High-tech net imports, % total trade	23.8	4	●◆
5.3.3	ICT services imports, % total tradeⓓ	0.0	122	○◇
5.3.4	FDI net inflows, % GDP	5.7	25	●
5.3.5	Research talent, % in business enterpriseⓓ	21.7	51	

		Score/Value	Rank	Notes
	Knowledge & technology outputs	**32.4**	**35**	◆
6.1	Knowledge creation	8.1	76	
6.1.1	Patents by origin/bn PPP$ GDP	0.9	67	
6.1.2	PCT patents by origin/bn PPP$ GDP	0.0	88	
6.1.3	Utility models by origin/bn PPP$ GDP	0.5	35	
6.1.4	Scientific & technical articles/bn PPP$ GDP	4.9	79	
6.1.5	Citable documents H index	11.3	57	
6.2	Knowledge impact	49.9	19	●◆
6.2.1	Growth rate of PPP$ GDP/worker, %	5.3	6	●
6.2.2	New businesses/th pop. 15–64	n/a	n/a	
6.2.3	Computer software spending, % GDP	0.3	45	
6.2.4	ISO 9001 quality certificates/bn PPP$ GDP	8.7	40	◆
6.2.5	High- & medium-high-tech manufactures, %ⓓ	0.2	47	
6.3	Knowledge diffusion	39.1	21	●◆
6.3.1	Intellectual property receipts, % total trade	n/a	n/a	
6.3.2	High-tech net exports, % total trade	29.9	1	●◆
6.3.3	ICT services exports, % total tradeⓓ	0.1	120	○
6.3.4	FDI net outflows, % GDP	0.6	64	

		Score/Value	Rank	Notes
	Creative outputs	**35.0**	**46**	◆
7.1	Intangible assets	46.5	49	
7.1.1	Trademarks by origin/bn PPP$ GDP	92.3	18	●
7.1.2	Industrial designs by origin/bn PPP$ GDP	3.5	37	
7.1.3	ICTs & business model creation†	56.6	80	
7.1.4	ICTs & organizational model creation†	53.3	66	
7.2	Creative goods & services	35.1	29	◆
7.2.1	Cultural & creative services exports, % total trade	n/a	n/a	
7.2.2	National feature films/mn pop. 15–69ⓓ	0.2	98	○
7.2.3	Entertainment & Media market/th pop. 15–69	1.1	56	○
7.2.4	Printing & other media, % manufacturing	1.0	59	
7.2.5	Creative goods exports, % total trade	7.2	7	●◆
7.3	Online creativity	12.1	54	◆
7.3.1	Generic top-level domains (TLDs)/th pop. 15–69	2.4	73	
7.3.2	Country-code TLDs/th pop. 15–69	1.8	70	
7.3.3	Wikipedia edits/mn pop. 15–69	7.1	70	
7.3.4	Mobile app creation/bn PPP$ GDP	39.4	16	●◆

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NOTES: ● indicates a strength; ○ a weakness; ◆ an income group strength; ◇ an income group weakness; * an index; † a survey question.
ⓓ indicates that the country's data are older than the base year; see Appendix II for details, including the year of the data, at http://globalinnovationindex.org.
Square brackets indicate that the data minimum coverage (DMC) requirements were not met at the sub-pillar or pillar level; see page 215 of this appendix for details.

340 The Global Innovation Index 2018

4. The Researcher

4.1 Individual Incentives

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In emerging economies, university-industry collaborations (UIC) are considered an important instrument to stimulate economic growth and thus governments actively encourage partnerships with universities to boost innovation in companies (Guerrero, Urbano, and Herrera 2017) . Universities in advanced economies are not only involved in their primary missions of education activities and generation of new knowledge, but also develop the "third mission" to transfer academic knowledge and research results (Perkmann et al. 2013). In the recent years, universities in emerging economies have been starting to implement this "third mission" in their agenda and setting up a structural procedure for knowledge and technology transfer. From the university side, an emergence of collaborations with industry is often depend on individual decisions of academic researchers who have necessary knowledge. The changing role of the university impacts academics' activities and increase expectations. It could be challenging especially at the early stage to change a mindset of academics. Therefore, it is crucial to understand why academics engage in such collaborations and what university management can do to support them.

4.1.1 University-Industry Collaborations (UIC)

Knowledge is a main driver for economic growth. The motivation of one organization to use the knowledge resources of another party to "explore new ideas or exploit existing capabilities" drives the emergence of inter-organizational collaborations (Bierly, Damanpour, and Santoro 2009). Thus, governments introduce policies and incentives to accelerate creation and exchange of knowledge. UIC are considered an important instrument to facilitate the knowledge flow and the exploitation of knowledge (Mueller 2006). UIC can be defined as: "University-industry collaboration refers to the interaction between any parts of the higher educational system and industry aiming mainly to encourage knowledge and technology exchange" (S. Ankrah and AL-Tabbaa 2015, p.387).

One of the main goals of universities is to generate new original knowledge and new approaches to problem solving (Debackere and Veugelers 2005; Mueller 2006; Perkmann et al. 2013). Universities that exploit their complementary knowledge between teaching and research can become strong players on the market (Debackere and Veugelers 2005). Universities can offer advanced knowledge, specific skills and educated graduates. Additionally, universities support the exploration and exploitation of innovative and entrepreneurial ideas by building productive knowledge-intensive environments (Guerrero, Urbano, and Herrera 2017).

There are different UIC types. The commercialization of academic knowledge involves patenting and licensing of research results or creating a new spin-off (Perkmann et al. 2013). Academic engagement is another way to transfer research results that includes formal and informal activities. Perkmann et al. (2013) highlight the importance of individual academic engagement, i.e. "knowledge-related collaboration by academic researchers with non-academic organizations" (Perkmann et al. 2013) in this context. Formal collaborations take on the form of joint research, contract research, consulting or training while advising and networking are considered to be informal interactions (D'Este and Patel 2007; Perkmann et al. 2013).

4.1.2 Why do academics engage in KTT

Academic researchers are the key actors in initiating and sustaining the collaboration process with industry. Researchers possess tacit knowledge that cannot easily be transferred as explicit knowledge without their involvement. "Explicit" or codified knowledge refers to knowledge that is transmittable in formal, systematic language. On the other hand, "tacit" knowledge has a personal quality, which makes it hard to formalize and communicate (Grant 1996). "Tacit knowledge is deeply rooted in action, commitment, and involvement in a specific context" (Novaka, 1994, p.16). Explicit knowledge is easier to transfer through patents, licensing etc., while a transfer of tacit knowledge is more costly and challenging and need involvement of key knowledge holders (Grant and Baden-Fuller 2004).

There are different motives that can drive academic researchers to engage in UIC. Lee (2000) conducted a survey among faculty members of US universities and identified the availability of funds for graduate students and equipment, the enhancement of research and the possibility to test practical applications of research results as the main motivations of academics to collaborate with industry (Lee 2000). Arvanitis et al. (2008) grouped motivations in four main categories: "access to industrial knowledge; access to additional resources; institutional or organizational motives; pursuing higher research efficiency – cost and time savings; access to specialized technology" (Arvanitis et al., 2008, p.1869). Arvanitis et al. (2008) also found that motives of researchers such as an access to companies' knowledge and specialized technologies are positively correlated with the propensity to collaborative research activities. Similarly, D'Este and Perkmann (2011) find the most of university researchers engage in UIC to advance their research rather than to commercialize academic knowledge (D'Este and Perkmann 2011). From the strategical point of view, partnerships between university and industry might be created to learn or acquire new external knowledge, absorb this knowledge, regenerate technologically and develop innovation (Guerrero, Urbano & Herrera, 2017).

One of the most comprehensive lists of motivations for universities and industry from the current literature was collected by Ankrah & AL-Tabbaa (2015) (see Table 1). The authors grouped these motivations in six categories: necessity, reciprocity, efficiency, stability, legitimacy and asymmetry (Ankrah & AL-Tabbaa, 2015; Oliver, 1990). Both parties have some similar motivations in the "necessity" group such as government initiatives, institutional policy and necessity to retain a competitive advantage in a knowledge based economy. In terms of reciprocity, universities look for employment possibilities for their graduates and want to gain an access to state-of-the art equipment and facilities. At the same time, companies search among students for new qualified employees for internships and permanent jobs. Companies also hire faculty members to solve specific problems. Collaborations with university may save costs to access knowledge directly at universities instead of obtaining a license to exploit oversees technologies. Additionally, universities want to have business opportunities to exploit research results. Risk reduction or risk sharing plays an important role in initiating collaborations. Although corporate image is important for companies, the legitimation pressure from society and government on Universities is much higher. The asymmetry group does not apply to university, but companies want to maintain control over their proprietary knowledge and technologies.

Table 1
Motivations for universities and industry: a comparison

	University	Industry
Necessity	Responsiveness to government policy Strategic institutional policy	Responsiveness to government policy Strategic institutional policy
Reciprocity	Access complementary expertise, state-of-the-art equipment and facilities Employment opportunities for university graduates	Access to students for summer internship or hiring Hiring of faculty members
Efficiency	Access funding for research (Government grant for research and Industrial funding for research assistance, lab equipment, etc.) Business opportunity, e.g. exploitation of research capabilities and results or deployment of IPR to obtain patents Personal financial gain for academics	Commercialize university-based technologies for financial gain Benefit financially from serendipitous research results Costs savings (easier and cheaper than to obtain a license to exploit foreign technology) National incentives for developing such relations such as tax exemptions and grants Enhance the technological capability and economic competitiveness of firms Shortening product life cycle Human capital development
Stability	Shift in knowledge-based economy (growth in new knowledge)Discover new knowledge/test application of theory Obtain better insights into curricular development Expose students and faculty to practical problems/applied technologies Publication papers	Shift in knowledge-based economy (growth in new knowledge) Business growth Access new knowledge, cutting edge technologies, state-of-the-art expertise/ research facilities and complementary know-how Multidisciplinary character of leading edge technologies Access to research networks or pre-cursor to other collaborations Solutions to specific problems Subcontract R&D (for example due to the lack of in-house R&D) Risk reduction or sharing
Legitimacy	Societal pressure Service to the industrial community/society Promote innovation (through technology exchange)	Enhancement of corporate image

	University	Industry
	Contribute to regional or national economy Academics' quest for recognition or achieve eminence	
Asymmetry	N/A	Maintain control over proprietary technology

Source: Ankrah & AL-Tabbaa, 2015, p.392

4.1.3 Tension field between the three missions

Some decades ago, European universities introduced a new role to their agenda to provide service to society. Universities added the third mission to valorize research results and bring these knowledge and technology to society. An introduction of a new mission increased requirements for academics who were primarily involved in teaching and research activities. To make this transition, the reward system of universities was reviewed and adapted. Universities developed clear regulations on a process of KTT. The researchers receive necessary training and support from the university and TTO.

The transfer of academic knowledge is high on the political agenda in emerging economies. Academics' motivation, incentive system, leadership and support from university managers are important factors that affect collaborations with industry from the university side (Schofield 2013). Universities should provide necessary support for researchers and create an environment where academics would be motivated to engage in KTT activities.

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4.2 From Researcher to Academic Entrepreneur

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How do scientists become entrepreneurs? That's a question that many researchers tried to answer taking different perspectives and influencing factors into consideration. In this chapter we aim to give a broad overview of some of the concepts that were already discussed in literature and help us to better understand the phenomena when scientists enter the business world.

When taking a look at the development of researchers into entrepreneurs, several aspects have to be taken into consideration. The following figure summarizes these different aspects, which are, (1) the development of an opportunity, (2) the researcher's knowledge network (3) the individual, (4) the context,

In the field of (1) the development of entrepreneurial opportunities, several steps have to be taken into consideration. Literature starts by identifying the sources of opportunities, i.e. technological, political, regulatory or socio-demographic changes (Shane, 2003a). Changes create

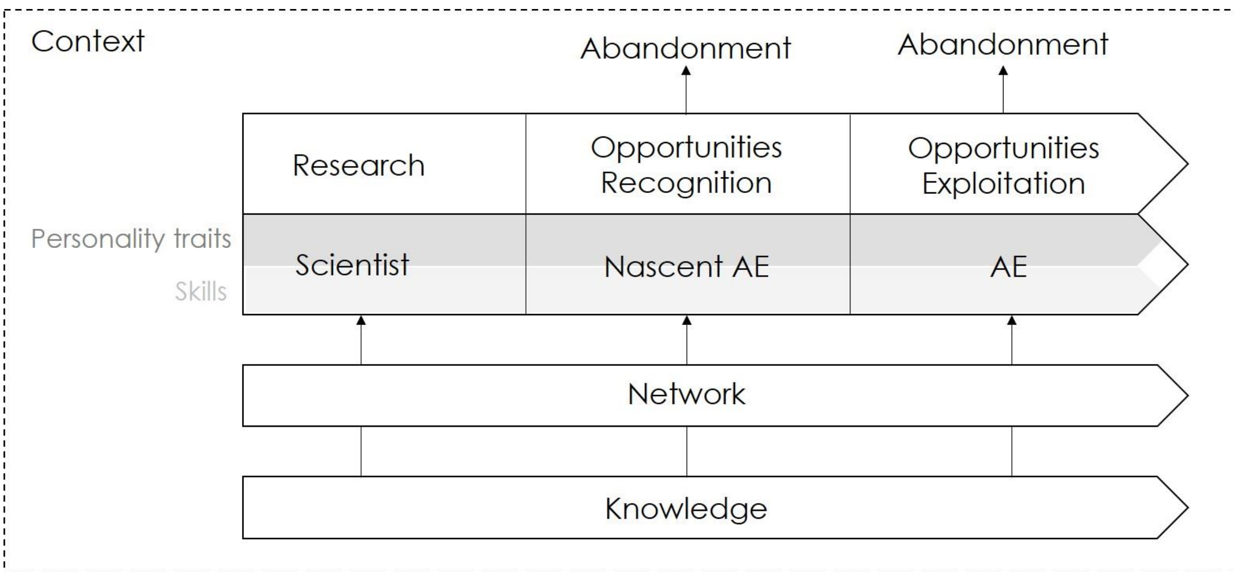

Figure 1 Integrative Framework.

new product/service opportunities in the market.

Regarding the identification of opportunities, several authors stress the importance of social networks (Companys & McMullen, 2007; Shane, 2003a; Wood & McKinley, 2010). Strongly connected to these social networks, and equally crucial to the identification of opportunities is the development and exchange of knowledge and information (Companys & McMullen, 2007; Shane, 2003a; Wright, Clarysse, & Mosey, 2012; Zahra, 2008). An academic researcher can access knowledge in different ways. He/she can access explicit knowledge (journal papers, theses, lab notebooks, etc.) or access tacit knowledge through interpersonal interaction. The sum of all inter-personal interactions of a researcher is his or her networks.

Findings show that network and knowledge resources are crucial from the initial stages of research in order to identify entrepreneurial opportunities in the own research field. Phelps, Heidl, & Wadhwa (2012) combined the configuration and characteristics of networks and the access to non-redundant knowledge into a concept defined as (2) 'knowledge network', i.e: "a set of nodes - individuals […] that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge - interconnected by social relationships".

This means that those key resources have to be searched, structured and bundled from the very beginning and form the basis for further development (Wright et al., 2012). The last aspect of entrepreneurial opportunities is the possibility of abandonment as presented by (Wood & McKinley, 2010). According to the authors, it is possible to either abandon an opportunity after it was recognized or even after the exploitation. In both cases, the abandoned idea, which is anyhow considered as an important experience, can be the starting point for future ideas.

With regard to (3) the individual Fini, Grimaldi, Marzocchi, & Sobrero (2010) investigated the causes of entrepreneurial activities, in newly established firms and found out that these entrepreneurial causes "are often nurtured by their founders' skills, knowledge, creativity, imagination, and alertness to opportunities" (Fini et al. 2010, p.388). These results show that a combination of individual skills and psychological factors support the identification as well as the exploitation of entrepreneurial opportunities. Skills comprise the search and interpretation of new information, the imagination of a real future, meaning to have a vision, as well as entrepreneurial alertness, meaning the ability to identify and exploit imperfections in the competitive market with the goal of earning profits, and absorptive capacity, which describes the ability to recognize the value of information and apply it to commercial ends (Companys & McMullen, 2007; Frese & Gielnik, 2014; Shane, 2003b; Wood & McKinley, 2010). Skills can be developed over time through training or on-hands experiences. Witnessing the development of an idea from the lab to its exploitation helps to enlarge the researcher's set of skills. The development of the needed skills goes in parallel with the development of the opportunity since each step requires different skills. Whereas the beginning is very much focused on research-related skills, the identification and exploitation require more business-related skills and also the willingness to get in contact with possible stakeholders and future team members. Active networking is crucial for the successful exploitation.

Psychological factors refer to one's personality and remain stable over time. Those include e.g. extraversion, overconfidence, self-efficacy or risk-taking. When it comes to the decision of opportunity exploitation or abandonment, human agency and psychological characteristics of the entrepreneur are important factors (Shane, 2003c). Particularly supportive for the exploitation are extroverted and outgoing personality traits, a strong need for achievement, desire for independence and overconfidence, because those help to follow an opportunity or idea in a very uncertain and risky situation (Antoncic, Kregar, Singh, & DeNoble, 2015; Frese & Gielnik, 2014; O'Shea, 2007; Shane, 2003b). However, despite the entrepreneurial mindset and the needed skills, motivation is the driving force whether a researcher actively pursues entrepreneurial activity or not. Without the right motivation, even a "text-book-entrepreneur" will not be successful.

(4) The working context impacts the development of skills and thus the development from a researcher into an academic entrepreneur (Fini, Grimaldi, & Meoli, 2018). The literature shows evidence that since entrepreneurial strategies are embedded within the overall mission of universities, commercialisation activities increase (D'Este, Mahdi, Neely, & Rentocchini, 2012; Grimaldi, Kenney, Siegel, & Wright, 2011). This is not surprising since the TTOs' role is to actively

assist researchers in their willingness to commercialise research results. Moreover, a strongly embedded strategy will sharpen the awareness of commercialization opportunities among researchers. However, even though entrepreneurial orientation is often already part of the overall university strategy, the efficiency of TTOs regarding the enhancement of commercial activities at the university has recently been questioned in the literature (Clarysse, Tartari, & Salter, 2011; Rasmussen & Wright, 2015; Riviezzo, Santos, Liñán, Napolitano, & Fusco, 2018). More specifically, the literature has shown evidence that the overall institutional influence at a management level, i.e., the activities of TTOs, on researchers' entrepreneurial engagement is marginal. Researchers have seen the causes for this marginal influence in an insufficient ability to attract new entrepreneurial researchers and develop entrepreneurial training that reaches new researchers or to arouse entrepreneurial interest in them. Until now, TTOs have focused on assisting those researchers who already chosen the entrepreneurial pathway and are seeking help in the exploitation of their entrepreneurial ideas (Clarysse et al., 2011; Rasmussen & Wright, 2015).

Bercovitz & Feldman (2008) investigated this departmental influence from the perspective of a chair's vision (leadership effect). Their findings indicate that researchers tend to follow and imitate the activities of a departmental leader and act according to his or her example and promoted vision, because it establishes a feeling of belonging (Bercovitz & Feldman, 2008). Having a departmental chair who exploits entrepreneurial ideas through patents, licenses, contract research or the creation of spin-offs, among other things, gives other researchers the opportunity to savour and witness the benefits of commercialization.

Key Take-Aways from this chapter:

1. What is the most important must-have characteristic to become an entrepreneur?
2. Why do entrepreneurs need a social network?
3. What is the role of the TTO in comparison to the departmental leader when pursuing an entrepreneurial opportunity?

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4.3 Entrepreneurship Education – Turning scientists into entrepreneurs

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In the context of this chapter, entrepreneurship education, is understood as any course, program, workshop or activity organized with the goal to teach entrepreneurial competences and provide practical knowledge on how to launch a start-up. We can argue that entrepreneurship education (e-education) is a contradiction in terms, because educational institutions suppress entrepreneurial competences such as curiosity, creativity, independence and non-conformity. Most universities prepare students for a corporate life and therefore focus on creating the perfect employees instead of entrepreneurs. If on top of that we look at very scientific university profiles it becomes quickly clear that they completely lack entrepreneurial competences, skills and mind sets. A scientist typically 'knows everything about nothing', whereas an entrepreneur needs 'to know nothing about everything'. (How) can universities turn scientists in entrepreneurs? What skills and competences should they focus on and what are the best methods to practically achieve this? In this section we mainly try to answer these questions and provide universities with concrete tools, examples and further reading.

4.3.1 The need for entrepreneurship education

Entrepreneurship is more and more considered to be the engine for innovation, meaningful impact and economic growth. Entrepreneurs identify opportunities and turn them into value for society. Not only by launching startups but also by innovating and changing processes within existing structures and organizations. Entrepreneurs are the engine of 'creative destruction' as described by Joseph Aloïs Schumpeter[1]: '*The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates. (…) This process of industrial mutation (…) incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism.*'

But it is not evident to continuously keep reinventing and improving the old as has been shown by the European innovation paradox: there is an increase in innovation, education and R&D spending, but this does not translate in the creation of new companies or jobs.[2] On top of that the challenges we face as a society (such as climate change, inequality, poverty, healthcare, etc.) can only partly be solved by entrepreneurial minds and people that take the initiative and have the skills and resources to solve these problems.

To try and solve this issue, new university models arise, creating more curious, independent and therefore entrepreneurial students, such as Code in Berlin[3]. There is an explosion in the number of entrepreneurship courses and programs in universities across the world and policy-makers are increasingly investing in entrepreneurship education. However, there is mixed evidence on the actual impact and sense of entrepreneurship education.

4.3.2 (How) does entrepreneurship education work?

From a theoretical point of view there is no consensus yet on exactly how entrepreneurship education can enhance entrepreneurship. Several angles are commonly explored (non-exhaustive) (Rideout & Gray, 2013): (1) education as a motivator for career choices (of which entrepreneurship can be one), (2) lack of knowledge and understanding of how-to set-up a business is perceived as a large obstacle to entrepreneurship, (3) enhancement in self-belief and self-efficacy of individuals to increase entrepreneurship outcomes, (4) entrepreneurial intentions as a precursor of entrepreneurial behavior, which can be enhanced by education. The systematic review from Rideout & Gray shows there is enough evidence to support the statement that e-education can enhance entrepreneurial self-belief and behavior, even though one study concluded that e-education has a negative effect on entrepreneurial intentions.

Even though more research clearly is needed, it seems reasonable to assume that based on current evidence e-education has the potential to have a positive impact on technological entrepreneurship. The exact extent of the impact of these different types of e-education on the actual creation of new (technological) start-ups is still unclear.

The next questions we need to answer is which competences make a good entrepreneur and what we should focus on when developing an entrepreneurship course or educational program?

4.3.3 Entrepreneurial competences

To develop courses, programs and curricula for e-education it is not only important to provide practical knowledge such as 'how to set-up and manage a business', but also to identify and develop the competences that make entrepreneurs instead of employees. Competences are broad and complex and are defined as the skills needed to successfully or efficiently do something. In the context of entrepreneurship this can be defined as the successful identification of opportunities and mobilization of resources to create value (which can be in the form of a new business) from these opportunities. Not all competences can be attained through education, but the goal of e-education should be the development of the necessary entrepreneurial competences in potential entrepreneurs that lack some or all these competences.

Since 2016 the European Commission has developed the European Entrepreneurship Competence Framework (EntreComp), to '*help Europe become an entrepreneurial society'*. EntreComp can be applied on all levels of society and looks at entrepreneurship in its broadest form. This however doesn't mean it cannot be applied to turn scientists into entrepreneurs.

Two other frameworks that summarize entrepreneurial competences are – the *entrepreneurial competencies model* and *the great eight model*. Gianesini et al. summarizes these three frameworks and structures them into 3 major categories: (1) identification and development of **ideas,** (2) mobilization of and access to the right **resources,** & (3) planning, adapting and taking the right **actions**. Additionally, they propose to type each competence as either **knowledge, skills or personality**. (Gianesini, Cubico, Favretto, & Leitão, 2018)

An advantage of EntreComp is that they identified 15 competences (*ie. spotting opportunities, creativity, vision, valuing ideas, ethical and sustainable thinking, self-awareness & self-efficacy, motivation & perseverance, mobilizing resources, financial and economic literacy, mobilizing others, taking the initiative, planning & management, coping with ambiguity, uncertainty & risk, working with others & learning through experience*), and translated them in 442 learning outcomes. EntreComp has a broader application field than for e-education alone, but in this context, it can be used to "*Tailor entrepreneurial learning outcomes to a specific context, create new or enhance existing teaching and learning activities to develop entrepreneurial competences & design assessment of entrepreneurial learning"* (McCallum, Weicht, McMullan, Price, 2018).

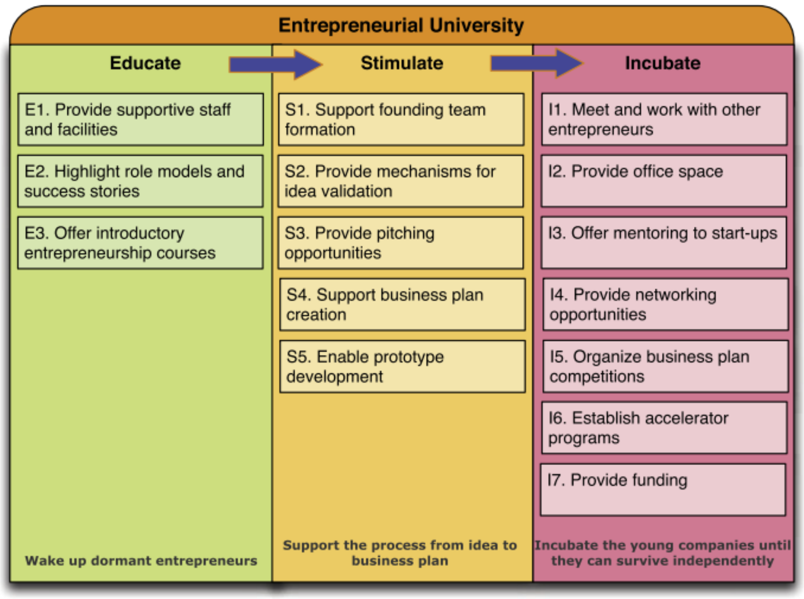

Figure 2: three stage Student Entrepreneurship Encouragement Model (SEEM), taken from Jansen et al. 2015

4.3.4 Concrete implementation

University level

Initially e-education was mostly the prerogative of business schools and business programs. However, we observe that e-education is increasingly demanded and implemented in other faculties and fields, such as engineering, soft sciences & arts. Additionally, universities should not only focus on their students, but also on their research and teaching staff to implement entrepreneurial competences across the entire university spectrum. We advise the creation of a high-level entrepreneurship management position within the university, responsible for the dissemination of e-education and entrepreneurial culture for all faculties and staff. This is one the steps needed to become a true entrepreneurial university, which can be a broader goal than just providing e-education. There exists an accreditation for entrepreneurial and engaged universities that also provides tools to analyze the current entrepreneurial level of your institution both in educational and management terms.[4]

To support entrepreneurship in academic environments Slinger et al. proposed the three-stage Student Entrepreneurship Encouragement Model (SEEM) based on a literature review and three case studies at Entrepreneurial Universities in the USA, Netherlands and India (Jansen, van de Zande, Brinkkemper, Stam, & Varma, 2015). They identified 15 activities divided over 3 stages: Education, Stimulation and Incubation (***Error! Reference source not found.***).

We observe again in this framework that e-education should not be limited to theoretical courses but should also have an active stimulating and experience-based approach. In the end the best learnings, skills and competences come from experience. Therefore, it is equally important to develop real life cases, workshops and even incubation programs when designing your e-entrepreneurship approach.

Individual course level

Most e-education courses aren't developed based on any theoretical frameworks and strongly rely on practical modalities, such as the development of a business plan or model. Commonly there are 2 very varying approaches: (1) working on a small firm business case or (2) working on a larger growth-oriented technological venture example. The reader should keep in mind that it is more likely that scientists will work on growth oriented technological entrepreneurship and any e-education targeted at scientist should be adapted accordingly. Typical elements that can be included are product/prototype development, business modelling, lean start-up, intellectual property, venture capital, strategic thinking and partnerships, team formation, product-solution & product-market fit, networking, etc.

A lot of courses and programs use traditional lecture-based teaching methods, complemented with an occasional workshop and guest-speaker. We encourage the development of hands-on courses where students get more real-life experience. A good example is the *technological business development project* at the Vrije Universiteit Brussel. For this course we form multidisciplinary teams, mixing business profiles with scientific/engineering profiles. The teams then tackle a real business development need/question of a research team at the university. The firsts semester is focused on desk research and the second semester on active field research, given the teams real-life business development experience. The outcomes of this course have been applied in multiple spin-off companies from the VUB.

A typical mistake scientist (and other aspiring entrepreneurs) make is to focus too much on the technology and not enough on the customer and his need. At the end of the day you will only be able to successfully valorize your technology if you solve a real pain of your customer.

As a final point, we want to mention that it's not possible to turn every scientist into an entrepreneur. As we have shown it takes a broad area of competences to be a successful entrepreneur and turn ideas into the right action using the right resources. Not all these competences can be thought and there is often a good reason that a scientist chose to be a scientist. It's equally important to point out the limitations of scientist and to emphasize the need to find complementary founding members. In the specific case of scientist, it makes sense to team up with a business/entrepreneurial oriented person. This is the reason why multidisciplinary courses and cases are important, such as in *technological business development project.*

One of the main things we aspire to achieve with our Starter Seminars[5], a successful and popular extra-curricular entrepreneurship program aimed at scientists, is to point out the broad range of skills and resources needed to launch a technology start-up. In the end we want to '*change the cogwheels in the back of their head*' and give scientist the feeling that they at least '*know what they don't know'*, before launching their own technological venture.

Questions:

What are the main competences that make entrepreneurs?

How do you best acquire those competences?

How could you implement a program to turn scientists into entrepreneurs at your higher education institution? Which tools are available to develop a new course or program?

What are the main differences between a scientist and an entrepreneur?

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Footnotes

1. SCHUMPETER, J. (1942), Capitalism, Socialism and Democracy, quote adapted by the author.
2. The European innovation paradox was first mentioned in a European Commission Green paper in 1995 - http://europa.eu/documents/comm/green_papers/pdf/com95_688_en.pdf
3. Code in Berlin is a new kind of university for the digital pioneers of tomorrow. More information: https://code.berlin/en/.
4. Accreditation council for entrepreneurial and engaged Universities - https://www.aceeu.org/
5. https://www.vub.be/events/2019/why-not-start-now-vub-starter-seminars-2019

4.4 Individual Incentives in Vietnam

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Governments in emerging economies promote university-industry collaborations as an important source of innovation and economic growth. A focus of our research is on individual academic researchers because they play a crucial role in initiating and supporting collaborations with companies. We investigate reasons why academic researchers in Vietnam engage in university-industry collaborations and what are the main barriers for academics who are not engaged in such collaborations. To answer these questions, we collected a survey among Vietnamese researchers.

4.4.1 Vietnamese context

There are specific aspects of countries such as levels of economic development, higher education systems etc. that influence university-industry collaborations (Perkmann et al. 2013). Therefore, it is necessary to analyze these patterns in a particular setting.

This chapter focuses on academic researchers in Vietnam. With an average annual GDP growth of 7%, the recent slowdown in the growth in Vietnam highlights the necessity for more innovation to boost the economy (The World Bank, 2014). Scientific community in Vietnam specializes in fields such as: science and technology, agricultural research and biology. Vietnam has substantial labor force and the government makes considerable national education efforts. These factors create an opportunity for further development of the country. Vietnam is attractive for multinational companies' investments (The World Bank, 2014). However, there are some points that need attention. Vietnam is still lacking in the production of fundamental research and transformation of these research results into technological innovation (Santarelli & Tran, 2016). Research infrastructure at universities is weak and the performance of public-sector research and teaching system should be improved (The World Bank 2014).

Knowledge and technology transfer development features in the development strategy for higher education in Vietnam (Decision No. 711/QD-TTg, 2012). Government R&D expenditures increase every year, but account only for 0,37% of GDP in 2013 (The World Bank 2014). At the same time, due to the high costs of R&D activities, SMEs do not have enough financial resources to afford their internal R&D (Santarelli and Tran 2016). The Ministry of Education and Training set up reforms to give full autonomy to universities by 2020 (Hayden and Lam 2007; Harman et al. 2010). At the moment, 23 Vietnamese public universities have become autonomous. The current transformation of the higher educational system changes the universities' agenda and increases the need for collaboration with industries.

In Vietnam, linkages between universities and industry are still weak. Vietnamese companies' R&D expenditures is limited and represent only around 3% of the public research funding (The World Bank, 2014). The major focus of science, technology and innovation reforms in Vietnam is on facilitating the exchange of knowledge between universities, public research institutions and companies (The World Bank, 2014). Thus, it is important to understand what drives academics to engage in UIC in Vietnam.

Differences in regional technological specialization in developing countries should be taken into account in exploring university-industry collaborations (Filippetti and Savona 2017).

4.4.2 Data collection

To test our hypothesis, we developed a questionnaire to collect data on interactions of Vietnamese academic researchers with industry. An online survey was sent by email & successfully delivered to a random sample of 4808 academics from all faculties at the six main public research-oriented universities in different regions in Vietnam from May 2018 to May 2019. We received 265 fully-completed questionnaires and 34 questionnaires partial responses (>50%) which could be useful for analysis. The total response rate was more than 6%. The information from this survey is self-reported.

The questionnaire includes general questions related to the academics' individual background and academic experience. We used two steps selection model. Based on academics' previous experience with university-industry collaborations, we divide respondents into two groups: one group with university-industry collaborations experience and the other group without university-industry collaborations experience.

For the group with experience in university-industry collaborations, we include questions on collaboration initiation, frequency of interactions with industry and main channels of collaborations. We ask for prior personal contacts with the company involved in a collaboration. To identify the most important drivers of academic engagement, we ask our respondents to rank the motivations to engage in university-industry collaborations from the systematic literature review on university-industry collaborations by Ankrah & AL-Tabbaa (2015, p.392). The list of motivations includes not only individual factors, but also organizational and institutional factors that influence academic engagement (Perkmann et al., 2013, p.430). Respondents rank these factors in a five-point Likert scale.

For the respondent group without experience in university-industry collaborations, we ask for the reasons as to why they were not engaged in UIC and rank the potential motivations on a five-point Likert scale.

4.4.3 Results

The detailed academic profiles of participants are presented in the Table 1. The respondents were asked to choose their current academic position. Lectures accounts for 50% of all population. This is a normal distribution due to the reason that lectures are usually represent the main part of university's staff in Vietnam in general.

Table 1. Academic profiles of the respondents

Position	Number of respondents, total = 265	Male	Female	PhD	Master	Bachelor	Other	MEAN age	STDEV age	MEAN academic experience	STDEV academic experience
Lecture	134	47%	53%	51%	46%	0%	2%	37	7	12	7
Academic Leader (Rector, Vice-rector, Dean, Head of Department)	52	73%	27%	71%	25%	2%	2%	43	12	19	6
Professor/ Associate Professor	36	78%	22%	94%	0%	0%	6%	46	9	21	10
Research Group Leader/ Senior Researcher/ Junior Researcher	21	67%	33%	52%	43%	0%	5%	36	9	12	10
Administrative staff & Other	22	55%	45%	23%	73%	5%	0%	38	7	12	7

The total gender distribution of the respondents was 58% male and 42% female (Firgure1).

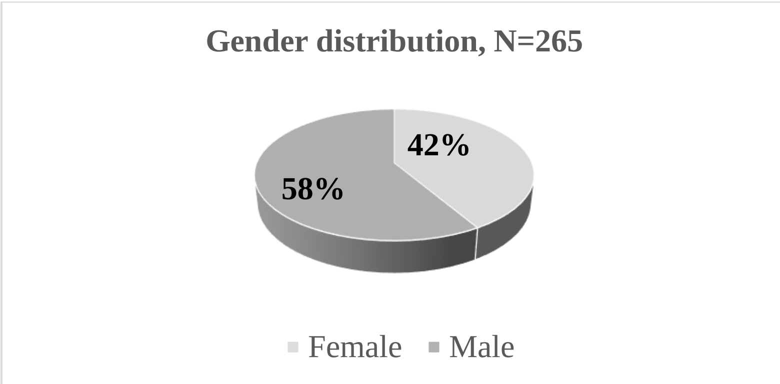

Figure 1. Gender distribution

Regarding scientific areas, participants were almost equal distributed among the three areas: life science & biomedicine, Technology and Social Sciences (Figure 2). While physical sciences accounts only for 10% of the participants.

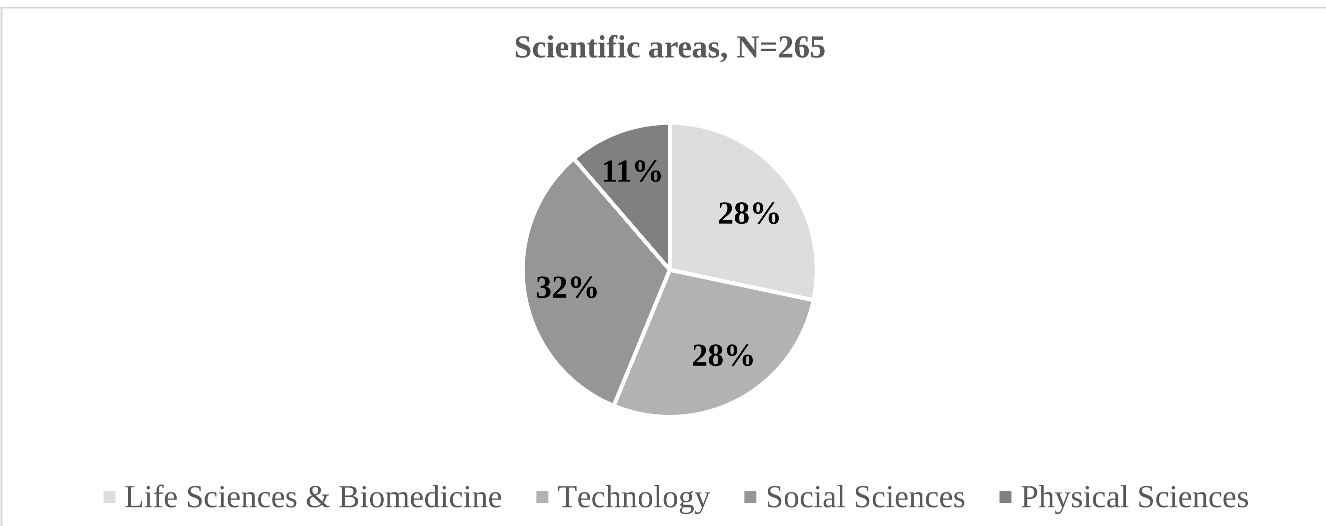

Figure 2. Scientific areas distribution

Only 59 academics (22%) who participated in the questionnaire had no collaboration experience (Figure 3). A half of respondents had from 1 to 5 collaborations with companies.

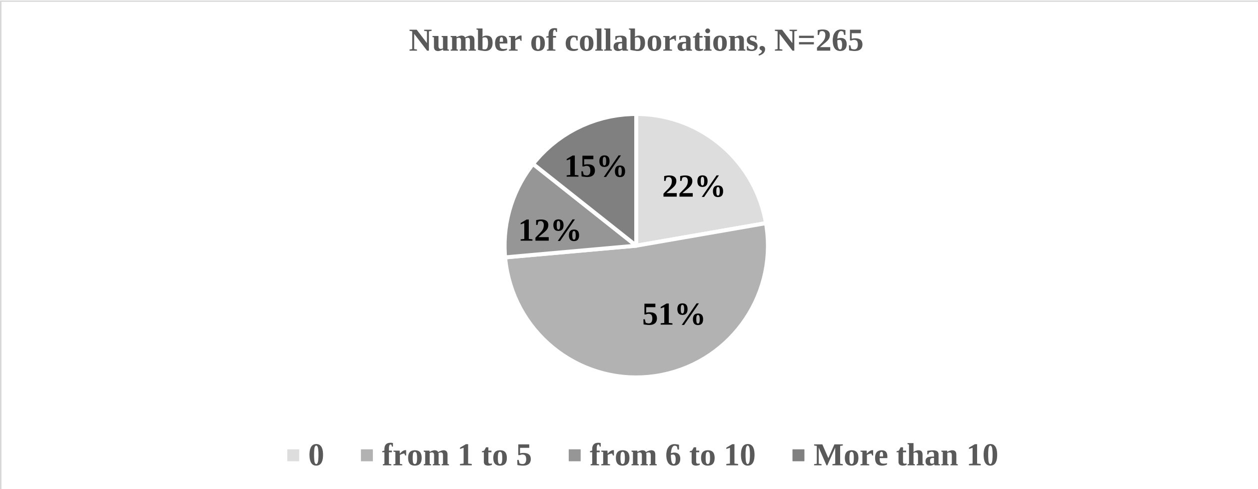

Figure 3. Academics and Experience in UIC

The respondents mainly participated in the following types of UIC: collaborative research to transfer university knowledge to industry, student placement to industry, consulting and contract research to solve a specific industry problem. In other words, universities were primarily involved in exploitation activities rather than exploration of new knowledge and technologies with an industry.

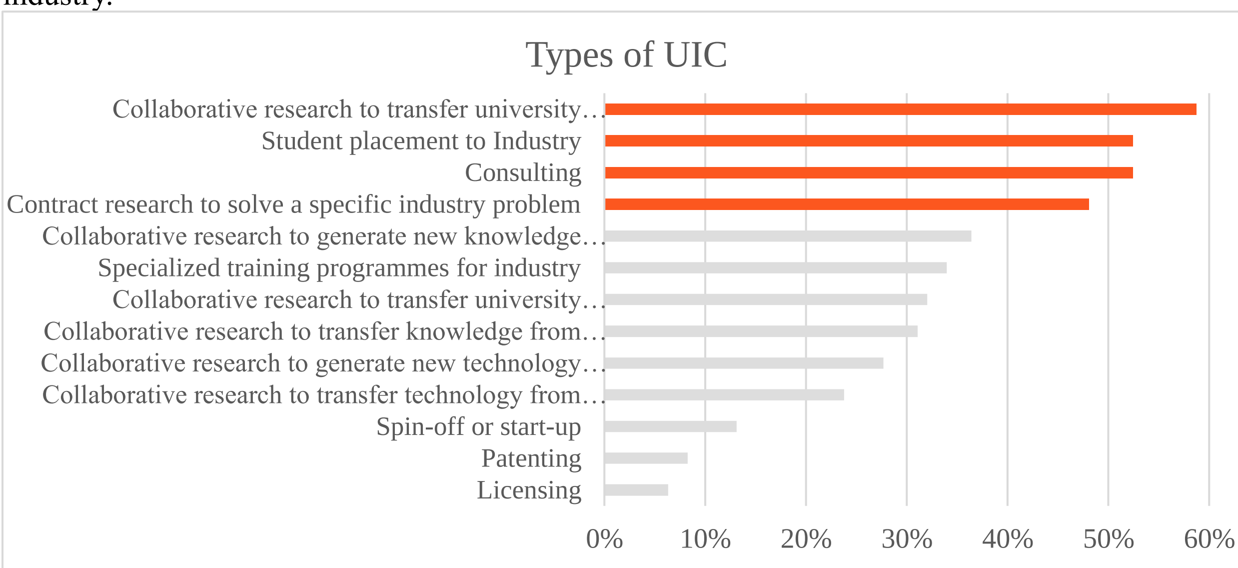

Figure 4. Types of UIC

Academics who were involved in UIC (N=206) were primarily motivated by *exposure of students and faculty to practical problems/ applied technologies; access complementary expertise, knowledge; Business opportunity – exploitation of research capabilities and results; access funding for research (Figure 5)*. University policy was not ranked among the top factors that motivated these academics to engage in UIC. The respondents found government policy is one of the least important factors. Therefore, existing government policies and reforms could be not efficient enough to have an impact on the individual decisions of academics in Vietnam to engage in UIC.

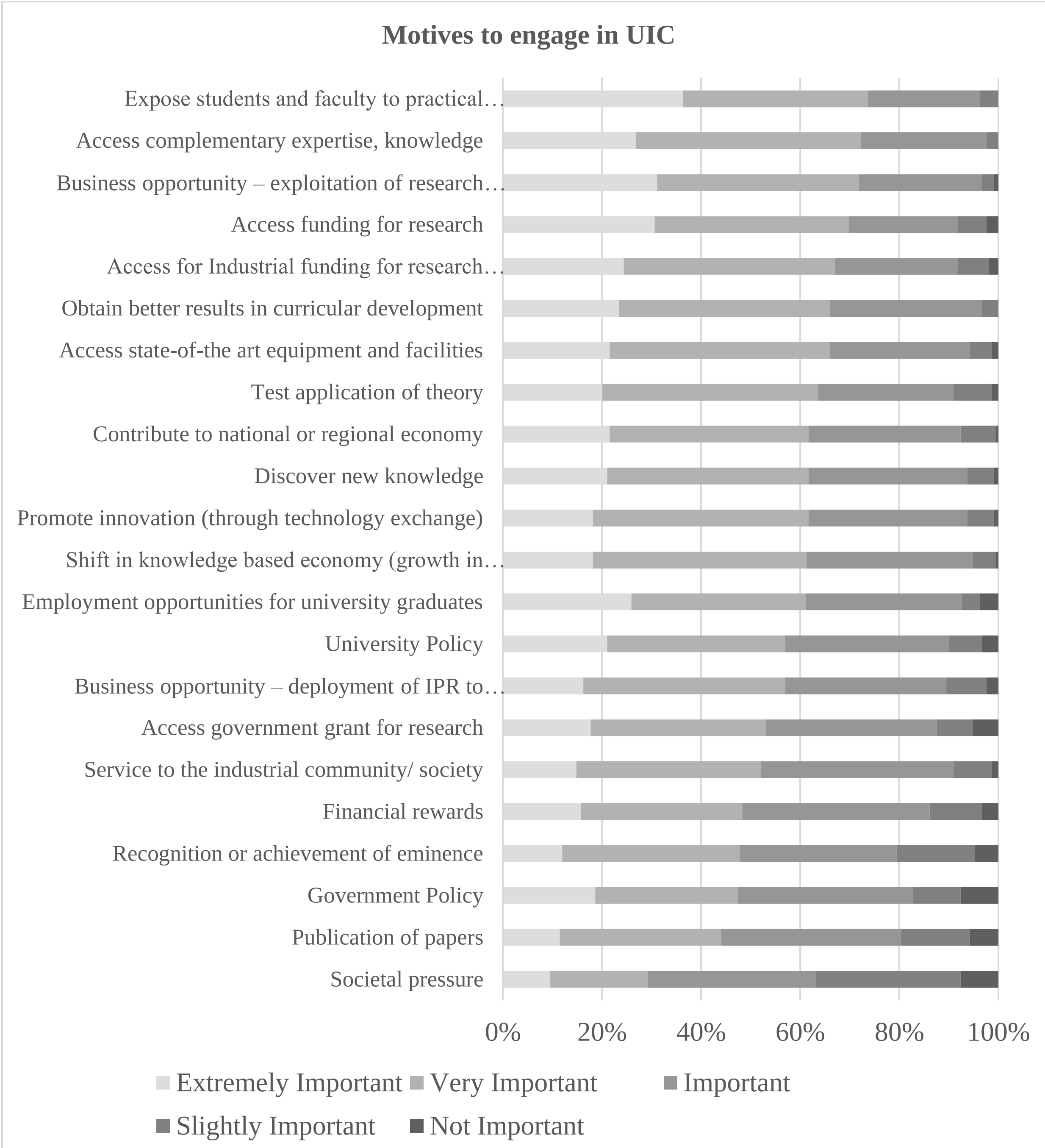

Figure 5. Motives to engage in UIC

Interestingly, academics who have never been involved in collaborations (N=59) chose University Policy as the first and the most important motivations!

VETEC
Vietnamese - European Knowledge and Technology Transfer Education Consortium

Co-funded by the Erasmus+ Programme of the European Union

Figure 6. Potential motives to engage in UIC

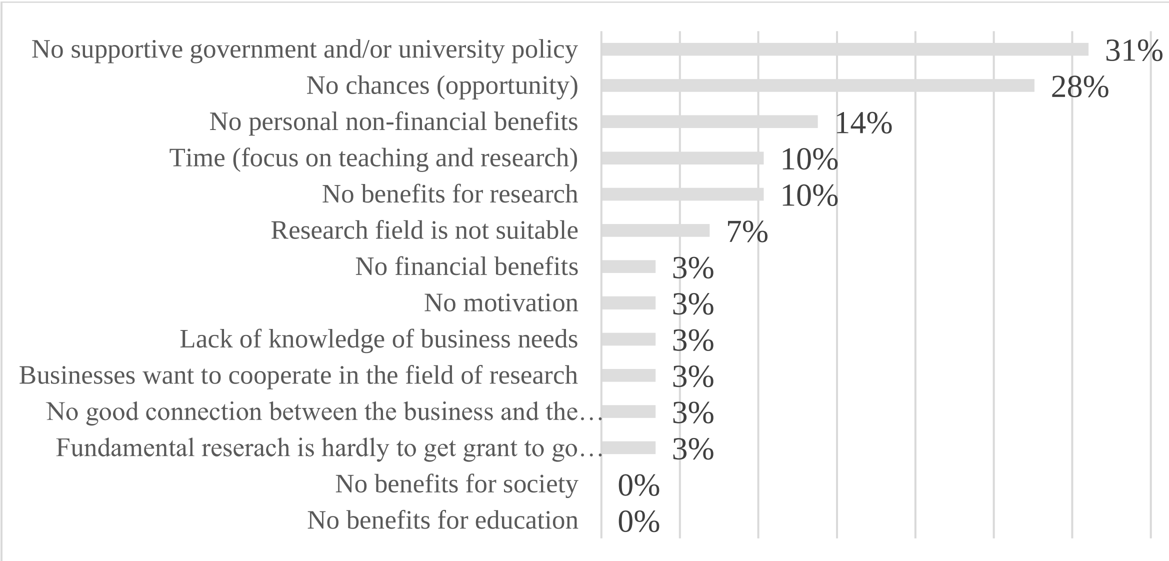

Figure 7. Barriers to engage in UIC

One more interesting insight from our results is that the main barrier to engage in UIC is a lack of supportive government and/or university from the perspective of academics who have never been involved in collaborations (N=59) (Figure 7). This is an open call for university management to build an efficient TTO which can support these collaborations, set up clear regulations and change their incentive scheme to motivate academics to engage in KTT.

The second barrier is that respondents did not have an opportunity to collaborate with companies yet. Vietnamese universities can take a successful example of VUB's "cross talks" to organise a similar initiative for connecting academics with industry. Therefore, there could be more chances for collaborations in the future.

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5. Policy and Government

5.1 Knowledge Transfer & Innovation Policies and Legislation

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This chapter gives an overview of some European programs, legislation and polies on innovation and knowledge transfer. We take the example of Belgium to show how these policies and legislation are reinforced on a national level.

5.1.1 Guiding policies and programs

Innovation has been placed at the heart of the European Union's strategy to create growth and jobs. Innovation is supported by (co)- funding mechanisms, like Horizon2020, and the creation of EU research & innovation bodies, like the Joint Research Center and the European Institute of Innovation & technology. Some of the guiding policies and programs are the following.

Horizon 2020

A 7-year program that integrates all research and innovation funding. The goals are to strengthen the EU's position in science, to strengthen industrial innovation, and to address major social concerns, like climate change, sustainable transport, renewable energy, food safety and security, ageing populations. The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation. Horizon 2020 is the financial instrument towards the development of the European Research Area.

European Research Area (ERA)

Aims at being a unified area, open to the world, in which scientific knowledge, technology and researchers circulate freely. This way, sharing research results and researcher mobility are being promoted.

Europe 2020

The EU's agenda for growth and jobs for the current decade. It emphasizes smart, sustainable and inclusive growth as a way to overcome the structural weaknesses in Europe's economy, improve its competitiveness and productivity and underpin a sustainable social market economy. One of the flagship initiatives within Europe 2020 is the Innovation Union.

Innovation Union

The Innovation Union focuses on Europe's efforts – and its cooperation with non EU countries – on the big challenges of our time: energy, food security, climate change and our ageing population. It stimulates the private sector and removes bottlenecks that prevent ideas from reaching the market (e.g. lack of finance, fragmented research systems and markets, under-use of public procurement for innovation and slow standard-setting).

5.1.2 Knowledge Transfer Legislation

Next to the relevant patenting laws, two treaties are worth mentioning with respect to knowledge transfer legislation.

Treaty of Lisbon (2007)

The international agreement which forms the constitutional basis of the EU. The Treaty includes fostering innovation and achieve higher industry investment in research & development within the EU member states.

Treaty of the Functioning or the EU (2007)

TFEU forms the detailed basis of EU law, by setting out the scope of the EU's authority to legislate and the principles of law in those areas where EU law operates. In particular, Articles 179-190 are relevant in the context of innovation and technology transfer. These may be summarized as follows.

- Development of European Research Area (ERA), a unified area, open to the world, in which scientific knowledge, technology and researchers circulate freely. This way, sharing research results and researcher mobility are being promoted.
- Allowing exploitation collaborations across borders trough opening-up national public contracts, defining common standards and removing legal and fiscal objectives to that cooperation.
- Development and demonstration programs, promotion of cooperation, dissemination and stimulation of training and mobility are key activities of EU.
- Consistency between Union policy and national policies.
- Multiannual evaluation of science and technology activities.
- Particular support dedicated towards the European space program.

5.1.3 Intellectual Property Legislation

European patent law covers a wide range of legislations. Some of the most important ones are the following. European patent law is also shaped by international agreements (e.g. TRIPs Agreement and Patent Law Treaty (PLT)).

Strasbourg Convention (1963)

Strasbourg Convention establishes patentability criteria. It intended to harmonize substantive patent law but not procedural law. This convention led to a significant harmonization of patent laws across European countries. This Convention is different from the European Patent Convention (EPC), which establishes an independent system for granting European Patents.

European Patent Convention (1973)

The multilateral treaty instituting the European Patent Organization (EPOrg) and providing an autonomous legal system according to which European patents are granted. The term European patent is used to refer to patents granted under the European Patent Convention. It provides a legal framework for the granting of European patents, via a single, harmonized procedure before the European Patent Office.

Paris Convention for the protection of IP (1883)

One of the first intellectual property treaties. It established a Union for the protection of industrial property. The Convention is currently still in force. The substantive provisions of the Convention fall into three categories: national treatment, priority right and common rules.

London Agreement (2000)

The agreement provides that Contracting States that have an official language in common with an official language of the European Patent Office, i.e. English, French or German, no longer require translation of European patents into one of their official languages. In addition, a Contracting State to the Agreement also keeps the right to require that, in case of a dispute relating to a European patent, a translation should be provided by the patentee in one of the official languages of the state.

(PCT)-EPO guidelines

EPO Guidelines (1978) concern the main aspects of the patent grant procedure: formalities, search, substantive examination, opposition and general procedural matters. The PCT-EPO Guidelines (2015): separate guidelines to cover the practice and procedure to be followed in various aspects of the handling of international applications before the EPO as International Searching Authority and International Preliminary Examining Authority.

Patents having effect in most European states may be obtained either nationally, via national patent offices, or via a centralized patent prosecution process at the European Patent Office (EPO).

Unified Patent Court

The Unified Patent Court will be a court common to the Contracting Member States and thus part of their judicial system. It will have exclusive competence in respect of European patents and European patents with unitary effect (UPC Agreement, 2012).

5.1.4 Country-level specifications: the case of Belgium

Europe allows the different knowledge transfer and innovation policies and legislation to be specified, reinforced and complemented on a national level. Let's take the case of Belgium. On top of Europe's guiding policies, Belgium has a Belgian Federal Science Policy office that prepares and implements various research and science policy activities resorting under the competence of the federal government, including research networks and programs, Belgium's participation in international and European scientific organizations (European Space Agency, European Southern Observatory, European Synchrotron Radiation Facility and so on), and the supervision of the ten federal science institutions. This may even be complemented on a regional level, e.g. with the Regional Innovation Plan (2006) of Brussels.

In terms of legislation, Belgian has its own Company Law to regulate the fundamental characteristics of signing and drafting of commercial contracts (e.g. on distribution, licensing, franchising, partnerships...) and certain decrees on a regional level, like the Decree on the organization and financing of scientific and innovation policies (2009), covering the possible entities dealing with these policies and the role of the university within this context, and the Higher Education Codex (2013) within the Code of Economic Law.

National patents are available in all European countries, thus also in Belgium. In some cases, it is cheaper and tactically advantageous to apply for a few national patents rather than for a European patent at the EPO. Researchers, designers and inventors who want to protect their work should contact the Belgian intellectual property office (OPRI), which is a federal agency. The Code of Economic Law (2013) has a specific book (XI) dedicated to Intellectual Property. The Belgian Patent Law (1984) includes that all results from innovation are protected. Overall, Belgium also has favorable conditions for innovation and R&D (e.g. exemptions from company tax, favorable tax policies for innovative companies, notional interest rate deduction, innovation bonus, exempted from person's tax.)

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5.2 IP Regimes and KTT

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Laws, regulation and institutions, on a national or other administrative levels, directly or indirectly influence Knowledge and Technology Transfer at the level of the organization or even the individual researcher. A fundamental decision to take by governments is how to allocate the right to use Intellectual Property (IP) that emerged during publicly-funded research. Currently, there are basically two different models in use, those following the "Bayh-Dole Act" in the U. S. and the somewhat more conservative "Professor's Privilege". After describing these two below, the section continues with thoughts on "Shared Ownership" and concludes with some "Practical Implications" of the IP regime to consider in day-to-day KTT.

5.2.1 Bayh-Dole Act

Historical roots and background

Bayh-Dole-like arrangements of IP allocation refer in name to an amendment to the law on patents and trademarks issued in the United States of America in 1980. The official name is the "Patent and Trademark Law Amendments Act", but it is commonly referred to as the "Bayh-Dole Act" after the two senators, Birch Bayh and Bob Dole, who played a vital role in the legislative process. The pre-1980 legal situation was tying the rights of ownership and exploitation of IP to the mode of financing. Especially, IP emerging during research funded by federal U. S. agencies was granted to the government. As a result, the government held a substantial number of patents, but only a minor share was actually commercialized (usually through licensing). With the motivation to increase industrial application and commercialization, the Bayh-Dole Act allocates the rights of IP protection (mostly patenting) to any grant receiving organization instead (especially relevant for universities). As a result, patenting in U. S. universities has risen tremendously (e. g., Shane, 2004) and the development of formal institutions for exploitation (e. g., TTOs) accelerated considerably.

Current situation and discussion

The Bayh-Dole Act is mostly seen as a huge success, despite criticism (Nelson, 2001) and some doubts on whether it has been the sole factor in accelerating university patenting (Mowery et al., 2001). Accordingly, most countries enacted similar arrangements for the allocation of IPR in the case of governmental support for research during the last 30 years. For the majority of countries this also entailed a shift from the "Professor's Privilege" to an approach that is more focused on organizations. The latter gain more autonomy in exploiting/commercializing IP, but also more responsibilities that put demands on staff and other resources. The question remains disputed, whether universities or publicly-financed research organization (PRO) can fulfill this role better than governments (pre-Bayh-Dole situation in the U. S.) or individuals (Professor's Privilege).

5.2.2 Professor's Privilege

Historical roots and background

Legislation on who owns IP usually seeks orientation in the circumstances of the creation of the property in question, notably the role of the creator and the resources used. In the realm of (privately-owned) businesses, the default is to grant IPR of employees' creations/inventions to the employer, especially if a substantial amount of employer resources have been used and/or the employee was acting under direct supervision. This principle is not used for independent creations/inventions, which the employee is pursuing in her or his free-time (so called "garage-inventions", see the origins of Microsoft, Inc. for a famous case). Most employees, whose connection with an organization is based on a formal employment contract, are subject to this regulation. This does entail scientists with an employment contract at universities and usually all scientists at PROs (because they are all "normal" employees). However, academic tradition for a long time had elevated the position of "Professor" at universities and granted them substantial autonomies (freedom of research and teaching). Moreover, professors are usually not normal employees, but civil servants. As such they are exempt from certain laws and granted the right to protect or exploit IP resulting from research in their own name (the "Professor's Privilege").

Current situation and discussion

The Professor's Privilege is currently in use only in a minority of countries, for instance those that never switched to a Bayh-Dole-like arrangement (e. g., Sweden) or those that switched back (e. g., Italy). The system does create more incentives to commercialize on the individual level, because revenues do not have to be shared with the university, but it has some severe drawbacks as well (see "Practical Implications" below). Moreover, with a parallel increase in competition-based financing (third-party funding from public organizations), the initial problem that led to the enactment of the Bayh-Dole Act, which is who owns externally funded research, resurfaces again. The Professor's Privilege originated from a situation in which the basic funding for professors and their working groups was through funds from province/state governments, which is a common element in decentralized higher education systems. Currently, a rising share of budget for research (in some cases the majority) stems from other sources, which might create legal conflicts.

5.2.3 Shared inventorship and shared ownership

Shared inventorship

Similar to other activities, invention today is often a team effort. Different IP regulations (mostly patent law, but also labor law) necessitate the explicit naming of all individuals that have contributed directly and to a significant extend to a certain invention. Furthermore, inventorship is important for at least two reasons: First, it is usually tied to a right of remuneration (labor law) by the employee. Second, it is almost impossible to change ex-post and defines the right of authorship to a certain invention. In the case of shared inventorship, the proportions of contribution (often in percent) are usually defined at the time of disclosure, but are not publicly available. In the case of collaborative inventions (see 2.2 "Collaborative Research"), inventorship is often assigned through formal contracts between the involved parties to mitigate subsequent dispute. The latter may arise, for example if the invention is licensed and yields positive returns that need to be distributed among inventing parties.

Shared ownership

Shared inventorship is a necessary, but not a sufficient condition for shared ownership. In KTT, the latter is usually the result of collaborative research (see 2.2) and refers to the collective ownership of an intellectual property right (often a patent) of two or more parties. In case of patents, shared ownership is easily identifiable by two or more applicants/assignees. Shared ownership secures IP rights for both parties, but entails a number of disadvantages. For example, licensing for patents with shared ownership is often more problematic from the view of a potential licensee, because the (contractual) consent of two parties is necessary to obtain the right of usage and payment schemes are a lot more complicated.

5.2.4 Practical Implications

The design of IP regimes is hardly to be changed by organizations and individuals tasked with KTT and has usually to be accepted as a "given". However, it has far-reaching consequences and practical implications. Bayh-Dole like arrangements entitle universities to claim IP rights and seek IP protection. Many universities have embraced this opportunity and patent applications by universities usually surge after a Bayh-Dole like arrangement has been introduced. The question, whether the original aim of Bayh-Dole – the acceleration of diffusion and application of publicly-funded research – has been fully achieved is still disputed (Mowery et al., 2001). Two considerations illustrate sources of difficulties in the following: the role of university endowments and principal-agent problems between researcher and university.

Many universities have embraced the opportunity to apply for patents (and other means of IP protection), under the assumption that they will miraculously turn into revenues (e. g., through licensing). However, high-revenue blockbuster technologies constitute a minority among university inventions. Moreover, Bayh-Dole like arrangements force universities to invest into activities that have traditionally not been part of the academic identity. Patenting, for example, demands familiarity with patent law, commercialization in general necessitates knowledge on market needs. Some of the related activities can be sourced-out (e. g., to patent attorneys) and many universities have done so. Still, commitment to and allocation of funds for KTT activities plays a crucial role, more so because KTT institutions still evolve and best-practices are still not fully developed for all environments and research ecosystems. In order to mitigate a lack of market knowledge and legal force, some universities have turned to a more "preemptive" or trust-based approach focused on long-standing industry partners. As a result, shared ownership in patents is rarely seen today, because contracts for collaborative research between university and industry specify distribution of IP rights ex ante (and often allocate it to the industry partner).

Granting the rights to exploit IP to the organization (Bayh-Dole) rather than the individual researcher (Professor's Privilege) creates or amplifies principal-agent problems stemming from information asymmetry. The agent (the individual researcher) is better informed about the technological uncertainty, because she is an expert in the field. In some cases (especially when industry partners are involved through collaborative research), she may even possess superior knowledge on market needs and, hence, uncertainty with regard to commercial potential. The principal (the university) on the other hand, holds the claims to IP and acts as a bottleneck on the way to successful commercialization. Moreover, the principal usually has a better network, more bargaining power with externals and an overview on possible complementary technologies within the organization. The challenge in this case is, however, to align the incentives of the individual researcher in order to ensure disclosure of quality inventions (not to focus on publication only or working "silently" with industry partners without being attributed inventorship) and subsequent commitment to further development. The latter is often needed for successful technology transfer, but is seldom part of the incentive system of academic researchers (Agrawal, 2006). Under the Professor's Privilege regime, incentives for the individual are usually less of a problem. Because IP protection is costly, it is only pursued for quality inventions that have a high commercial potential and commitment is longer lasting, because the individual gets 100% of the revenues. The downside of the Professor's Privilege is a lack of transparency and potential for outright corruption. Moreover, benefits for the university occur only indirect if at all, because it has no direct control over the transfer mechanism and does not receive a share of the revenues from licensing or patent sales.

Learning Questions and Discussion:

1. Who is the owner of IP stemming from research at universities under a Bayh-Dole like arrangemet in contrast to the "Professor's Privilege"? Why might Professors (not) like the one or the other arrangement?
2. What is the difference between shared ownership and shared inventorship with the regard to IPR protection (e. g., patenting)? Why may shared ownership be problematic in a university context?
3. What may be a downside of a university's focus on KTT a) in terms of resource constraints and b) in terms of organizational identity?
4. What kind of incentives does your university/organization provide to facilitate KTT? What more would you wish for to strengthen the focus on KTT?

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5.3 From Research to Technology Transfer: University Funding as an opportunity to promote incubation and Intellectual Property for commercialization

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The situation of technology transfer at Hue University and an intention to set-up a Technology Transfer Office (TTO) for the dissemination of research results and outputs to society and commercialization for sustainable economic development has been proved to be strategic for the policy makers at Hue University. There were 38 out of 200 research products and technologies that have been incubated and transferred to industry for the period of 2011 – 2016, which earned about 4,412 million VND, and 35 products commercialized for the period of 2017-2019, which brought about 10,895 million VND. According to Vietnam Law of Technology Transfer (2017) and intellectual property registration by Vietnam law of Intellectual Property (2012), the trade-market and commercialization are more appealing to generation of higher income and benefits for researchers and institutions than intellectual property registration and publications. Therefore, when making proposals and recommendations to ministries and government it is essential for researchers to learn from practice and enterprises' requirements. There should be a shift of focus on applied sciences for commercialization from fundamental sciences. The current economy ecosystem of the country is worth consideration for the application and transfer of technologies.

5.3.1 Rationale for technology transfer in Vietnam

Rationale

There is a high-demand need of research outputs to be transferred to industry. However, more requests from the government and enterprises to universities and research institutes to apply innovations and technologies and seek for funding and financial supports for incubation stages and commercialization. The question has been challenged and it is indicated that the researchers have to generate research ideas from practice for research requirements with IPs or trading products, research products to be transferred to industry, whereas there is a need for their products trading which results in setting up so-called *Science and Technology Enterprises*, which are currently encouraged and supported by the government in terms of exception from tax and land use cost.

Technology Transfer Requirements

The temporary connection between different types of technology transfer mechanisms is that different technology transfer channels are used consecutively, and we are searching how this sequence actually works at Hue University and its technology markets. Some studies have clustered technology transfer channels according to whether they are used in combination or cooperation between stakeholders. However, it is not clear whether these channels are used simultaneously or sequentially and might be modified through different channels. The relation between technology transfer and the business cycle is that while there are analyses of technology transfer over time, there is not yet much reflection on whether evolving macroeconomic and institutional conditions affect technology transfer dynamics; whether technology transfer grows or declines along with the business cycle? or what impacts crises have ever had. The changing facets of individual-level characteristics and technology transfer are posed in some questions like "do individual characteristics change because of engagement in technology transfer?" We have learnt much about the influence of personal characteristics, including attitudes and motivations, on technology transfer. However, the impact engagement in technology transfer has on personal characteristics remains relatively unexplored. Questions like “Do people change after engagement in technology transfer activities?” has remained unanswered.

5.3.2 Methodology and approach

Objectives and purposes

The objective of this subchapter is to present qualitative analysis methodologies and approaches which technology transfer offices (TTOs) can utilize to improve research valorization and effectiveness. Such qualitative tools and procedures will be presented in the following subchapters. Besides, it presents information that facilitates understanding of the processes, procedures and structures required for technology transfer such as a set of best practices.

From December 2008 to September 2010, there was a variety of methodologies and data from Hue University about KTT to industry, which led to development of a theoretical regime in Hue University, leading to a future possible TTO. Moreover, from 2011 to 2019, research data revealed that there were 200 products and technologies drawn from research works and projects carried out by Hue University’s researchers and lecturers.

Receivers and placements

- Access to intellectual property registration and franchising for businesses or localities through technology brokers or online virtual markets,
- Transfer to businesses for pre-testing and proper incubation at the enterprises, and
- On a win – win basis.

5.3.3 Vietnam law of technology transfer in 2017

Contracts can be devised by both intellectual property’s authorities and enterprises, by Vietnam law of Technology Transfer in 2017, according to Article 2, item 7: “Technology transfer is the transfer of technology ownership or transfer of the IPs to use technology from the right to transfer technology to the transferred partners; and item 11: “Commercialization of research and technological development products is the exploitation, completion, application, transfer and other activities related to the results of research and technological development for benefit”. Lecturers and researchers need a stage of technology transfer brokerage which is an activity to support seeking partners to implement technology transfer and technology marketing online, as App stores and dissemination channels of Hue University.

Ratios for different stakeholders, as prescribed by law:

- Ownership of IPs will get 5 % valuation of the products (normally government).
- Authors of IPs will get 30% of valuation of the products (contract value)
- Partner brokerage will get 10% of valuation of the products (contract value)
- The host institution will get 50% of valuation of the products (contract value)
- Taxes are 5% of charge. (Vietnam law of TT, 2017).

5.3.4 Results and discussions

Best practices and approaches in a number of fields

Among more than 200 potentially commercialized research products, only 38 products and technologies have, in fact, been transferred to industry.

Table 1. Technology transfer from 2011 - 2016

No.	Signed transfer contracts	Implemented transfer contracts	Total Income (VND, mil.)
2011	5	5	100
2012			
2013	6	6	510
2014	6	6	410
2015	10	10	2,210
2016	11	11	1,182
Total	**38**	**38**	**4,412**

For the period of 2011-2016, there were 38 products from the science & technology projects of Hue University researchers and lecturers that have been transferred to industry, described in Table 1.

Table 2. Details of technology transfer activities and impacts

No	**Product Name**	**Authors and IPs**	**Partners for receiver**	**Years**	**Technology transfer**	
					Products	**Value (VND, mil)**
1.	Data and recommendations from heritages of Quang tri Citadel.	Prof. Nguyen Van Tan	Quang Tri province	2015		No income, just indication for policies
2.	Nano technology for Silic oxydation linkage to DNA for treatment and diagnosis of cancer	Prof. Tran Thai Hoa	Nafosted	2016	Incubation period	
3.	Materials of TiO2 Nano	Dr. Truong Van Chuong	Nafosted	2011		
4.	Chitossan oligosaccharides (COS) for chicken livestock	Prof. Tran Thai Hoa	Thua Thien Hue province	2014	No benefits for Uni.	May be in sold to the black market
5.	Technology Zeolite 4A from Carbon for water control in aquaculture	Prof. Tran Ngoc Tuyen	Thua Thien Hue province	2014	No benefits for Uni.	May be sold to the in black market

6.	*Pseudomonas putida* for prevention of insects in pepper	Prof. Tran Thi Thu Ha	Binh Dien Company	2015		1,500
7.	Techniques for prevention of insects on pepper	Prof. Tran Thi Thu Ha	Forest Com. 1/5	2016		57
8.	Technology for gene selection for pepper that is resistant against insects and pest	Prof. Tran Thi Thu Ha	Forest Com. 1/5	2016		590
9.	Technology for prevention of pest on pepper	Prof. Nguyen Vinh Truong	Minh Phat Com. Ltm. (Donatechno)	2011 - 2015		100
10.	Technology for prevention of pest on pepper	Prof. Nguyen Vinh Truong	Quang Tri province	2013		100
11.	Data and maps of Thua Thien Hue for implemention and policies to rice production	Tran Thi Phuong et al.	Phu Vang district	2014	04	
12.	Data 3D for Hoi An city, Quang Nam	Tran Thi Phuong et al.	Hoi An committee	2015	03	
13.	Data and 3D for Quy Nhon city	Nguyen Hoang Khanh Linh et al.	Binh Dinh province	2016	03	
14.	Risk map of Dai Loc to avoid drought and flood	Nguyen Huu Ngu	Dai Loc district	2015	02	
15.	Risk map of Dai Loc to avoid drought and flood	Nguyen Huu Ngu & Duong Quoc Non	Dai Loc	2015	02	
16.	Biochar technology	Pham Xuan Phuong	Incubation	2015	05	100
17.	Biochar technology	Pham Xuan Phuong et al.	Incubation	2015	05	100

18.	Film "Tam Giang lagoon systems for sight-seeing tours"	Prof. Bui Thi Tam	Thua Thien Hue	2011	01	
19.	Tour courses for tourism and hospitality: Ecosystems and landscapes.	Prof. Bui Thi Tam	Thua Thien Hue	2011	03	
20.	Hotel and hospitality in Hue	Vo Viet Minh Nhat	Enterprises in Thua Thien Hue	2013	01	
21.	Application for students to get courses online	Le Van Hoa	Hue University	2013	01	
22.	Software for management in Education	Ngo Van Son	Administration	2013	01	
23.	Data and Digital techniques	Nguyen Thi Bich Ngoc	Library systems in HU	2011	01	
24.	Education Tours & Pagoda Tours	Nguyen Thi Ngoc Cam	Hue tourism	2014	01	
25.	Bokashi Betel (Bio-product)	Nguyen Quang Linh et al.	- Công ty Vietnam	2013 - 2016	4.000 litre	4000 L/Year and 1,2 – 1,5Mil.
26.	Bio-products EM2, EM5	Tran Quang Khanh Van, Tran Vinh Phuong, Nguyen Van Khanh	Bac Lieu, Soc Trang, Tra Vinh, Ben Tre	2013-2016	500 litre/year	10/year
27.	Vitro technology (*Phalaenopsis* Blume)	Nguyen Thi Thu Lien	Garden and Companies	2016	5.000 trees	25
28.	Silic species	Nguyen Thi Thu Lien et al.	Aquaculture enterprises	2016	1000 litre	50
29.	*Nannochloropsis* sp., *Tetraselmis* sp..	Nguyen Thi Thu Lien, et al.	Aquaculture enterprises	2016	1000 litre	50

Table 3. Numbers of technology transfer period: 2017 - 2019

	From 2017 – 2019		
2017	10	8	2,220
2018	12	9	3,410
2019	15	10	5,265
Total	**38**	**27**	**10,895**

5.3.5 Technology transfer at Hue University

Totals, proceeds and impacts

Thanks to the implementation of research projects, a great deal of science and technology products have been transferred to companies, businesses and enterprises, contributing to promoting production activities and planning orientation mechanisms and policies for socio-economic development of the Central region, the Highlands in particular, and the whole country in general.

Advantages

The research results and products obtained from science and technology activities of Hue University lecturers, though still modest compared to their potentials, have initially contributed to the formation of science and technology markets to create closer links between scientists and local businesses. The above achievements have affirmed the position and contribution of scientists and researchers of Hue University member universities, institutes or research centers to its human resource training strategies and socio-economic development of the Central region, Highlands and the whole country. The above achievement is thanks to Hue University's inheritance of leadership and support from the Ministry of Education and Training, the Ministry of Science and Technology, national and local authorities in development policies, plans and science-technology implementation tasks. Besides, Hue University has focused on enriching supporting resources and updated equipment, revising internal laws and regulations for science and technology management in accordance with the new guidelines and policies by the Party and the Government, creating favorable legal environment for lecturers' and students' science and technology activities.

Disadvantages and challenges

A number of challenges have been figured out: (1) No science and technology development strategies have been propperly developed in accordance with the government policies to promote the specific strengths of each university; (2) the development of annual and periodical science and technology plans remain insufficient and lack of orientation; (3) investing in science and technology resources has not stably set up; (4) research capacity building projects have not been responded to the plan of building up leading scientist teams and to the key missions of Hue University; (5) there is no strong mechanism to effectively exploit the common resources of Hue University; (6) the implementation of innovation management mechanism is still impractical and the assessment results by the advisory councils have not yet been genuine; (7) the incentive policies in science and technology have not created ample motivation for lecturers to do research and ready for transfer; (8) the role of intellectual property right registration has not been paid due attention, so the follow-up for the "post-acceptance" stage is still limited and ineffective; (9) the connection between enterprises' needs and scientists' research capacity is somewhat missing; (10) the network of science and technology organizations of Hue University operates and develops unstably, ineffectively and somewhat lack sustainability; (11) the coordination and unification in the management and implementation of science and technology tasks among functional departments and member universities, centers and research institutes have not yet been synchronized.

5.3.6 Recommendations

- There should be more support from higher education institutions to researchers and lecturers to register for intellectual property rights and trademark registration before doing technology transfer and commercialising their research products.
- Government authority should act as a bridge (brokeragers) between research groups, universities, local province authorities, and enterprises to carry out applicable research and technology transfer.
- The Ministry of Science and Technology needs to make efforts to promote technology incubation activities, and building up science and technology enterprises.
- To develop a legal framework for the incubation and development of science and technology enterprises together with the connection between research institutes, universities and businesses and promoting the commercialization of research results so that it facilitates institutions' incubation effectively.
- Orienting research into prioritized key issues supported by the Government and Ministry of Education and Training.
- There should be a special mechanism for research projects that solve urgent local problems.

Questions:
1. How to evaluate the value of IP or research outputs for TT?
2. How to balance between research and teaching works for lecturers in Universities?
3. How many percentages for research works to contribute for university' annual income?
4. What are research ideas or innovations for students to start-up or entrepreneurship while they are still studying in universities or graduated time?
5. What are important factors/components for universities to connnect enterprises or industrial communities?

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6. Funding KTT

6.1 Funding KTT: Bridging the Valley of Death

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6.1.1 KTT: evolving funding needs

As indicated in previous chapters many obstacles separate the observation of a basic scientific principle from an operational application of this principle, let alone from an economic entity generating profits based on the application of this principle.

As we move from fundamental to applied and industrial research the scientific relevance of the research diminishes and the focus becomes more applied; science becomes engineering and business. This has two consequences:

Firstly, these activities may no longer be taken into account in the performance appraisal of the academic. For this point we refer to the chapter 6 on Policy and Government. Secondly, and this is the subject of this chapter, current research funding agencies may lose interest in the subject, while the technology is still too immature to attract professional investors.

All authorities acknowledge that research funding needs to go beyond basic research. But authorities must be aware that changing the scope of research funding has implications in many dimensions.

The Technology Readiness Level (TRL) Scale

In order to provide an objective measurement of the maturity of technologies NASA developed in the 1990's the TRL Scale. It subdivides the innovation process in 9 steps.

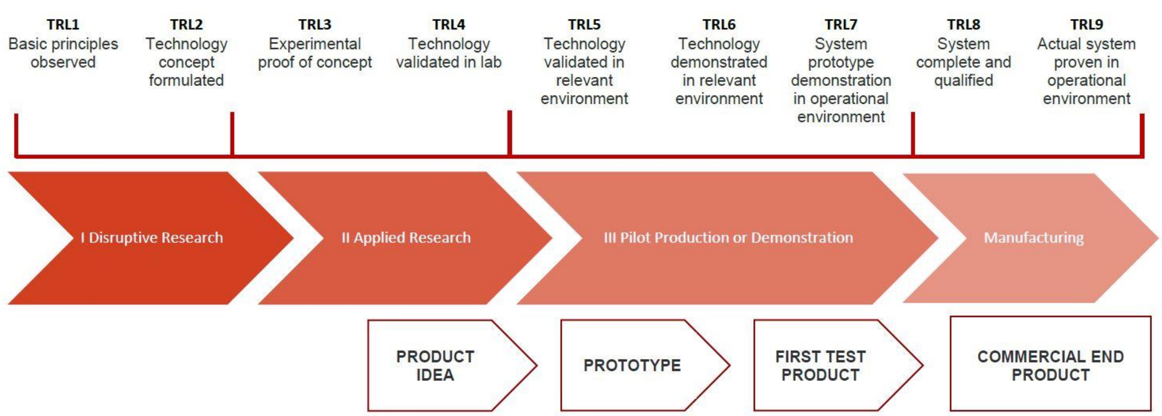

Figure 3 source: https://redknightconsultancy.co.uk/wp-content/uploads/2019/01/TRL-1.jpg

The process starts with the observation of basic principles (TRL1) and the formulation of a technology concept (TRL2). The next steps are translating these technology concept into applications, starting with an experimental proof of concept (TRL3), evolving into a technology that has been validated in the lab (TRL4) or in an (industrially) relevant environment (TRL 5), and then demonstrated in this environment (TRL 6).

TRL 7 implies that the system prototype has been demonstration in operational environment. Finally, TRL 8 means that the system is complete and qualified, and TRL 9 implies that the system has been proven in an operational environment.

Technology Transfer can be described as the process of advancing technologies up the TRL scale. Depending on the sector Technology Transfer starts between TRL3 and 5.

The evolution of funding schemes along the TRL scale

As we move along the TRL scale the scope of the project evolves beyond science and engineering. Business dimensions of the project must be tackled: performing market research, developing the business case, assessing financing needs, setting up alliances, preparing go-to-market strategies.... And therefore: assembling a team with the range of skillsets needed to tackle all of the above.

As a consequence, the funding process evolves with the TRL level of the project. Following elements evolve:

- The objectives of the funding. The description of TRL levels indicate that scientific considerations are gradually being replaced by engineering and business milestones.
- (and therefore) The needed team composition and -competences change. Non-scientific expertise becomes more and more important.
- (and therefore) The project evaluation criteria. Non-scientific arguments start to predominate in the assessment of the project.
- (and therefore) Jury composition. Voices other than purely scientific must be heard while assessing the value of the project.
- The percentage of costs funded. For fundamental research 100% funding is the rule; as we evolve into applied research the percentage diminishes. Therefore, matching funding from other sources becomes required.
- The source and the format of the financial contribution change. Initially funding comes from public (research) authorities under the form of grants. As we move up to TRL scale a switch towards private capital happens.
- Private funds are supplied as loans or equity investments in the company; in other words: money with strings attached.
- The decision-making process. As we move along the valorization cycle of a technology decision making moves away from objective and formal jury processes towards heavily negotiated custom deals.

The evolving contribution of Public Authorities along the TRL scale

Public authorities have different alternatives on how to contribute to the funding of these phases. Some elements to take into account:

- Where does the funding decisions power lie? Within the universities, in independent boards, within public authorities, as part of sector-specific policies…
- What criteria are used to define eligibility of the project and of the team?
- Are teams or projects being funded?
- Are specific activities being funded such as patenting, proof of concept development, business plan development…?
- Are sector-focused strategies being developed, with separate instruments and organizations for strategic industrial sectors?

Preparing for Business Funding

As we move up the TRL scale, interest from the business world increases. As a rule, professional investors start listening when concrete and realistic applications of an idea or technology, that respond to a concrete and sizeable demand, are presented by a credible team with a (a/o financially) credible plan.

The evolving need for funding is only one dimension. Investors also wish to limit the number of risks the project faces. There are always business risks: market acceptance, new competitors, regulatory challenges, commercialization strategy... Investors don't want too many technological and team risks on top of the business risks. Therefore, the further up the TRL scale a project can be brought before having to reach out to investors, the higher are its chances of accessing this investment money. Investors call this de-risking a project.

This implies reaching out to investors at a TRL level of at least 4 and ideally 6 or 7, and if possible, with a strong IP position. Note that certain industries, such as Life Sciences, use different criteria and cut-off points. This is typical for vertical markets, each with their specific rules of engagement. Here too we identify the importance of sectoral expertise, within public authorities, KTT and the entrepreneurial team.

The Valley of Death

Cash is King: the Cash Flow of a company is a very important indicator. It measures the cash inflows (mainly from sales, but also subsidies and investments) minus cash outflows for working costs and investments. Simply said: money in minus money out. Especially in early stage companies, but also in fast-growing companies, cash flows will be negative.

This applies all the more for academic spin-offs, as these companies often have to bridge the gap between research and market acceptance. Other start-ups, especially those founded by industry professionals, are much less R&D-centric, start closer to the market and have a better understanding of their target market.

By accumulating cash flows over the years, we calculate the Cumulative Cash Flow, see below. This curve is called the Valley of Death…

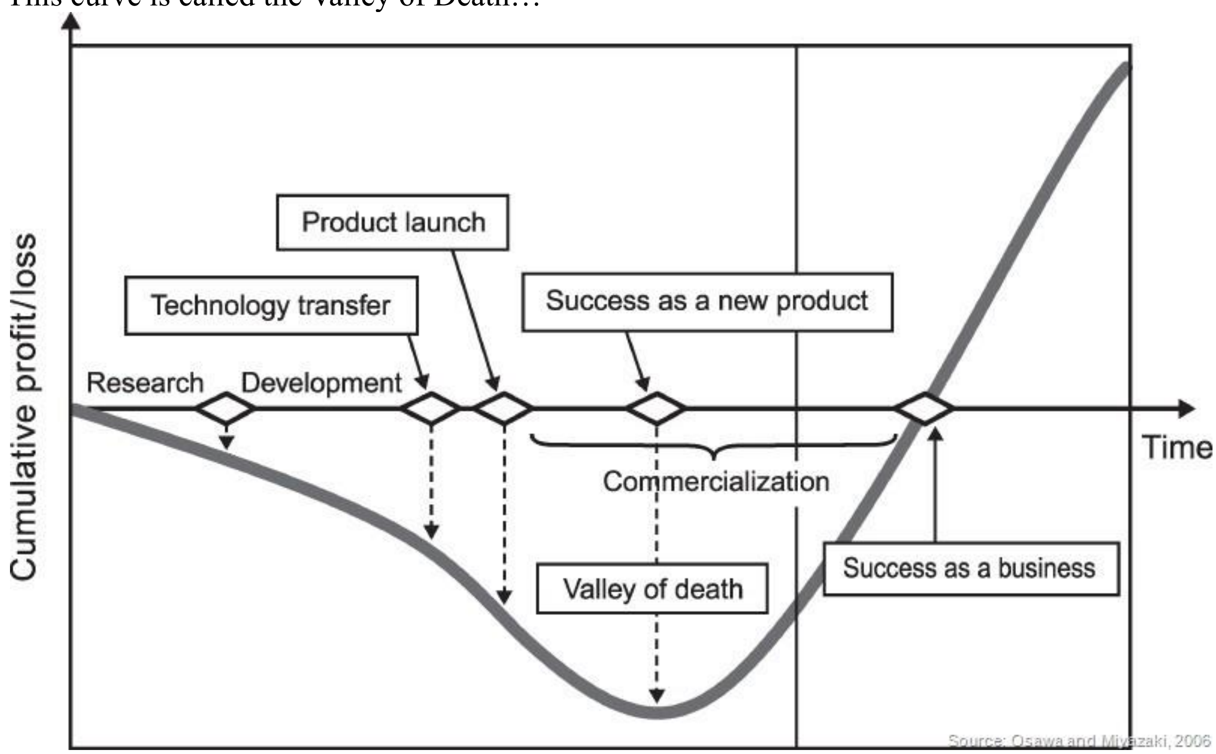

Figure 4source https://billringle.com/10-ways-for-startups-to-survive-the-valley-of-death

The deepest point of this curve is also the maximum amount of money that is needed to mobilize in order to become a successful company. Or, to be more correct: it is the maximum amount of money needed according to the current 'guesstimate' of the evolution of the company. This guesstimate is almost guaranteed not to materialize. Professional VCs are aware of this, but they want to see that the team has a grasp of all the variables, that it has thought through all aspects of a number of scenarios.

The lowest point of the Valley of Death occurs when incoming cash from operations is sufficient to cover outgoing cash. In other words: when we are Cash Break Even. This is an important milestone: the company proves that it can be viable. It also is a strong point in negotiations with VCs, as : the company has proven that break-even is feasible. Growth oriented companies will still need additional resources to fund expansion plans.

Some companies don't require large investments before they reach break-even, especially if founders are willing to work with little or no salary the funding threshold is very low. But in many cases substantial additional funds are needed; more often than not they exceed the funding possibilities of the founders.

6.1.2 Public funding tools

Strategic Basic Research

The first step is away from fundamental research to Strategic Basic Research: high-level basic research with a clear perspective on valorization in 3 to 10 years. This research is still generic, but it has clear applications in sight and potential end-users are showing interest in the topic. Often industrial partners will be involved, as research partner or on the Advisory Board.

Applied and industrial research

Applied and Industrial Research is strongly driven by industry (including start-up) needs. Often a financial contribution by the industrial partners is required.

Topical Funding Schemes

Topical Funding schemes can be powerful tool in policy setting. It allows both to tackle concrete stumbling blocks in the process and to set priorities. For instance, authorities can develop funding and/or support schemes for the submission of patents by KTTI's, preparing the submissions to calls of large (transnational) funding agencies, setting up international collaborations, writing Business Plans, …

Sectoral Funding Schemes

Authorities may focus their efforts on a limited number of business or technology sectors. This allows for a much more focused and holistic approach. In this case KTT is part of a wider ecosystem which may include dedicated research institutes, investment in infrastructure…

Business related Funding Schemes

Project leaders must look for entrepreneurship-related grants and subsidies, as well as support schemes. Often support for start-ups is organized by the Ministry of Economy and Business rather that the Ministries of Research and Education.

6.1.3 Business Funding

This is the point where we no longer look to grants and to Public Authorities for the funding of our project. We are now entering a different world, with different players. This is also the point where the company starts to fly on its own wings, with academia as an important but no longer the main player. These players have their own agenda's and measurement points. Entrepreneurs should assess their project from the perspective of these other players.

Private contributions can be brought into the company under different forms. An important distinction to make is whether or not the donor of the funds receives stocks: equity of the company, in exchange for his contribution. We discuss this further in Chapter 2.4 on Dilution, pre and post money valuation.

In developing countries some elements of this ecosystem may not yet have materialised. It is part of public policy to take care of the development of such complementary assets.

The entrepreneurs'/entrepreneurial teams' time and money

Almost all entrepreneurs invest their own time and money, in the start-up. Alternatively, they don't pay themselves a salary for their work. Such funding is also called sweat equity, as the entrepreneurs receive shares in exchange for the work done. This reduces the capital needs of the start-up, but also that it has an upper limit.

The 3Fs: Friends, Family and Fools

Entrepreneurs may raise so-called Love Money: funds from relatives, friends and others. While it has some advantages, one must be aware of the. Often these are inexperienced investors that can't contribute to the strategic thinking of the company and may panic when things are not going as expected. It is important that expectations are set clearly, often it's best not to involve 3Fs in the Board of Directors.

Crowdfunding

Crowdfunding is internet-based funding by 'The Crowd'. Organizations can mobilize resources from third parties to fund their projects. Several international crowdfunding platforms have arisen over the last years.

There are four types of crowdfunding; what changes is the kind of 'return' that the funders receive in exchange for their contribution. They can provide the money as a gift, in exchange of a reward (such as a special version of, or discount on, the product); they can lend the money or receive equity in exchange.

Banks

Especially in the initial phases banks rarely are a suitable financial partner. Often they are limited by law in the risks they are allowed to take. Therefore they will ask for collateral to mitigate their risks. And as often the start-up does not have physical assets to use as collateral, the banks turns to the entrepreneur for personal warrantees. Authorities can mitigate this risk by providing warrantees in name of the entrepreneur.

Supplier and customer credit

Payment conditions have a substantial impact on the capital needs of companies. Substantially less money is needed to cover operational costs if customers pay cash and suppliers grant long payment terms. But often substantial amounts of cash are tied up in stock, work-in-progress, payment terms…

Partners and alliances

For some projects strategic partners and alliances can be a source of funding. Often the logic is as follows: a capital-rich established company invests in a start-up, in exchange of long-time revenue streams.

For instance, a biotech start-up signs a deal with an established pharmaceutical firm, where the biotech firm commits to licensing the drug-in-development to the pharma company. The pharma company receives the right to (manufacture and) distribute the drug, in exchange for an upfront payment, milestone payments (when agreed-upon targets are attained) and a royalty on the sales volume. These upfront payments allow the biotech company to finance the development of the drug.

Cash flow positive

Every company must, somewhere down the line, start generating cash flows and profits

Once the company generates enough cash flow to fund its expansion it no longer needs external sources of capital for its day-to-day operations. Only very few companies manage to be cash flow positive from the start. Especially product-oriented companies need to invest in development, but also manufacturing, stocks... Also, cash-flow positive companies may still require additional funds for expansion plans.

It always makes sense to look for ways to generate revenues from early on in the process. Biotechnology companies excel in this process (see 3.6), but other companies may convince their customers to pay upfront, in exchange of substantial discounts, early access, influence on development priorities; or develop a strategic alliance with a complementary, established player in the value chain …

Questions

1. At what TRL levels is research happening in your institution?
2. What funding schemes are available along the TRL scale in your country? In how far are these being used within your institution?
3. In how far are composition of the decision-making committee and the decision-making criteria adapted to the TRL level of the project in your country?
4. What funding schemes along the TRL scale are according to you missing in your country?
5. Which Topical and/or Sectoral Funding Schemes are available in your country? In how far are these being used within your institution? Should other Topical and/or Sectoral Funding Schemes be introduced? If so, which and why?

6.2 Financial Support Schemes for KTT (government focus)

Matthias Geissler, Sophia Bittner-Zähr, Anna-Maria Kindt
(Research Group Knowledge and Technology Transfer, TU Dresden, Germany)

Given the economic implications of successful Knowledge and Technology Transfer for society (faster diffusion of technology, growth in emerging industries, etc.), governments seek to enhance the quantity and quality of KTT through a number of instruments. The most widely-used ones usually encompass some form of subsidization for collaborative effort between universities and industry and/or support of founding activities. The following distinction is not without overlap, especially because instruments sometimes fall in more than one category. Driven by research results confirming crowding-out effects of private investments and disincentives when financing transfer and R&D initiatives, most governments follow a "complementary principle". This requires grant/subsidy receivers or other private investors to contribute a certain share in order to receive government support.

6.2.1 Cost-based funding

Tax deductibility

A powerful tool that is not restricted to transfer funding, but often used to spur innovation in general is an amendment to tax laws allowing firms to deduct certain cost categories (e. g., staff costs for R&D personnel) effectively reducing their tax burden. This is an ex post instrument that does not specifically target transfer and makes some crude assumptions (basically "the more R&D staff, the higher the innovative output"). It is not suitable as a "standalone" but can flank other initiatives and help to incentivize investments into better (human) capital. However, it requires trust in the bookkeeping of firms and demands governments to exert control over diligence in applicant firms. It also lowers tax income in the short run, with the hope of strengthening innovation, competitiveness and growth in the long run.

R&D service vouchers

R&D service vouchers (e. g., Cornet et al., 2006) are an instrument specifically targeting Small and Medium-sized Enterprises (SMEs) that are often important for economies but are reluctant in engaging with universities or other research organizations. Vouchers are handed to SMEs and grant a certain amount of money for (unspecified) use for "services" that are provided by research organizations/universities (for example: measuring, validating, sample testing, certification) but also collaborative research. The rationale is that the engagement with the academic in general (through services) or researchers in particular (through collaboration) will also lower the barriers for future transfer between universities and SMEs.

6.2.2 Project-oriented funding

Project-oriented funding usually demands the application of one or more parties for the realization of a rather specific undertaking. In the case of government support, detailed descriptions and cost calculations usually have to be provided. For reasons of tax and competition law, support for transfer projects is usually limited to a certain time period (e. g., up to two years), cost categories (e. g., staff costs) and in the case of firm involvement follows the "complementarity principle". Support of collaborative research is more common (than support of transfer), because it is easier to justify it as an area of market failure and, hence, public policy intervention.

Collaborative research support

Support of collaborative research assumes positive spill-over effects between universities and industry, when working together in research. Financing schemes usually demand the participation of both, university and industry partners. Whereas universities usually receive 100% reimbursement of costs, firms are limited to significantly less (usually < 50%). Collaborative research support may be tied to certain partner characteristics (e. g., SMEs), scientific fields or industries (e. g., Biotech or high-tech industries) or even technologies (e. g., lasers). Positive effects of collaborative research on KTT may hinge on whether the partners actually exert collective effort or simply form a "wolfpack" to gain access to government funding and do not work together after receiving a grant.

Support targeting applied research

Aside from support targeting collaborative research, support schemes can focus explicitly on applied research, rather than basic science. An advantage is the stimulation of R&D that is already closer to market needs. The disadvantage is a potential crowding out effect of private investments (Almus & Czarnitzki, 2003). The latter leads to a replacement of private resources through public ones without creating "additionally". The use of the "complementary principle" is therefore imperative in funding for applied research.

Support for transfer projects

Governmental support for explicit transfer projects is a relatively new instrument (see STTR program in the U.S.). A challenge for governments is to draw a line for projects entering industrial application, because subsidies can be seen as an unjust distortion of competition. Contrary to start-up funding, financial support for transfer projects aims at pushing (basic) research results further down the TRL without necessarily specifying the final channel of transfer or commercialization. Accordingly, the time horizon for such undertakings is usually limited (often 2 years) and focusses on scientific fields where the "Valley of Death" is most problematic, because of capital intensity and missing links between academia and industry.

A new approach: Mission-oriented innovation policies

While technically not a separate form of financing, mission-oriented innovation policies (Mazzucato, 2016) have garnered some attention among politicians. They constitute a pro-active approach that emphasizes the need of nations to focus their support efforts on promising (strategic) areas, with the aim of creating markets rather than just fixing them (ibid.). With regard to financing KTT, governments may decide to strengthen specific areas rather than engage in an scattershot approach that distributes resources without higher strategic aims.

6.2.3 Start-Up funding

A central characteristic of knowledge and technologies developed at universities is their embryonic stage (Jensen & Thursby, 2001) and/or the potential to displace existing technologies or disrupt established business models. Incumbent firms tend to neglect those, because they would corrupt revenue streams and challenge the value of past investments. Licensing and collaborative research with incumbents is therefore often more in line with existing technologies and follows rather incremental development paths. Therefore, government support for transfer is often directed towards the founding of new firms to a significant extend.

Pre-Seed funding

Pre-seed schemes target the "Valley of Death" (VoD) directly, by providing funds for more applied research with the aim to develop prototypes (further), include design elements and/or proof the feasibility and up-scaling to industrial production. Similar to the deliberations in subsection 3.2 funds are usually allocated to universities. However, the difference is that pre-seed-funding specifically has the aim to develop a technology far enough in the TRL-scale to establish a firm at the end of the process (which is also somewhat different from more general transfer project funding described in subsection 2.3).

Seed funding und support

Whereas pre-seed funding targets the under-developed technology and the VoD between TRL 4 and TRL 7 (see section 7.1), seed-support intends to lower the entry barriers, once feasibility has been proven. Because of the incentive problem outlined in the introduction to this subsection, incumbents may still not be interested in a certain technology and private investors may be reluctant to provide cash without a proven business case. However, firm establishment is usually connected to significant investments up-front, especially in high-tech industries. Government support can lower entry barriers and can also be targeted at specific groups (e. g., students) or industries (e. g., Biotech). Still, governmental support for seed investments is usually limited and often perceived as too low and needs to be accompanied by private initiatives (for example through strong Venture Capital providers).

6.2.4 Practical Implications

To support technology transfer different financial support schemes are available and can be used by policy makers appropriate to the higher-order aims (support industry-university collaborations, start-up founding and growth) as well as the budget. From the governmental side, coordination between ministries should be taken into account to avoid overlap or conflicting programs. Research funding, for example, is typically coordinated by the Ministries of Science and/or Education, whereas Ministries for Economic Affairs usually handle start-up funding. This distribution in responsibilities may create internal competition for budgets. This limits the size of individual programs, which is often perceived as an obstacle. Moreover, governments should be aware that funding for transfer projects and start-ups is still risky and not all endeavors will turn into commercial successes. Therefore, it is recommended to pursue a portfolio approach and evaluate policy success on the program level rather than on the results of individual projects.

Learning Questions and Discussion:

1. What is the difference between cost-based and project-oriented funding? Does your government use tools such as “tax deduction” for research costs in firms?
2. Why may a government that is interested in control of the research/development agenda prefer project-oriented funding?
3. What are general opportunities for start-up financing at your university/organization? Is there something like a “seed fund” for new ventures owned by the university?

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6.3 Private investors: Business Angels and Venture Capitalists

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6.3.1 Introduction

While previously mentioned sources of funds may help mitigate funding needs, often these needs are so substantial that professional investors are required, as they are able to provide large amounts of risk capital.

An equivalent -but substantially larger- source of private funding is available for established enterprises with growth and/or consolidation plans: Private Equity. In this document we focus on risk capital for growth-oriented start-ups.

6.3.2 Venture Capitalists versus Business Angels

We differentiate between two main types of capital investors in growth companies.

- Venture Capitalists (VCs) provide Venture Capital (VC): risk sharing investment money, with a limited investment time horizon, by professional investments firms (VC Funds); to growth-oriented companies, in exchange of company shares and seats on their Board of Directors.
- Business Angels (BAs) are individuals that perform essentially the same tasks as VC Funds, but most often on a smaller scale and in an earlier stage. They focus on a limited number of sectors they are acquainted with. Often BAs are successful entrepreneurs who wish to invest a part of their wealth and expertise in new ventures. Most properties of VC Funds apply to BAs, be it on a smaller scale.

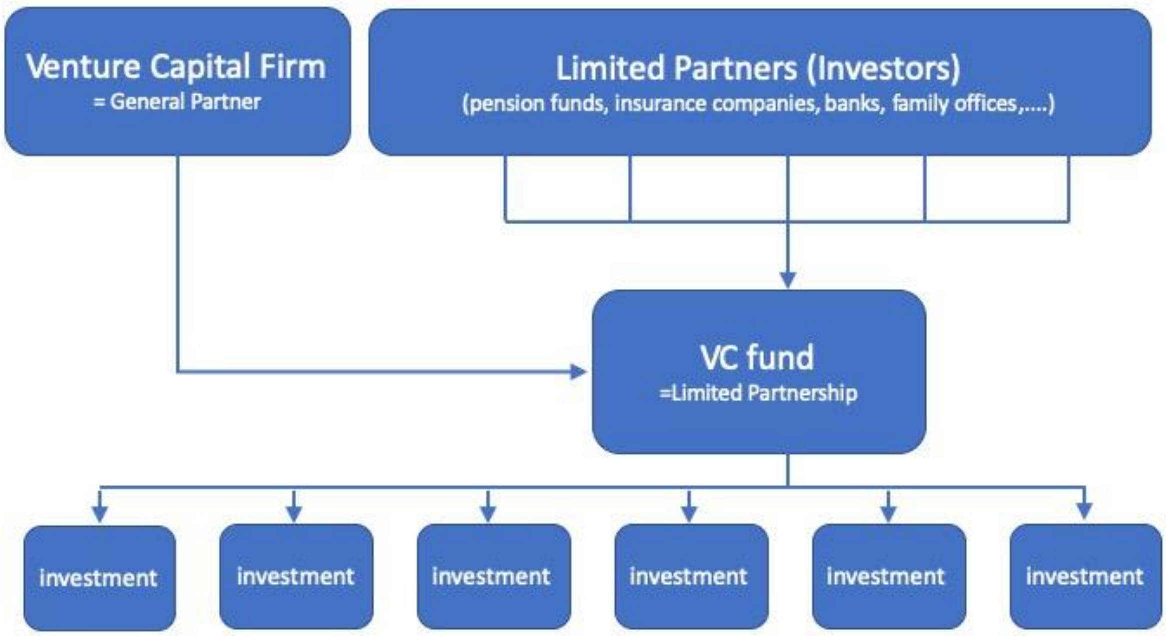
Most developed economies have Business Angels networks. These networks often act as first point-of-contact towards their member, through meet-up sessions. The ecosystem develops in the direction of matchmaking sites where startups connect online with investors.

In the remainder of the chapter we will mostly talk about VC Funds, most information also applies to BAs.

6.3.3 Corporate Venture Capital

Sometimes established firms provide VC; we speak about Corporate Venture Capital (CVC) when established firms take an equity stake in growth-oriented start-ups and young companies. The objective of the established firms is generally to gain some form of competitive advantage for themselves, for instance by developing new application areas for their technology or by developing complementary offerings to their products. Other considerations may therefore play in the investment decision making; in some cases this may increase the attractiveness of the spin-off.

6.3.4 The structure of a VC Fund



As a rule, VC functions as follows:

- A number of experienced investment professionals, called the General Partners (GPs) start up a Venture Capital Firm (VC Firm).
- These GPs contact organizations and individuals with substantial financial reserves, such as pension funds, insurance companies, banks, family funds, as well as public authorities. The GP's propose these organizations and individuals to invest an amount of money in a common VC Fund.
- These parties invest a limited percentage of their reserves in these funds as part of their wider investment diversification strategy. Public authorities' involvement is driven by policy reasons. These organizations and individuals are called Limited Partners (LP): their commitment is limited to the funds they have provided.
- The GPs manage the VC Fund. They invest in a limited number of carefully selected companies, in exchange for shares of these companies. The VC Fund has a seat on the Boards of Directors of these companies.

Often more than one round of capital injection is needed to bring the company to full fruition; VC Funds are prepared and equipped to participate in a number of investment rounds.

Within its lifespan the VC Fund needs to exit from all its investment, by reselling the shares it has received.

At the end of its lifetime the VC fund is dissolved, and a substantial percentage of the generated profits -if any- is returned to the Limited Partners.

The VC Funds as described above are closed-end: they have a limited life-span, between 12 to 15 years. Other, so-called evergreen VC Funds have an unlimited life span.

Business Angels act on a smaller scale and only invest their own capital, therefore the legal structure is simpler.

6.3.5 The financial logic of VCs

quality of investment	bad	alive	ok	good	super	total
# projects	2	4	2	1	1	10
amount invested in €	200	400	200	100	100	1000
Multiple after 5 years	0	x1	x5	x10	x20	(x4,4)
Cash from trade sale in €	0	400	1000	1000	2000	4400
Revenue in €	-200	0	800	900	1900	3400

Figure 5 Prof. Rudy Aernoudt, guest lecture 2007

The financial logic of a professional VC or BA can best be explained using the table above.

- A VC Fund has 1.000 to invest. It spreads the investments over 10 high potential projects. In each it invests 100, with the objective of reselling the shares in a 5- tot 10-year timeframe.
- Over time some projects succeed, others fail. In this -representative- case:
  - 2 projects fail completely; the VC Fund loses all the invested money
  - 4 projects barely survive and generate enough to recoup the original investment
  - 2 projects are relatively successful and generate 5 times the invested amount
  - 1 project is good and generated 10 times the invested amount;
  - 1 project is a real success, it generates 20 times the invested amount. This project generates more revenues than all the other combined and covers all the losses incurred on the failed projects.
- As a result, the VC Fund generates a multiple of 4,4: 1.000 has become 4.400. Over a 13-year timespan this results in an Internal Rate of Return (IRR) of 12%.

The example shows the importance of the growth potential of projects in which VC Funds invest: one successful project makes up for several unsuccessful projects. A VC Fund will therefore only invest in projects with a high potential. Nevertheless, still only +/- 2 in 10 will be real successes.

This limits the application area of VC: the overwhelming proportion of starters do not comply to the requirement of high growth potential. In the world of academic entrepreneurship growth-oriented start-ups occur more frequently.

BAs generally invest in earlier stages of the project. They invest smaller amounts and in fewer deals; sometimes they get personally involved in the project.

6.3.6 Dilution, pre and post money valuation

An implication of attracting VC is dilution of the shareholder position of the founder. As the VC Fund receives newly issued shares for the funds it invests in the company, the existing shareholders hold a smaller percentage of outstanding shares after the transaction.

For example

- An entrepreneur starts a company with € 100.000 in capital; he receives 100.000 shares = 100% of the shares

- After a while, a VC Fund invests €3.000.000 in the company, in exchange of 100.000 new shares.
- After the transaction the entrepreneur still owns 100.000 shares, but now this represents only 50% of all outstanding shares.
- As the VC Fund paid €3 million for 50% of the shares, the company -100% of the shares- is now worth 6 million. The valuation after the transaction is called the 'post-money valuation'; when subtracting the additional investment, you get the pre-money valuation. In this example: Post-money valuation €6 million, therefore pre-money valuation = €6 million - €3 million = €3 million. As a result, the initial investment by the entrepreneur of €100.000 is now worth €3 million.
- But on the other hand, the entrepreneur cannot decide the course of the company by himself any more. The VC Fund will have negotiated seats on the Board of Directors of the company and will probably have received veto rights for key decisions. We will see later on that the impact of dilution can be mitigated or increased by clauses added to the shareholder agreement.

How VC's screen and evaluate projects

Professional VC Funds often receive hundreds of projects per year. They gradually select a limited number, which they screen thoroughly.

A large number of criteria is taken into account when deciding whether or not to invest, and at what conditions. These will always include the quality and maturity of the project and the underlying technology, the market the project serves, and the team that will make the project happen.

Other considerations are the quality of the business model, its scalability, project complexity, the Intellectual Property and Freedom to Operate status of the project, possible exit scenario's, and the financial expectations of the founders and IP owners.

6.3.7 Negotiating with VC Funds

Investment negotiations with VC Funds can take several months. To succeed, a very different skillset from the average scientist is required. There are a number of potential pitfalls when negotiating with VC Fund.

Valuation

What is the project currently worth? If a VC Fund invests €1 million, and it receives 50% of the shares for this investment, it implies that the project currently is worth as much: €1 million. This is a complex and sensitive subject, as both parties have opposing interests.

Putting a value on a project in this stage of development is an act of faith. It is much easier to put a value on an established firm with existing revenue streams and known costs. A VC Fund will insist on the immateriality and immaturity of the academic contribution, compared to their hard cash.

A few approaches that can be used to estimate the current value of the project:

- look for examples of valuation of comparable projects in the past
- try to estimate future revenues streams and costs over a period of 5+ years.
- Study recent investment deals
- take into account sunk costs

There are ways to circumvent the discussion by adding clauses to the term sheet that allow to re-assess the valuation in case certain targets are not met.

Due diligence

VC Funds will perform an in-depth study of the company in all its facets, in order to avoid unpleasant surprises after signing the deal. They will have (confidential) access to all documents related to the company.

Term sheets

At the end of the negotiation all parties will have to agree on a Term Sheet. They will sign a document which contains the conditions under which the parties collaborate. It discusses the invested amounts, the percentage of shares the VC Fund receives, the rights that are attached to these shares (generally different classes of shares are created, each with their own voting and veto rights). The conditions under which these shares may/may not/must be resold are agreed upon. Clauses that protect minority and majority shareholders can be added. This is a very complex endeavor; it is important that all the negotiating parties have sufficient expertise on board.

6.3.8 Funding Stages

VC Funds and BA's do not invest all the needed funds in one go: very often this happens in many stages. The most noteworthy funding stages of start-ups (in preparation) are called as follows

Stage	Amount raised	Use of Proceeds	Sources of capital
Pre-seed	€ 50k - € 150k	technical and/or commercial Proof of Concept, business plan	angels, FFF, (semi-) public investors, university, crowd funding
Seed	€ 250k - € 1,5M	Develop Minimal Viable Product, initial sales in first target market	angels, early stage VCs
Series A	€ 1M - € 5M	International expansion	certain angels, VCs
Series B	€ 5M - € 20M	Further expansion (scale-up)	VCs

Figure 6 Source: QBic, presentation Guy Huylebroeck, October 13 2016

Pre-seed funding

This is the very first, often informal, financing round of a company in preparation. Small amounts of money, often provided by the entrepreneur(s), (university) funding agencies or 3F's (friends, family and fools) are used, to develop a Minimum Viable Product (MVP), validate a market through market research…

The main objective is to validate the project/product/team/market so that the company is (more) ready for a next investment round

Seed funding

Seed money/funding/capital is a capital investment in exchange for shares in a very young company. It supports the business until it can generate its own cash flow of or until it is ready for further investments. The funds can originate from 3Fs, business angels, crowdfunding and specialized VC Funds.

Series A, B, C, D… Rounds

The first round where VC Funds are fully involved is called Series A Round. The investors receive shares with preferential conditions (see Term Sheets). Follow-up investment rounds are called Series B, C, D… Generally, the invested amounts increase substantially, as the company gets traction in the market and opportunities for (international) expansion are exploited. VC Funds anticipate the fact that follow-up rounds are required and will budget accordingly.

Often this is the moment when BAs hit the limit of their investment abilities. Later on, when the start-up becomes a full scale-up, even the first generation of VCs reach their limits. Some large US VCs are can fund $100M+ investment rounds.

6.3.9 Exits

VC Funds are temporary investors. Within 12 tot 15 years the General Partners needs to return the funds to the Limited Partners; by then must have sold the shares they own. BAs too want a return on their own invested funds.

They can exit through mainly three mechanisms:

- either by selling the entirety of the company to another company, in a so-called Trade Sale. In that case the company loses its independence.
- or by bringing the company to the Stock Exchange in a so-called Initial Public Offer (IPO). In that case the company remains an independent entity. The VC can exit by selling its shares to the wider public.
- a third option is that another private investor buys over the shares of the initial investor in one of the investment rounds. This may happen when the life span of a VC Fund comes to the end, but no exit is planned in the short term. For Business Angels this form of exit is a realistic option.

Questions

What is according to you the current state of VC in your country?

Describe the projects in your university that could have benefitted from VC. Assess initial capital needs. Explain your reasoning.

To which institutions could you possibly turn for the capital required to start a VC Fund? Develop the pitch towards them.

6.4 Should Universities Start Venture Capital Funds?

Marc Goldchstein (Vrije Universiteit Brussel)

6.4.1 Should Public Authorities Start Venture Capital Funds?

Currently the VC industry is concentrated in a limited number of countries and regions. The absence of a VC industry not only affects the chances of success of KTT, it can also be an obstacle for other forms of growth-oriented entrepreneurship in a country. This illustrates the intertwinement of different dimensions in economic development, and therefore the need to have an integrated approach across these different dimensions.

In many countries public authorities play(ed) an important role in the establishment of a (U)VC industry. Authorities must evaluate whether they should encourage and support the development of a national VC industry, and more specifically, one focusing on universities. In the initial phases of development of a VC industry it may be a good idea to focus on establishing a generic VC industry, while using universities as one of the sources of projects.

6.4.2 Should Universities Start Venture Capital Funds?

Local circumstances may encourage the involvement of universities in Venture Capital initiatives. Legislation may limit the freedom to operate of academic partners in business-oriented activities. If such is the case, one should consider adapting the legislation.

Why should Universities Start Venture Capital Funds?

Once a VC industry is present it may be of interest to develop specific UVC Funds. In general, VC firms share two traits: they focus on those domains (industries, technologies) where their General Partners feel comfortable; and, while they are willing to take risks that are greater than most other financiers, they still avoid projects that are too risky in their eyes: too early stage, unknown team, unfamiliar technology…

The assessment of the project by KTTI may differ from the one made by VC's: KTTI is more familiar with the technology at hand and with the early TRL levels, while VCs aren't; KTTI may trust the team while the VCs don't...

These may be valid reasons to develop dedicated VC funds that focus on academic startups. Closeness facilitates the development of trust between investors and entrepreneurs; (but) it also makes the investment decision more personal. We discuss the related governance issues further in this chapter.

How should Universities Start Venture Capital Funds?

Universities must understand that setting up such UVC Funds from scratch is an important challenge which brings them outside of their comfort zone. Different dimensions need to be taken into account when starting a VC fund.

Funding

The capital needed to start a VC Fund is substantial. As indicated, in order to spread risks a fund must invest in a number of different projects. Moreover, sufficient funds are needed to make follow-on investments in the subsequent investment rounds.

The capital needed to start a VC Fund often comes from a combination of sources:

i. Financial players (banks, insurance companies, pension funds…) already invest in general purpose VC funds. UVC funds offers additional attractive dimensions: it links the capital provider to valuable societal initiatives; it gives early access to research-based innovation. But on the other hand, risks are higher when investing in earlier stage technology projects.

ii. Large corporations may be interested. They too, are looking for early access to novel technologies, both as an investment and from an internal perspective.

iii. Public authorities can play a role of catalyst. The authorities can either set up a separate VC fund, and/or co-fund private initiatives. Schemes whereby public authorities add to the capital raised by a private VC funds can be interesting. As the private investors have skin in the game, they will act with care. The additional funds allow VCs to invest larger amounts and take additional risks.
In some cases, authorities may require that the fund focuses on specific aspects; academic spin-offs can be such a focus.

iv. Academic institutions may invest some of their own resources.

v. Wealthy individuals, trusts and endowments can also be a source of capital.

Governance

Governance of the Fund is another key challenge. Who decides what, and how are these decisions made? Often, a separate organ makes the final investment decisions: the Investment Committee. Its task is to decide independently on investment proposals.

One of the important questions is in how far the General and/or Limited Partners are involved in decision making. The Investment Committee can be composed of the General Partners, who then decide among them. But often independent people, often industry veterans and sector specialists, are asked to sit on this Investment Committee; large Limited Partners may also have a representative on this Committee. In some instances, General Partners are not involved in the final decision making. Also, the degree to which co-funding public authorities wish to be involved in the decisions making differs strongly: some may request a seat on the Board of Directors and/or the Investment Committee, others trust the decisions of the Partners.

University-specific or Interuniversity VC funds?

UVC funds can either focus on projects of a single university (UVC) or of a group of universities: a so-called Inter-University Venture Capital (IUVC) Funds. The advantage of IUVC Funds is that the deal flow -the number of projects that are submitted for consideration- is substantially larger compared to UVCs. This allows for specialized General Partners, who are knowledgeable in certain industries. On the other hand, compared to UVC funds, the intimacy of contacts between investors and entrepreneurs is less. Note that this also has a positive side, as the assessment may be more objective.

The choice between university-specific, interuniversity and generic funds boils down to trade-off is between proximity to the entrepreneurs, presence of specialized sectoral expertise and size of initiative. Both models can work.

6.4.3 The challenges of setting up an (I)UVC Fund

As indicated above UVCs can be managed by KTTI staff. Dedicated resources may be needed for such project, but involvement of many members of KTTI is required (business, legal, organizational…). UVC funds may allocate the investment decision making to the Board of Directors or set up an independent Investment Committee.

IUVCs are almost always managed by professional investors; an Investment Committee may again take the final decisions on the investment proposal.

Irrespective of the organizational form: (I)UVC or generic funds, a number of requirements must be met:

- An experienced team: Making value judgements on untested products from an untested team in an untested market is hard. Prior experience in the VC industry is a great plus.
- Sufficient sectoral expertise: VC Funds need to have an understanding of the sectors in which they invest. As universities have a large diversity of potential projects, the VC Fund needs be able to answer to a wide range of requests. Note that in some cases sectorally focused UVC Funds can develop around a top-level research center.
- Sufficient deal flow: if the VC Fund cannot attract sufficient projects it cannot justify attracting dedicated resources.
- Independence: GPs must be able to take business-only decisions. Organizational politics must be kept at arm's length.
- Sufficient Funding: the VC fund must have access to enough capital to function on a large enough scale.
- Co-investors: as a rule, a VC never invests alone in a project. The availability of colleague-VCs in the ecosystem allows for risk spreading. If this is not the case the (I)UVC need sufficient capital to fund projects on their own.

One of the greatest challenges of (I)UVC funds is to effectively be willing take more risks than traditional VC funds. If (I)UVC funds use the same investment criteria and coves the same domains as regular VC funds, then their value is limited. The Investment Committee must be aware of the objectives of the (I)UVC and act accordingly. It must especially be open to a large field of application domains and to early stage projects.

6.4.4 Pro's and cons of UVC Funds vs. IUVC Funds

Pro's and cons depend very much on the governance structure of the Fund. The degree to which KTTI staff is involved in the management and decision making of the VC fund determines the degree to which both actors are aligned.

Relying heavily on KTTI for VC Fund management has a number of implications:

- KTTI must have a high degree of authority in deciding which projects to support.
- This is also the greatest weakness: another potential field of conflict between Researchers and KTTI arises. Besides IP valuation KTTI also controls access to VCs. The governance structure must be well thought through, and in case of refusal to invest in the project research groups must have the opportunity to reach out directly to external investors.

6.4.5 The limitations of (I)UVC funds

(I)UVC funds fulfill an important role in funding university start-ups, especially in the initial stages. Nevertheless, even they have an upper limit to their investment capacity. In case of very successful start-up later stage financing needs may exceed the ability of the (I)UVC fund. This should not limit the freedom of initiative of the entrepreneurs.

6.4.6 The VUB experience

The VUB is currently at its third (I)UVC Fund. The first fund, Brussels Imagination, Innovation and Incubation Fund (BI3) was a VUB-only fund, while QBic I and II are IUVCs, regrouping the majority of Flemish universities and a number of other (research-related) institutions (such as hospitals).

VUB's purpose with BI3 was to invest in startups related to the VUB in an early stage, when other investors were not interested to take the risk. The aim of QBic I's was to finance the technological spin-offs of the university associations in Ghent, Brussels and Antwerp; Qbic II invests in companies which use the research of University of Ghent, University of Antwerp, VUB, University of Liège and the research centers VITO and IMEC.

Funding

BI3 raised €6 Million, more than 90% of which came from major banks and insurance companies; the remainder came from the university and a public investment fund.

QBic I raised € 40,7 million and Qbic II € 58,9 million. Here too, a number of banks and insurance companies, as well as public investment vehicles were involved.

Governance

For BI3 The Board of Directors was the central decision-making organism, while VUB TechTransfer was the operational arm of the organization. VUB TechTransfer managed the contacts with the spin-offs (-in preparation), formulated investment proposals and represented BI3 in the Board of Directors of the spin-offs. No separate Investment Committee was installed.

QBIC installed an Investment committee with heavyweights from Venture Capital and industry (especially life sciences and electronics).

In Qbic II the Investment Committee consists of the three General Partners, three independent experts, one representative of the Shareholders Advisory Board and one representative of the Strategic Committee, the committee that controls the link of the projects to universities.

Results

BI3 recently closed down. The Fund invested in 8 spin-offs of the Vrije Universiteit Brussel, one of them being Collibra, the first Belgian unicorn. Thanks mainly to this project the fund generated a positive return. The two other funds are still underway.

Questions

1. What are according to you in your country the most important obstacles and opportunities for setting up VC/UVC/IUVC funds?
2. Assess the opportunity of starting an IUVC Fund between the universities in your country:
3. List universities and research institutions which could be part of the initiative
4. For each university and research institution: list known potential investment projects over a 5-year period.
5. Discuss the spread of the projects over different economic sectors; assess the type of specialists do you will need on-board in the IUVC
6. List possible funding sources for the VC fund:
7. Public Authorities, Banks, Pension Funds, Insurance Companies, Corporations, Alumni, donations…
8. Identify network contacts

6.5 Funding opportunities for KTT in Vietnam

6.5.1 Funding opportunities in the North Vietnam

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It can be said that in Vietnam, the funding sources for KTT activities aimed at promoting innovation in research units such as universities and businesses are developing strongly. These funds may come from the public sector (the State) or from the private sector (big corporations or venture capital funds). These fundings and programs will be generally outlined below. The detail informations including application procedure and requirments can be accessed from program's website or representative office.

National Foundation for Science and Technology Development

National Foundation for Science and Technology Development (NAFOSTED) aims to improve the quality of scientific research for universities through funding basic research for young scientists to develop research capacity and create research networks at home and abroad. Annually, NAFOSTED announces the call on website (nafosted.gov.vn) including the submission procedure. The grant is around 300,000 Euro for 2 -3 years of project with the output of SCI/SCIE articles. NAFOSTED is not directed towards KTT activities, however it supports the creation of valuable basic research results for commercialization and transfer.

Project to support the creative innovation ecosystem - Program 844

Project 844 (http://dean844.most.gov.vn) aims to support the entrepreneurship and innovation ecosystem. The total fund of about VND 1,000 billion will support 800 projects, 200 start-ups. This is the source of funding that universities, research institutes and organizations related to innovation activities such as training, management, service delivery organization, telecommunications, incubation, etc. can reach for assistance in carrying out their activities.

Along with Program 844, other programs and funds have been formed such as Small and Medium Enterprise Development Fund (SMEDF, http://phattriendnnvv.mpi.gov.vn) covering small and medium enterprise support programs for innovation and creation, Project 939 to support women to start a business (startup.gov.vn), and Project 1665 to support students to start a business and focus on specific objects.

National Technology Innovation fund - NATIF

NATIF was established in 2011 to improve the growth quality of the economy, innovate the growth model in the direction of taking science, technology and innovation activities as a foundation. With a chartered capital of VND 1,000 billion, NATIF provides great opportunities for the scientific community and businesses to seek solutions to innovate technology for developing new products, improving the added value of products and services, and enhancing the competitiveness of businesses (http://old.natif.vn).

Hanoi startup support scheme

Not only at the national level but also in Hanoi City and many neighboring provinces, there are also funding sources for start-ups and innovation. Hanoi City has a project to support start-up businesses in the city by 2020 (according to Decision No. 4665/QD-UBND of Hanoi City) with the objective of supporting the development of 500 innovative start-up projects including 150 innovative start-up businesses in commercializing products. The project is aimed at individuals who have start-up projects, small and medium enterprises with creative startups, organizations providing services, material and technical facilities, communication and investment organizations for startups, and domestic and foreign investment funds.

Private innovation funds, venture capital, and angel investment funds

Additional to Government funds/program, there are also many private innovation funds, venture capital funds, and a network of angel investors in Vietnam who are ready to support innovation and start-up activities in the country. Currently, there are more than active 40 venture capital funds (according to the information from startup.gov.vn) (see section 7.5b and 7.5c). Morevoer, many large domestic corporations have participated in venture investment, such as FPT, Viettel, Vingroup, CMC, CenGroup, etc.

Vingroup Innovation Foundation (VINIF) (http://vinif.org), recently established by Vingroup, has the function of supporting organizations and individuals to conduct scientific and technological research, innovation and creation. VINIF focuses on more than 50 leading research institutes and universities across the country that signed a cooperation agreement with Vingroup, final year students, lecturers, and Vietnamese scientists working in Vietnam and abroad. Every year, VINIF organizes programs and activities to support, sponsor research institutes, universities, young researchers and individuals working in different field with the orientation to create products and technology solutions that bring practical benefits to the community.

Conclusions

It can be said that the opportunity of funding sources to support the current activities of knowledge and technology transfer in Vietnam in general and the Northern region in particular is tremendous. Understanding the scopes and targets of each funding source is very important for startups, researchers, intuitions and organizations to select effectively the appropriate funding source.

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6.5.2 Funding opportunities for KTT in Vietnam: in the central Vietnam

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Currently at the national level, there are many opportunities to seek investment for technology transfer, incubation, innovation as well as product commercialization through different programs at the national level, such as the Program to support the development of science and technology enterprises and public scientific and technological organizations on the basis of autonomous mechanism operations and self-responsibility (Decision 592/QD-TTg dated May 22, 2014); the Program to support national entrepreneurship, innovation and creation ecosystems until 2025 (Project 844); and the Program to develop the science and technology market until 2020 (No. 2075/QD-TTg dated November 8, 2013). However, there are not many big enterprises or big investment funds that are ready to provide financial support for start-up projects as well as commercialize products in the Central region. It is more difficult to seek funds for investment in incubation and technology transfer than in Hanoi and Ho Chi Minh City, although there are 2 major universities, Hue University and Da Nang University, who have the good science and technology potential to create commercial products.

Current situation of technology transfer activities in Vietnam and the Central region

According to the report of the Ministry of Science and Technology, in the 2006-2016 period, technology transfer in Vietnam has taken place but is not really strong, not yet as expected to contribute to socio-economic development throughout the country.

Technology transfer activities in Vietnam have not been achieved the expected results. Research results are not applicable to production practices, not meeting the needs of enterprises. The number and value of technology transfer contracts are low. Not many businesses are interested in investing in research and technology transfer activities.

[Source: https://bnews.vn/thuc-trang-chuyen-giao-cong-nghe-tai-viet-nam/54690.html].

As you know, the big firms often concentrate at big city, such as Ha Noi capital and Ho Chi Minh city, because in these they have much chances to develop for their company, addition, the North and the South of Vietnam where are the highest product consuming regions of the country. Beside, the central Vietnam where have bad weather and flood that often happen every year. May be, these are one of reasons the central regions are very difficult to find out opportunity to seek investment for every activities in which including both KTT and start-up.

Even so, Hue University still must be founded two centers, that were Center for Incubation & Technology Transfer and a Center for Entrepreneurship and Innovation for U-I connection to make ideas become products as well as to apply scientific research results into practices. However, technology transfer activities are still faced with difficulties due to inadequate policies and mechanisms.

Funding sources for technology transfer and innovation in Vietnam and Central Vietnam.

Opportunity to seek investment at the national level

Currently, there are many sources to support the activities of technology transfer, innovation on the national scale. The Prime Minister has given Decision No. 1069/QD-TTg dated July 4, 2014 approving the Program for foreign technology search and transfer by 2020. The Program aims at finding, evaluating, consulting and transferring advanced technology in the world, timely meeting the demand for development of new technology products and services, contributing to improving productivity, quality, added value of products of Vietnamese enterprise. The Prime Minister has released Decision No. 1381/QD-TTg dated July 12, 2016 on amending and supplementing a number of contents of Decision 592/QD-TTg dated May 22, 2014 of the Prime Minister on the decision to approve the Program on supporting the development of science and technology enterprises and public scientific and technological organizations to implement autonomous mechanism and self-responsibility. Decision No. 844/QD-TTg dated May 18, 2016 of the Prime Minister on supporting the ecosystem of national entrepreneurship and innovation up to 2025, supporting students to start up their businesses until the year 2025, and supporting women to start up their businesses in the 2017-2025 period has been approved and implemented with the goal of supporting startups with their development potentials. In this project, the Center for Entrepreneurship and Innovation, Hue University was supported VND 1.5 billion (EUR ~60,000) in 2019 and VND 2.5 billion (EUR ~ 100,000) in 2020. The program will support for individual, groups that have start-up project, enterpreneurship business and organization where supply service, material-technical, investment, communication for entrepreneurship and innovation that is effective activities even. Beside that the Prime Minister have given Decision No. 1665/QD-TTg dated October 30 2017 approving the program support for start-up in pupil, student until to 2025. In this project, the Center for Entrepreneurship and Innovation, Hue University was supported VND 200 million (EUR ~8,000) in 2019 and in 2020-2025 the funding have to belong eachs group competition capacity. In addition, the Ministry of Science and Technology has also implemented a number of outstanding programs and projects such as the BIPP project funded by the Belgian government to support start-up incubation; the VCIC project funded by the World Bank and the Australian Government to support creative startups to cope with climate change. Apart from seeking fundings from the national budget start-up programs, Korean DT&I Investment Fund decides to invest USD 1.4 million in Startup Propzy in the second quarter of 2019. The VinaCapital Foundation will sign a strategic cooperation agreement with two Korean Funds to mark the Fund's intention to invest USD 100 million for startups in Vietnam within the next three years. The representatives of the European Chamber of Commerce in Vietnam (EuroCham) also share the information about the latest EU Fund, worth 3 billion euros for start-ups. In total, there are 18 domestic and foreign investment funds committed to spent USD 425 million, equivalent to about VND 10,000 billion, to invest in startups in Vietnam in the next 3 years. [Source: http://vneconomy.vn/18-quy-dau-tu-cam-ket-rot-10000-ty-dong-cho-cong-dong-startup-viet-20190610124024169.htm].

Opportunity to seek investment in the Central region

The central region of Vietnam spreads from Thanh Hoa province to Binh Thuan province, including the Central Highlands region. The development of incubators and technology transfer activities are mainly concentrated in Hue (Hue University) and Da Nang (Da Nang University). To seek investment for technology transfer, incubation, product commercialization as well as start-up innovation in the Central region; the Department of Science and Technology at the two provinces/cities have programs for approving scientific and technological research projects. Enterprises in the region in start-up projects with good ideas as well as commercialization-potential products have the opportunity to seek investment support.

Hue University is always at the forefront of incubation, technology transfer and innovation in the Central region. Currently Hue University has a Center for Entrepreneurship and Innovation and a Center for Incubation and Technology Transfer as a focal point in connecting businesses to develop and commercialize products.

Da Nang is in need of establishing an Innovation and Creation Center that is organized in the form of a harmonious combination of a public non-business unit and a business operation mechanism to provide start-ups services as well as to connect other innovation centers to create an innovative community in Da Nang. This center is also to support universities and colleges with training programs related to innovation, events, technology transfer activities etc., and to support start-ups in connecting businesses to sell their products.

There are some investors at central of Vietnam such as: Thua Thien Hue development investment fund (06 Phan Boi Chau St. Hue city), VN Da Thanh Group (105 Le Loi St., Thach Thang, Hai Chau, Da Nang city). Beside that, at central region, we could call supporting sources from angel investors netwoking, in which there were 2 angel investors at Thua Thien Hue province: BAO KHANH CO,. Ltd and Duc Cuong Granit Co., Ltd who supported for 3 start-up groups belong Center for Entrepreneurship and Innovation, Hue University was VND 01 billion (EUR ~ 40,000). Beside, start up and KTT activities still can call support funding from provinces and Hue University budget.

Opportunity to seek investment from others for central region.

Not only finding opportunity to seek investment from national level and central region of Vietnam for start up center and technology transfer activities at Hue University but also can call investment from others region outside central. At 2018, the Center for Entrepreneurship and Innovation, Hue University was supported 2,800 € by EVENT project and 7,500 € (2018); 15,000 € (2019) by AUF (Agence University France) for star up and innovation activities.

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6.5.3 Funding opportunities for KTT in Southern Vietnam

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Research and KTT funds are divided from the country level to the university level. Except for the university level, the funding for scientific research and KTT is granted to all researchers in Vietnam. In addition, some regions also have their own funding for scientific and technological activities, such as the funding for sustainable development of the Mekong Delta, Vietnam. Enterprises are also focusing on research and KTT, such as Vingroup Innovation Foundation. Recently, there have been a number of venture capital funds to support young startups and enterprises.

Introduction

Vietnam, dividing into 63 provinces and 5 municipalities, is grouped into 3 macro-regions: Northern, Central, and Southern. The Southern region consists of 17 provinces and 2 municipalities, which are divided into 2 main sub-regions: the Southeast and the Southwest Region. The Southeast region has 1 municipality (Ho Chi Minh City) and 5 provinces: Binh Phuoc, Binh Duong, Dong Nai, Tay Ninh, Ba Ria-Vung Tau. The Mekong Delta, also known as the Southwest region, is known as the Western Region, which has 1 municipality (Can Tho City) and 12 provinces: Long An, Dong Thap, Tien Giang and An Giang. Ben Tre, Vinh Long, Tra Vinh, Hau Giang, Kien Giang. Soc Trang, Bac Lieu and Ca Mau. Each province or municipality has its own budget for socio-economic development. In particular, part of the budget is used for scientific and technological development. In addition, the Southwest Region also has a budget for scientific and technological development.

From the Vietnam Government Budget, funding sources are divided into central budget and local budget. The central budget includes a balanced budget from the Ministry of Science and Technology and other Ministries, Such as Ministry of Education and Training. Local budgets are sources to be balanced from the budget of the provinces and municipalities. From founds outside the state budget including from enterprises and from universities. The remaining funding comes from overseas. According to management level, the funds for scientific research and KTT in Vietnam are divided into different levels: State, region, ministry, province, and university level. In particular, the funds due to the region are specific to the development of science and technology in that area. For example, the scientific research fund of the Southwest region. In addition, there are research and KTT funds by corporations, such as Vingroup Innovation Foundation.

Funding opportunities for scientific research and KTT

Funds for scientific research and KTT are offered under research program and projects with different levels: country level, ministry level, city level, university level, and other.

Funding for scientific research and KTT with country level

These are national key scientific research programs, country-level projects, or international cooperation protocols. Funding for the programs/projects with country level is up to hundreds of billions of Vietnam Dong. These programs/projects are decided by the Minister of Science and Technology to implement or approve the list. In the Southern Vietnam, the research program of the Southwest Region is also at country level.

Funding for the projects with ministry level

Most universities in Vietnam are managed by the MOET. However, some universities are managed by other Ministries, such as Unver ties of Medicine and Pharmacy belong to Ministry of

Public Health, Universities of Industry belong to Ministry of Industry & Trade, and so on. These ministries often have the funds to the university that they manage to implement the research project. These projects usually are from 2 to 3 years with funding up to a billion Vietnam Dong and are approved by the ministries

Funding for the projects with province/ municipality level

Each province or municipality always spends a budget for scientific research and KTT to bring sustainable development to the province or municipality. The budget is granted to researchers under research projects. Each project has a budget and a level equivalent to the Mistry level project. Projects usually take from 1 to 3 years and are applied research. The projects are approved by the chairman of the city people's committee.

Funding for the projects with University level

Vietnamese universities also have funding for scientific research and KTT. The funding is granted to the researcher in the form of a project. The funding for these projects is small (about 50 millions of Vietnamese Dong) and usually lasts from a few months to a year. The projects are approved by the Rectors of Universities. In addition, there are two national universities in Vietnam: Hanoi National University and Ho Chi Minh City National University. Each research project of these two universities has a budget up to hundred million. Therefore, some research projects are considered equivalent to the ministry-level project.

Other funding

The research projects are usually funded from foreign governments (not protocol projects) or companies.

Startup Vietnam Foundation

Venture capital funds

In recent years, the Vietnamese government is very interested in startup. Venture capital funds are also formed to support young entrepreneurs and startup businesses. Currently, Vietnam has about 37 investors for startups and young entrepreneurs.

Crowdfunding

Currently, Vietnamese law has not allowed the establishment of crowdfunding. So, crowdfunding in Vietnam has not officially established.

Supporting of KTT

Recently, to develop science and technology, technology transfer as well as startups, the Vietnamese government has issued many policies. The Law on supporting of small- and medium-sized enterprises (SMEs) was issued in 2017 focuses on supporting SMEs and Start-up [1]. Decision No 844/QD-TTg dated May 18th, 2016 approval for assistance policies on national innovative startup ecosystem to 2025 [2]. Decree No. 76/2018/ND-CP dated May 15th, 2018 of the government on providing guidelines for certain articles of the law on technology transfer [3]. Addition, we also have the funds to support for science and technology projects or technology transfer under provides grants, loan interest grants, preferential loans, and lending guarantees for research, technology transfer, and technology innovation. Two big funds managed by the Vietnamese Ministry of Science and Technology are: (1) The National Foundation for Science and Technology Development (NAFOSTED) was established by the Vietnamese government as a funding agency in 2003 and officially started operation in 2008 [4]. (2) The National Technology Innovation Fund (NATIF) was established in 2011 and officially started operation in 2015 [5]. Both funds are operating for non-profit purpose.

Conclusions

In general, funds for scientific research and KTT are very diverse. In the Southern Vietnam, besides the national funds, we also have the regional funds that are managed by provinces, municipalities, as well as main sub-regions. Venture capital funds can also be found in the Southern Vietnam, but crowdfunding has not established yet due to the Vietnamese law.

Questions

1. What are the venture capital funds in southern Vietnam?
2. What are NAFOSTED and NATIF? What are the missions of them?
3. What are recent policies of the Vietnamese government to unlock KTT?

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7. Governance

7.1 KTT Governance (Centralized vs. De-Centralized TTOs)

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During the last decades – especially since the late 1970s – universities have experienced various changes in their governance structure (see Geuna, 1999). Amongst others, particularly the organization and the implementation of knowledge and technology transfer (KTT) activities was focused on (e.g. compare Gibbons et al. (1994) on *triple helix*). These activities are usually coordinated via dedicated technology transfer offices (TTO). Integrating TTOs into a university structure requires certain considerations about the purpose, scope, size and budget topics (e.g., Dodds, 2007). Accordingly, various suggestions have been made how to best integrate a TTO into a university organization (Matkin, 1997). This section briefly discusses general organizational factors for TTOs and subsequently outlines centralized and decentralized elements of TTO governance.

7.1.1 General organizational factors

A key determining factor of TTO organization is its scope, which should be discussed prior to setting up its operation. Matkin (1997) discusses organizational models for TTOs and how they fit needs of a modern university. Further, he mentions the dynamic nature of an organizational set up (which can change over time) and the importance of a cultural match. Moreover, he stresses the commitment of the universities' leadership as a success factor. From a more heuristic angle, Dodds & Somersalo (2007) and Nelsen (2007) discuss mainly two scoping options. First, the more restricted view of a TTO, which means to be solely focused on KTT into the industry with commercial intent. Thus the TTO acts as an "assistant for the legal transfer of technology and research" (Dodds & Somersalo, 2007).

Second, the rather open view under a broader scope. This scope has low or no commercial intent and views TTOs as to convey KTT into the society. The main purpose of a noncommercial TTO would be founded in teaching, building and maintaining research networks, and fostering research project cooperation in order to contribute to society (Nelsen, 2007).

Kruecken (2003) points out that the tasks attributed to TTOs influence the organizational subdivision. This means, that the 'form' interpreted as the organizational design, the physical infrastructure, the staffing, the funding, etc. shall serve to fulfil the intended 'function'. A TTO acting under purely commercial objectives requires a different set of skills (e.g. lawyers, patent agents) and organizational setup (e.g. location to patent office and law firms, operating business model) than a TTO operating under noncommercial terms. Hence, the organizational setup needs to be adjusted (location on campus, funding) accordingly. It should also take universities' mission and vision into account to ensure the "cultural" fit.

7.1.2 Organizational anchoring of TTOs

Matkin (1997) describes how American universities have placed technology transfer activities within their organizational structure. On the one hand, the *Integrated Organization* is emphasized and characterized as a faculty operated technology transfer organization, rarely seen as a distinct university unit. The faculties report to a dean or academic officer and "require heavy faculty involvement, providing resources to a department (…) rather than to the university as a whole" (Matkin, 1997). Conversely, the *Peripheral Organization* is outlined as a separated, non-faculty operating unit with an identifiable compartment and administrative staff. Figure 1 shows the three most common organizational models: internal, external, and mixed (Brescia et al., 2014).

TTO structures differ by their degree of centralization, as well as, communication or reporting format. According to Bercovitz et al. (2006), four organizational structures could be identified which use the degree of centralization of the TTO as key characteristic: the Unitary or U-Form, the multidivisional structure (M-Form), the holding (H-form) and the Matrix structure (MX-Form). As shown in figure 2, the degree of centralization plays a vital role and deserves some further discussion in the following.

Centralization

According to Matkin (1997), centralized TTOs, specifically defined as *Peripheral Organizations*, enable a considerable simpler control and coordination for the university administration. An important benefit is that professionals are employed whose "job is to perform (technology transfer) activities" (Matkin, 1997). Furthermore, within the strongly centralized U-Form, a vertical control structure is given. Hence, coordination across units can be performed relatively easily. For faculties, it is problematic to perform transfer efficiently, as knowledge transfer with commercial intentions is not a core-activity of the university. This is crucial as the decision to actively engage in technology transfer by universities is strongly dependent on faculty involvement. Bercovitz & Feldman (2006) find that active involvement in technology transfer by the chairs of the department influences other members of the department significantly. Therefore, a centralized TTO can give the faculties the impression that KKT is something "far away" or "not my business". Due to peer effects this attitude is likely to lead to whole departments, which are resistant to KTT efforts.

In sum, a centralized TTO enables stability within the whole university organization, accountability and a better control and coordination of transfer activities. Moreover, it can provide a "one-stop-entry-point" for outsiders more easily. However, the centralized model decreases identification with the KTT objective (if not already strong within departments) and increases perceived distance between researcher and TTO as a mediating institution.

Decentralization

The decentralized model of TTO refers to an organizational structure where faculties administrate transfer activities independently. An advantageous effect of the model is the encouragement of faculties to interact with different internal stakeholders, but also with the external market. This helps to increase the universities' culture in favor of technology transfer.

The M-Form and H-Form that are also characterized by a decentralized decision-power allocation have a strong information processing capacity that consequently enables faster responses. However, coordination across the units within the decentralized H-Form is difficult. In contrast, as the M-Form is characterized by a central coordination unit, the top-down coordination is considerably better. Furthermore, for both forms of decentralized power allocation, incentives across units are difficult to promote, as organizational ties are rather weak.

In sum, a decentralized structure increases the risk of sole decision making within the faculty units, which may not be in the interest of the university as a whole. Moreover, bargaining power towards outsiders is reduced. Separation of KTT activities may be a result of diverging emphasis on commercial activities and traditional incentive schemes of universities. Decentralized TTOs may therefore be beneficial if KTT affine units are few and flexibility and speed in decision making outrank bargaining power and the need for central coordination.

Hybrid Models

Modern organizational structures for TTOs usually combine centralized and decentralized elements to leverage advantages of the two idealized models. Centralized offices coordinate contracts and legal obligations (disclosure, patent applications, research contracts), but also engage in active technology marketing and networking with industry partners. This central unit gains in efficiency through task specialization and catering of the whole university, even if individual disclosure of inventions or contracts with industry are relatively rare. Bargaining power with externals is also increased, because the office represents the whole university. In order to increase contacts and identification with individual researchers they are usually companied by internal "scouts" or "innovation managers", who have offices in schools, departments or colleges. They report to the TTO, but work with individual researchers more closely (and may have an academic background in a related field). Additionally, these scouts can also be used to facilitate communication between university leadership and individual researchers.

7.1.3 Concluding remarks

The successful integration of commercial activities relies on the acceptance of university members. If designed accordingly, organizational support structures can have an impact on academic entrepreneurship and increase the likelihood of successfully responding to the needs of industry. Externalization of transfer activities harbors the risk of a negative attitude towards KTT activities and might lead to neglected support of commercialization. In contrast, the internal establishment of a TTO increases the likelihood of successful adoption, but is relatively costly. More so if central and decentral elements are combined as is common practice in developed countries.

A careful analysis of KTT relevant units within a university might help to shed light on whether a full-fledge central TTO is needed. Furthermore, instead of assuming full-time equivalents when thinking TT-managers or scouts, a conceptualization along the line of "roles" may be sensible. For example, scouting and support duties in departments could be undertaken by "normal" researchers or lecturers if there teaching and/or research load would be reduced at the same time.

Learning Questions and Discussion:

1. What is the difference between "integrated" and "peripheral" organization with regard to KTT activities in universities? Which model do you believe to be more suited for the current situation at your university/organization?
2. How would you characterize the trade-off between efficiency (cost-benefit, speed) and effectiveness (receiving good inventions for transfer from faculty) of a highly professionalized TTO? What is the danger if TTOs "loose contact" to the researching faculty?
3. What would be benefits of "centralized" and "decentralized" elements of KTT at your university/organization? What could be examples of those elements and how could they work?

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Figure 1: Excerpt of TTO models (Brescia et al., 2014)

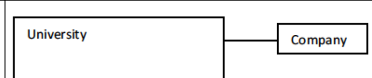
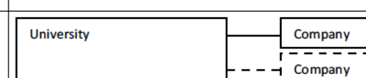
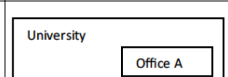
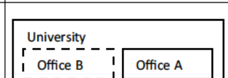
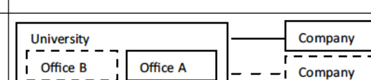
Model	Description	Configurations	Description	
EXTERNAL	The KTOs are independent companies outside the university	E-SINGLE	The KTO activities are conducted by a 'single' company fully owned by the university or by a consultancy company of which the university is a customer	
		E-MULTI	The KTO activities are managed by different companies, two or more, with specific focuses	
		E-JOINT	The KTO activities are conducted by a 'shared' company that works for different universities.	
INTERNAL	The KTO activities and processes are managed by dedicated internal offices	I-SINGLE	All activities related to the KTO processes (patenting, licensing, legal agreements, sponsored research contract and entrepreneurship support) are managed by a single office.	
		I-MULTI	Some universities do not centralize all KTO activities in one office. They create two or more offices each managing specific KTO activities.	
MIX	The KTO activities are divided between internal and external structures	MIX	This model is made up of different actors, an internal office (single or multiple) and an external company (owned or consulting company).	

Figure 2: Competencies of alternative organizational structures (Bercovitz et al., 2006)

Organizational structure	Information-processing capacity	Coordination capability (across units)	Incentive alignment (across units)
U-Form	0 Limited by HQ size; the need to funnel decisions through top management group creates a bottleneck	Coordination capabilities among sequential work units are relatively strong given vertical control	0 Difficult to create unit-level incentives compatible across units and in-line with organizational goals
H-Fom	Decentralized decision-making leads to higher overall information-processing capacity	0 Weak central body allows for limited top-down coordination across units	0 Strong unit-level incentives; sub-goal pursuit often problematic due to weak organizational ties
M-Form	Decentralized decision-making leads to higher overall information-processing capacity within units	Strong central body allows for moderate top-down coordination across units	Strong unit-level incentives; Sub-goal pursuit problematic but tempered by stronger organizational ties
MX-Form	Multiple dimension responsibilities may tax information processing capacity within units	Dual Dimension responsibilities drive coordinated action	Dual Incentives: Functional and product incentives are integrated to reflect organizational goals

Impact on Capabilities: 0 weak; semi-strong; strong

7.2 The role of Technology Transfer Offices in research driven universities: it's organization and critical success factors.

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This paper intends to contribute to a better understanding of the role of the technology transfer offices (TTO) and its organization in the process of transferring the results of research into new products or services that can be adopted by companies. Independently of the centralized or de-centralized TTO governance, the TTO should have the necessary level of governance autonomy, as well as a strategic flexibility and a financial autonomy in order to provide the best valorization knowledge service to the university community. However, the governance of the TTO should be aware of the expectations of all stakeholders, both formal or informal, in order to align the common objectives such as the contribution to the university income, to the creation of new companies and qualified jobs, to the valorization of university trademarks and to increase the transfer of the research results to society (public and private entities).

The TTO organization should also take in consideration the university knowledge workflow and value chain, in order to align its front and back-office operations with all the interface structures that are located in the different schools, departments and research units. Like mentioned by Campbell (2007), a TTO should be aligned with and supported by the institution it serves, being consistent with its mission and adding value to it. This statement is also reinforced by Young (2007), that advocates that a TTO should possess some key characteristics such as transparent policies and procedures, entrepreneurial staff, strong links to potential industry partners and access to risk or venture capital.

The strategic flexibility of the TTO should also allow the implementation of co-action activities (co-creation, co-develop, co-transfer) with industrial and commercial partners, in order to promote innovation-driven joint research between the academic and industrial researchers. Such co-action activities will be the trigger for the reinforcement relations between the TTO and the regional innovation partners of the university (incubators, science parks, chambers of commerce, technological centers, industrial clusters, etc.). Nevertheless, the *modus operandi* of TTO staff should promote an intrinsic relation (technical, scientific and social) with all academic members (students, professors and researchers), having also a clear understanding of the external partners (business and industry) challenges and needs. Due to the fact that the TTO activities are not restricted to the university region, a consolidated international network should be required to get contacts, knowledge and the international best practices in technology transfer.

Taking in consideration that the TTO is the interface structure that should represent the interests of universities in the relations with society (companies and industries), namely in the definition of industry pathway to the access of research results, inventions and new innovative products or services, in our opinion the terminology that should be adopted is KTO - Knowledge Transfer Office instead of TTO - Technology Transfer Office. However, due to the fact that the acronym of TTO is already well embedded in the innovation community and policy makers we will use it, nevertheless the meaning of "technology" should be understood in a more knowledge-based broad sense.

Given that the majority of the research results have a very long and complex route to the market, the function of TTO attempts to provide one of the many answers needed to the challenges raised by the European Paradox[2]. Based on that, nowadays it is well known and extensively documented that TTO operations should be understood from the perspective of uncertainty and non-linearity characteristics of the innovation process (Debackere, 2012). Besides that, in the last years the majority of European universities have economical stringency imposed by the governments which creates new expectations in the TTO function, namely, in the management of intellectual property portfolio and in the exploitation and commercialization of scientific discoveries. Taking this into account and considering also the role of the universities in the regional development context, the TTO has now a larger scope including the relations with small and medium enterprises (SME), as well as the entrepreneurship promotion and the support in the creation of new spin-off companies.

7.2.1 TTO Organization

Nowadays the TTO activities has a considerable weight in the so called third mission of the universities due to the multidisciplinary demands from society as well as to the necessary synergies across its core mission (education and research). Taking this into account and considering the reality of each university, it is reckless to indicate one common formula that will fit all the scenarios and resources available in each institution. Nevertheless, based on the best practices of UATEC (Technology Transfer Unit of the University of Aveiro), a TTO organization should have, at least, the following offices:

Marketing Office - This office should be responsible for the entire communication of the TTO, following the rules and the communication strategy of the university. Being the main target of the potential TTO digital citizens (the so-called Z Generation), forcibly the way of its communication should be laid in the social platforms (Facebook, Linkedin, Instagram, etc) and in a modern and actualized web page. The organization of events, such as training courses, workshops and conferences should also be their responsibility as well as all the TTO front office and the internal intermediation with other TTO offices.

Intellectual Property Office - This office should manage all the assets related to intellectual property (IP) that belongs to the university. The management of invention disclosures, the drafting of patents and relations with IP attorneys, the registration of intellectual property rights (IPR) in the national offices and the control of intellectual property portfolio are their main tasks.

Licensing Office - The technological screening activities, the drafting of technological offers, the scouting and valuation of IPR, the market search of potential licensees, the negotiation of license contracts as well as the management of pos-license process are some of the more important activities that the licensing office should perform.

Entrepreneurship Office - This office is responsible for one of the most important tasks that TTO nowadays should provide to the academia, i.e., induce in each student, professor or researcher an entrepreneurial culture/mindset. To do so, this office should promote and organize entrepreneurship events, such as: workshops, courses, acceleration programs, bootcamps, business idea contests, etc. The supporting of students, researchers and faculty members that are willing to explore commercially the knowledge generated in university, should be made by these staff through business consulting and business development activities. The management of business idea disclosures, the development of mentors and proof-of-concept programs, as well as the

[2] European Commission Green Paper 1995

support in seeking funding and giving guidance in the negotiation process with investors, are some of the knowledge valorization activities provided by this office.

Liaison Office - The promotion and management of the links with companies should be supervised by this office, in order to guarantee that the university's public goods, that could be available on the market, are made at fare prices and according to the free competition laws. The management of consulting services, collaborative research and research and development (R&D) funding applications are some of the activities provided by this office.

7.2.2 TTO Critical Success Factors

The key role of people, namely TTO staff, professors and researchers, are one of the main critical factors guarantee the success on a TTO. In fact, the absence of the existence of one well recognized technology transfer career, in the majority of universities, is one of the biggest barriers for the maintenance of a stable and organized TTO team. Campbell (2007) mentioned that there is no rule for the type of background that TTO staff need, since most of it could be learned on the job or by specific training. Despite this, in a research-intensive university, the specialization and professionalization of the TTO staff is fundamental to achieve the best performance of TTO in order to serve business and academic community in the valorization of the scientific discoveries. Besides that, an efficient services administration, namely at the juridical and financial level is crucial for the maintenance and accomplishment of the contracts with companies. Nevertheless, the TTO staff should understand very well the academic environment and its *modus operandi*, in order to give their insights and experience with the business environment enabling the promotion of knowledge transfer to society. As mentioned before, it is crucial that the research driven universities give a clear message to academia as well as to the companies that the TTO has the necessary autonomy and freedom to operate in its name, in order to protect the status of professors and researchers in the negotiation processes with companies. In fact, the management of TTO staff in negotiation process will avoid any conflict of interest as well as will protect the image and the position of the faculty members in the future relationships with companies.

Other very important key role in the success of a TTO is the involvement of professors and researchers in the technology transfer processes. Indeed, they are one of the most important triggers in the relation with companies. From the perspective of TTO staff, as well as from the leadership of universities, they should not be seen only as suppliers of knowledge or technologies, but they should be seen as one of the main valorization agents. In order to ensure their constant involvement, internal incentives at economic and career levels should be created, i.e., the universities should have clear regulations that defines their rights and obligations as well as an evaluation system that take in consideration all the technology transfer activities developed by them. Besides that, special attention should be given to the definition of code-of-conduct in order to avoid any conflict of interest in the relations of professors and researchers in license contracts or spin-offs creation.

Another critical success factor already mentioned above is related with the juridical and financial autonomy of TTO, since the majority of European universities are public funding. The creation of some legal framework (like company or non-profit association) or a clear statement from the leadership of universities, given governance and function autonomy to the TTO, is mandatory to facilitate the transfer of research results financed by public funds to the market. The TTO autonomy should be promoted according to the structure and process that best fit the interest of universities.

The democratization of TTO activities through the promotion and implementation of a transversal structure should be one of the most important critical success factors for the new TTO generation, i.e., the central TTO should create smaller infrastructures in departments, schools and research units that will "replicate" some of their upstream functions and activities in order to develop innovation-drive joint research platforms where researchers from universities and companies work together in co-creation, co-developing and co-transferring activities.

7.2.3 TTO Internal Network

Taking into consideration that the resources available for a TTO are finite and scarce, mainly at human resources level, it is suitable to define new strategies and operational plans in order to overlap this strong need, as well as to turn the TTO more inclusive and integrated in the activities of education and research in universities. We report some practical measures implemented by UATEC that could be seen as a starting point of an internal technology transfer network creation. This network starts with the implementation of the UATEC Pivots, UATEC Technological Platforms and UATEC Mentors Club (MentAll).

The UATEC Pivots were created in order to potentiate the relation between the TTO and the Departments, Schools and Research Units through the appointment of one (professor, researcher or technician) representative member. The UATEC Pivots has the responsibility to be the intermediary and facilitator of the process related with Intellectual Property Office, Entrepreneurship Office and Liaison Office. This win-win 4 year mandate relation is normally materialized by the continual training provided by UATEC staff to Pivots in technology transfer, for one hand, and for the other, Pivots will give training to the TTO internal network members about competences, services and research results developed in his department, school or research unit.

UATEC Technological Platforms were virtual structures that had a supra department and supra research unit mandate to transfer knowledge of excellence and the technological means developed at the university to business sectors. The Technological Platforms falls within the university commitment to coordinate internal skills addressed to key sectors of the national economy, with the purpose of giving an articulated and multidisciplinary answers to the needs and challenges of companies.

The MentAll, is the trademark created to UATEC Mentors Club. This mentors club has the main purpose to support the Entrepreneurship Office in the relations with entrepreneurs. The support of entrepreneurs in the definition of business model, the market search, proof-of-concept needs, identification of business experts as well as the identification of funding schemes are some of the tasks that mentors will provide to entrepreneurs in the process of validating ideas and creating Startups.

The positive results of creation and management of the internal technology transfer network allows the recognition of the UATEC trademark inside the academia since the majority of students, professors and researchers are daily involved in their mission and they are also recognized as being innovative and contributing to innovation in companies. Besides that, the relations with companies increases, showing a better and a more confident industry cooperation, that are translated in bigger and longer collaborative research projects.

7.2.4 Conclusion

Research driven universities with high performance in scientific production has an advantage position in the relationship with companies, since the market has the ability to recognize the best scientific outputs (know-how, research results, discoveries, inventions, etc.). However, in our opinion, if these universities desire to empower their third mission, they should provide autonomy to the TTO and generate conditions to their interconnectivity with the functions and missions of education and research areas.

The creation of TTO internal network were the first step provided by University of Aveiro in the direction of new TTO generation, allowing the implementation of transversal structure model by the dynamization/creation of TTO centers in some departments and research units. In fact, all the diligences, top down or spontaneously generated in the departments or research units, taken in order to implement the TTO centers, will provide the necessary mechanisms, incentives and recognition to the researchers that will promote collaborations with companies, reinforcing the mission, procedures and rules endogenization of the central TTO in the valorization of the scientific results in the society. The integration of the TTO managers in the TTO internal network, also potentiated better results and performance in the TTO indicators, such as the number and the value of collaborative research contracts, services contracts, inventions disclosure and patents, license contracts and spin-off creation.

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7.3 Benchmarking and Monitoring

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Fast changing environments and the fact that TTOs are a relatively recent phenomenon determine a high dynamism in its development. As with spin-offs or start-ups, setting up a TTO in itself can be considered an "entrepreneurial" activity by universities. Accordingly, TTOs' structure and processes often change in the first years of their establishment until the university has found a model that best suits its needs. Under these circumstances, TTOs are both, a driver of change/improvement by monitoring KTT activity within the organization and a subject of change by being compared to other, similar units outside the organization. This section briefly discusses key performance indicators (KPI) for the monitoring of KTT activities and subsequently proposes benchmarking as a tool to spur the development of TTOs themselves.

7.3.1 Key Performance Indicators for KTT activities

Establishing KPIs for KTT activities is not easy, because of the uncertainty involved in all processes dealing with transfer of complex, embryonic and early-stage technology invented at universities. Moreover, the traditional academic incentive system, which is based on reputation and publishing, is not always conducive to KTT. Therefore, almost all KPIs in KTT have one or more drawback that needs to be kept in mind, when installing it as a measure of performance.

Individual Level

KPIs on the basis of individual scientists very often do not take into account different orientation of scientists and should be used only in conjunction with other performance measure, for example, in research and/or teaching (e. g., in a Balanced Scorecard approach). Possible measures for "traditional" KTT activities include: invention disclosures, patent applications, board membership in spin-offs, licensing revenues, co-inventorship on industrial patents and contract research volume. Less traditional are: number of external (industrial) PhDs, participation in practioner conferences, consulting activities, appearances on TV, reception of civic honors, number of twitter followers (for a university-owned account). Installing some of these as individual performance indicators is likely to boost KTT activity. But university faculty is relatively fast in learning and adaptation behavior towards the specified KPIs is to be expected (meaning that researchers will tend to inflate their activities). Also, setting incentives for KTT will direct time and effort away from other activities (teaching/research) and may lead to neglect and quality decrease in other areas.

University Level

For university comparison (see also benchmarking below), Tornatzky (2001) suggests invention disclosures, patents, licenses, and spin-off companies originating in the university as performance indicators. These are relatively easy to identify and can also be used to communicate performance to other stakeholder groups (university leadership, (regional) governments, general public). Ratio figures like patents per scientist or royalties received per scientist may yield a better picture and can take the initial capacity into account. Polt et al. (2001) use patent citations of scientific publications and the share of researchers moving into industry to quantify the European knowledge markets.

7.3.2 Benchmarking

General considerations

Benchmarking is essentially a feedback strategy for organizations to automate the process of improvement. It analyzes factors determining the performance of a certain process by comparing different modes of conduct. The aim is to determine a "best practice" for running an organization (or single processes) under deviating conditions (Polt et al. 2001). In its core, benchmarking is simply a way of comparing information. The aim of this section is a short introduction to the concept of benchmarking and to highlight some consideration when applying it in a context of universities' technology transfer.

The Benchmarking Cycle

The benchmarking process can be divided into five stages (Spendolini, 1992) (see Figure 1). Starting with the determination phase, the main target is to define the benchmarking unit. Next is the formation phase in which a benchmarking team is announced. This is followed by the third phase where benchmarking partners are identified. Afterwards, benchmarking information is collected and analyzed. At last action is to be taken. Because development and continuous improvement require a contingent benchmarking, the cycle emphasizes that the whole proves has to start anew after the "action" phase.

Stage 1-3: Benchmarking unit, team and partners

First of all, the aim of the benchmarking, its addressee(s) and the goals have to be clarified. The attributes and needs of the audience have to be understood. Strategic benchmarking goals may also affect actors outside of the universities direct power structure. Because benchmarking is a comparative approach, the identification of (a) comparable organization(s) is undertaken. For universities other higher education institutions would be suitable for comparison. The identification of the best practice example is a crucial task and may also follow strategic considerations. If the aim of the university is, for example, to become a "National Champion" (in KTT), the best practice case would be the best national university. If the aim is to become a "Global Leader" benchmarking would naturally have to involve international organizations.

Before the benchmarking process starts, the time horizon for the benchmarking period, the funds allocated and the staff involved should be fixed. Also the range of processes to be benchmarked has to be decided on. Often this necessitates organizational structure and its processes to be described first, because they sometimes evolve without proper planning in universities (and other public organizations).

Concerning KTT one has to keep in mind that metrics and measures are still disputed and suitable benchmarks may not be publicly available (see above). In universities and especially in KTT activities the process will therefore not yield exact results, but rather identify tendencies.

While it is fully up to the benchmarking investigator to determine where benchmarks are appropriate, it is highly recommended to establish at least a few benchmarks in the most vital processes. Planning, management, quality, and financials should be covered at least to some extent.

To gather insightful information, the involvement of individuals with diverse experience is important to draw an unbiased picture of the unit under investigation. In complement to the benchmarking team, which carries out the analyses itself, it is vital to find partners within but also outside the organization, who are not directly involved in the process (neither within the unit under investigation nor part of the benchmarking team). These help to ensure quality of the data, but also interpretation of results and may add to the overall quality by suggesting further suitable units of comparison or benchmarking metrics.

Collect and analyze benchmarking information

Different sources and levels of data should be addressed to get a comprehensive picture of the unit under investigation. The inclusion of different groups might help to get deep insights into processes and standardized data collection protocols help to reduce bias and ambiguity. The Analyses of data can be quantitative or qualitative in nature. While quantitative comparison of determined metrics is straightforward, qualitative information on why the benchmarking results came about will yield additional insights because complex systems, like KTT processes will not be appropriately described by quantitative indicators alone. The comparison to best practice examples usually identifies a performance gap (unless one is the "best-in-class"). Comparison of the different benchmarking metrics helps to determine the most likely reason for this gap. Because benchmarking is a tool that is based on comparison, the largest deviation from the best-practice example usually highlights the area(s) that currently limit development and performance.

Take action

A reasonable instrument for this final part is an action plan. The latter contains detailed information on the processes to be updated. Scouting ahead for possible obstacles eases the implementation of new processes. This can be done by a force field analysis which will visualize hindering and helping forces. A key factor for successful transformation is usually communication with the units affected by the change to ensure a common understanding of aims and consequences of the process update. A basic instrument to prepare employees for transition is a benchmarking report detailing the process and its results. Reviews of progress should not take place too often, because change needs time and frictions will exist in the transition period.

7.3.3 Concluding Remarks

The dynamics in the field, the various models of TTOs and KTT activity in general and the still evolving role of universities in modern socio-economic systems make it hard to come up with universal recommendations for KPIs and continuous improvement. Although (global) comparison is undertaken (e. g., through a number of international rankings), well-defined standards and universally applicable measures do not exist. Benchmarking as a process of improvement for organizations, is a useful, yet demanding management tool. Moreover, benchmarking theory often builds on the assumption of operation in competitive markets. According to Tomlinson and Lundvall (2001), complex interactions are the source of academic knowledge creation in (publicly-funded) research organizations. Therefore, best practices for use in a benchmarking framework might simply be undetectable.

Learning Questions and Discussion:

1. What would be suitable key performance indicators for your university/organization a) at the individual level and b) at the university/organizational level? Why did you choose these? What my be advantages and drawback?
2. What could be suitable indicators for your university/organization to start a continuous benchmarking against other universities/organizations in KTT? Which information can you obtain easily? What would be your "comparison group" that you would like to benchmark against (e. g., national universities, international universities, all universities of a certain size, etc.)?
3. How would you communicate the benchmarking results within your university/organization? Who would probably be the stakeholders most likely to resist a continuous and formal benchmarking according to your indicators?

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Figure 1: Benchmarking Cycle (Spendolini, 1992)

7.4 KTT Capabilities - A Set of "Facilitators" That Drives the TTOs Toward the Best Practices

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This sub-chapter presents a set of "Facilitators" that drive the Technology Transfer Offices (TTO) in the actual effective and efficient practices of KTT.

People perfectly recognize that life quality depends today on their science and technology advances. An increase in the economic and cultural levels (progress) is only possible if the development of human resources has a high priority. KTT has a central position in these problems and the cooperation between R&D institutions and enterprises is one of the most important instruments to govern the process. Today, science becomes a more important human activity, and questions related to science are criteria of its maturity (Novozhilov, 1991).

This scenario of science and technology change/evolution, seen in conjunction with the R&D institutions and companies, as key players in the innovation ecosystem, enforce a central role for these institutions. Moreover, today, it is impossible to manage the relationships between the most important actors without taking into account the most important interface structure to manage the processes - the TTO.

This sub-chapter suggests a Master Plan that explains the high-level view in the management of KTT. We show this plan as steps in a KTT process, each step with its facilitators, and each facilitator with its rules (of best practices).

The collection of facilitators reflects an overview and translation, to our Master Plan, of what is largely understood as the actual best practices.

The compilation of 275 rules referring to 54 facilitators distributed in seven groups of facilitators reflects the complexity of the KTT process.

7.4.1 A Master Plan to Transfer Technology

The Master Plan is based on a collection of what is proven to be the actual best practices in the Technology Transfer Offices (TTOs), in order to suggest, for a given TTO in an R&D institution, a set of rules for its procedures, processes, and structures.

This approach is a simple way to show the complete process, which reflects a simple "system" with "input, processing, and output". It is obvious that the level of abstraction of this perspective is very high and does not show the complexity of the various system feedbacks.

Accordingly, the entry point ("input") is the technology development stage, the "processing" is the effective transfer stage and the "output" is the usage stage, by the receptor partner.

In this simple view, the sequence begins with the R&D institution developing a technology (does not matter the motivation by now). Then, the technology is transferred to the partner and finally, the partner uses technology. The R&D institution controls the first step and part of the second, while the receptor partner shares part of the second and controls the 3rd.

Unfortunately, the simplicity of the above description cannot be used effectively when discussing the various process' phases. To better understand the transfer process, and discuss it properly, we need a more detailed view. As an example, cooperative R&D is common in the development phase involving the receptor partner of the technology.

In addition, this discussion does not make distinction between "technology push" or "market pool". Despite this, we describe a plan for the transfer step that is independent of the side that drove the TT and is that one the TTO manages.

A Plan for the transfer step

The second step in the technology transfer process, described above, is that one we will address, mainly because it is the stage where the management of the transfer itself is indispensable. This is the stage where a TTO is needed as a central actor.

David Resende et al. (2013) showed a degree of consistency in how to organize and manage this stage in US R&D institutions, which is consistent with studies of the Fundación Cotec (2003) in Europe.

The plan described here, in a superficial way, since it is not our intention to describe a model for KTT, is based on recent studies of the activities to transfer technology, found in various universities and branches in the US and Europe. Studies conducted by EIMS (European Innovation Monitoring System) confirm this trend, although they are not well grounded as the US, with regard to (local and national) legislation, which facilitates and encourages the continued transfer of technology developed by public institutions.

The transfer itself can be seen as a phase with several activities (steps). In general, the (set of) 6 activities shown in **Error! Reference source not found.** are the main ones, although, depending on particular characteristics, the sequence may be different or could not have the same activities.

Using the supplier point of view, the master plan is performed by three groups of actors synchronized as shown in **Error! Reference source not found.**, where we could see that the "researchers", the "local R&D Group" and "TTO officers" could share responsibilities in some activities.

In this scheme, the researchers are co-responsible for identifying technologies that are potentially available for transfer, to promote those most likely to succeed and make the transfer itself, following the process to the end, by the technological side. The local R&D group has responsibilities in three activities (steps) in the process: Strategy, technology promotion, and document/manage all the process and the results. The TTO officers have responsibilities in all stages of the process. Therefore, these actors are very important during the entire process.

With this understanding, let's discuss the six groups of activities from the TTO point of view, who have the main responsibility for the transfer agreement.

Most of the time, each local R&D group have the freedom to define how they will develop its activities in each step of the process. Some activities, such as the definition of the strategy, are on an annual basis, while others are developed for each transfer agreement, such as in "manage/document results".

Strategy

The purpose of these activities is to integrate the technology transfer in the overall strategy of the institution. The most commonly observed in the various institutions is to have a strategy for TT in accordance with the mission of the institution.

Another issue about the strategy that drives the TTO is the position regarding the internal partners and the market. This could be pro-active or reactive, to protect or to make deals.

As an example, each local R&D group could work its local strategy in order to reflect the coordination of the top management of the institution, reflected in TTO. The various local R&D groups establish a particular annual "Business Plan" with short- and long-term objectives. In this case, it is important to note that the budgetary requirements for a given "Business Plan" must be guaranteed, since at this stage there are still elements to be characterized in detail for the transfer activities.

Internal technology vigilance – Scouting Technologies

A definition for Technology vigilance could be - "the systematic, structured and organized information gathering on economic, technological, social and commercial developments" (Resende et al., 2010). In this case, the "internal" vigilance is an ongoing process where the generators of the technologies are not passive. The local groups should be active in supporting the collection of data to the technologies database of the institution, which have the selected research and development projects in which the local groups are engaged, and which, in its opinion, may have commercial potential application. Technologies in this context include products, processes, knowledge, and unique equipment and facilities that are not in the market.

This assessment or identification process can be done by outside firms with greater market assessment expertise or internally by the TTO experts.

However, there are various methodologies for market assessments in determining the commercialization potential of technology. Each organization determines which method best suits their needs. Whatever process is used, the following attributes should be considered: (1) Technology Strengths; (2)Commercial Strengths; (3) Technology Weaknesses; (4) Commercial Weaknesses; (5) Technology Ownership; (6) Market Sales Potential; (7) Ease of Replication; (8) Public/Government Benefits; and (9) Commercial Applications.

Technology Promotion

The purpose of this step is to promote those technologies with higher commercial potential, assisting in the coordination and synergy links between the local groups, the TTO and the host institution in promotional programs coordinated by the TTO.

The TTO always take into account the value-add advantage of an institution's external relations office (or communication office) depicting a positive image of the institution to society.

The promotion can be deeply focused on a particular technology or completely broad. In the last case, it is to promote the institution, its capabilities, expertise, and the ecosystem interface. However, it is largely recognized that the more focused is the marketing campaign, the better and effective is the interest created.

Vehicle identification

Not all transfer vehicles are appropriate for all technologies and all conditions. The purpose of identifying the transfer vehicle is to match the best transfer agreement vehicle with the needs of the outside partner and the institution. The actual practices in KTT use a large set of different transfer mechanisms to fit the needs of the partners and the local group as well as in the best interest of the university and its TTO.

To identify the most appropriate transfer mechanism in a given scenario it is important to take care of some issues in the vehicle identification process, as the technology maturity level, the environment, incentives and financial support available and the target market. This phase of the Master Plan could be split into a subset of steps (activities) as in **Error! Reference source not found.**.

Transfer

This is the stage of the transfer itself. The formalization is done with the written agreement, which confirms compliance with the legislation and what was previously agreed.

The document must have information regarding expectations about the benefits of using the technology in question, in order to be able to measure the return to the institution regarding profit from the transfer. This information is also important for the next stage Management and Documentation Results.

The agreement must be formally endorsed by all institution's participants enrolled in the transfer process, in the same document or in another internal or attached, where should be stated all their responsibilities, as well as the expected counterparts.

Regarding the signing of these agreements, the delegation of authority should be seen as a normal procedure, free of bureaucracy, to increase the efficiency and simplify the process. A counterexample is the case of universities where the bureaucracy comes to require the signature of their dean to even simple transfer agreements.

It is supposed to and desirable for the transfer generates some kind of income or counterpart. However, this is not always possible (although benefits to society are also counterpart). The revenues involved in the transfer process are mostly license payments, royalties, and research expenditure. In the latter case, the local group should be responsible for negotiating and receive what is due to the costs involved.

With respect to compensations/counterparts, there is an endless number of possible arrangements. In agreements involving universities, for example, the provision of internships for students (paid or unpaid), the payment of research grants or equip a laboratory may be the counterparts the partner company supports.

One of the last tasks of the local group, for each agreement they are involved, is the publication of a "success case", whenever appropriate, with the final report to the TTO. The TTO will be responsible for forwarding the publication as a means of promoting the institution.

Manage and document results

The purpose is to document the lessons learned from the activity performed, publish the institution TT success activities, reward and identify, with recognition, the participants in the institution and forward to the strategic sphere.

The adjustments to the processes are made at this stage. With the help of external partners, it is possible to consider the transfer vehicle used - the mechanism, the incentive programs, the economic and budgetary agreements, and shares and licenses, in order to improve the process in different possible scenarios.

Using the Master Plan

This vision of a Master Plan, although it is not enough detailed so that it can be used as a guide, gives an idea of what could be a guide for the inclusion of activities and structures of KTT in an R&D institution with strong entrepreneurship capacities.

The KTT mechanisms, including those mentioned in the preceding paragraphs, together with the vision proposed by the master plan, is the starting point for the next step – collect a set of rules that help in pursuing the transfer according to that master plan.

The next sub-chapter completes the vision and show how to use the Master Plan and a set of "Facilitators" and "rules" as a guide to the best actual practices.

The KTT Facilitators and its Rules

This chapter started presupposing the existence of processes, practices, procedures, and structures that facilitate the TTO interaction with its host institution and other entities in the surrounding environment. Thus, a set of facilitators was collected, with its rules, from an exhaustive study of the actual practices, and mapped in standard structures observed in various active institutions in this field. This standard structure is the TTO Master Plan in figure 4, created with the aim to join all the interest points of the discussion around what it was defined as *groups of facilitators* and its *rules* of actual good practices, shows the Master Plan, the actors that interact with the TTO and, inside the TTO, the 6 stages (or sets of activities) with its 3 responsible groups.

The six stages, in the Master Plan, drive the study of the KTT facilitators in an institution. The practices in these stages plus the TTO practices in the institution induce the increase or decrease in efficiency and/or effectiveness of KTT projects. Hence, we defined them as Facilitators for each stage and for the institution. We named them "Group of Facilitators" (GFs).

The rules associated with each *facilitator* are defined in accordance with its improvement capability of the corresponding facilitator's characteristics, always with special attention to KTT. The set of rules are produced from many discussions about the theme in interviews with experts and was born from the documental analysis of the current practices in some TTOs and institutions that have TT as part of its mission (Resende et al., 2010).

The "*Group of Facilitators*" (GF) are as follows:

- GF to the TTO;
- GF to the strategy;
- GF to the vigilance;
- GF to the promotion;
- GF to the vehicle identification;
- GF to the transference; and
- GF to the management and document results.

Many facilitators from this collection are not mandatorily visible and/or important to all institutions. In other words, we have facilitators that are not necessary, others without an application in a given scenario, and some that are critical to an institution (regardless of presence). An illustrative example is the TT mechanism "*extension/specialization training courses*" that could not be used because it is not important in a given R&D institution. As a facilitator to transfer technology, it's not part of the set of facilitators that characterize this institution and it is not a relevant facilitator that helps characterize this institution. At the same time, in another scenario, with another institution, this mechanism could be the most important one to transfer technology.

7.4.2 Final Notes

This Chapter shows a Master Plan to the TTOs that explains the high-level management view of KTT. It shows this plan as steps in the transfer process, each step with its Facilitators.

The collection of Facilitators reflects an overview and translation to the Master Plan, of what is largely understood as the actual best practices.

The Master Plan does not have the pretension to be a model. It was born from its necessity and importance to drive and organize a collection of Facilitators. The foundations of the plan are the actual good practices of the KTT processes. Furthermore, it was created thinking in the profitability of the structures and infrastructures present in the host institutions that would take part in those transversal processes managed by its TTOs. Its most important part is the set of facilitators, each one with its own rules. The Master Plan compiles 275 rules referring 54 facilitators in seven groups of facilitators. This collection is not static, evolves over time. The initial version was published in Resende et al. (2010).

It is possible to analyze a TTO, by the observation of the facilitators and rules it implements. As it has better implemented (and necessary) facilitators, it will be better prepared to transfer technology (a facilitator is well implemented if its rules are well implemented).

The next sub-chapter shows a case study using the BTP – Best Transfer Practice methodology, based in the Master Plan, adapted to analyze the KTT processes and procedures in three Southeast Asian HEIs.

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Master Plan Images

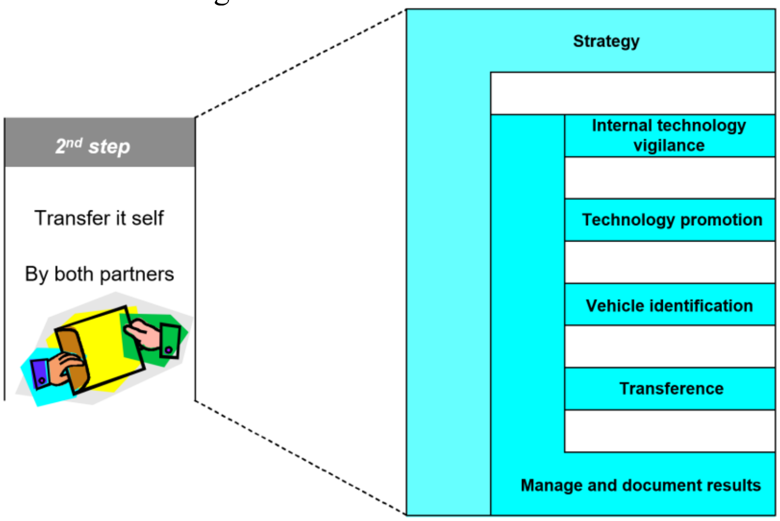

Figure 7. Master Plan. A generalization from the cases observed in this study.

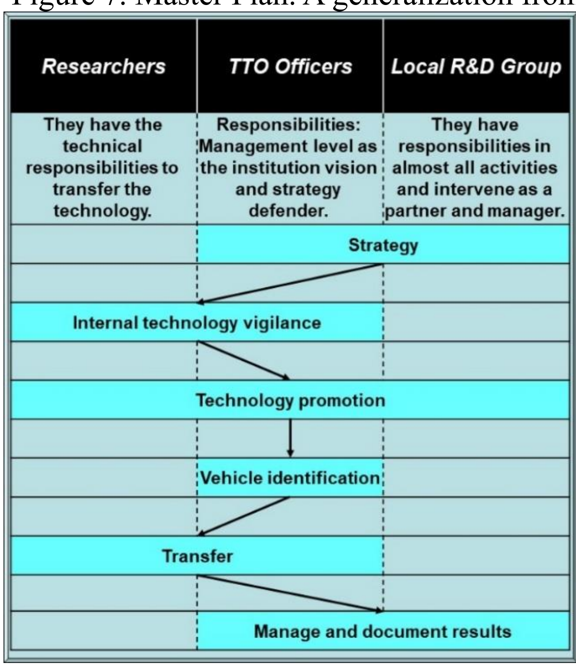

Figure 8. Perspective of the three main actors in the steps of the Master Plan.

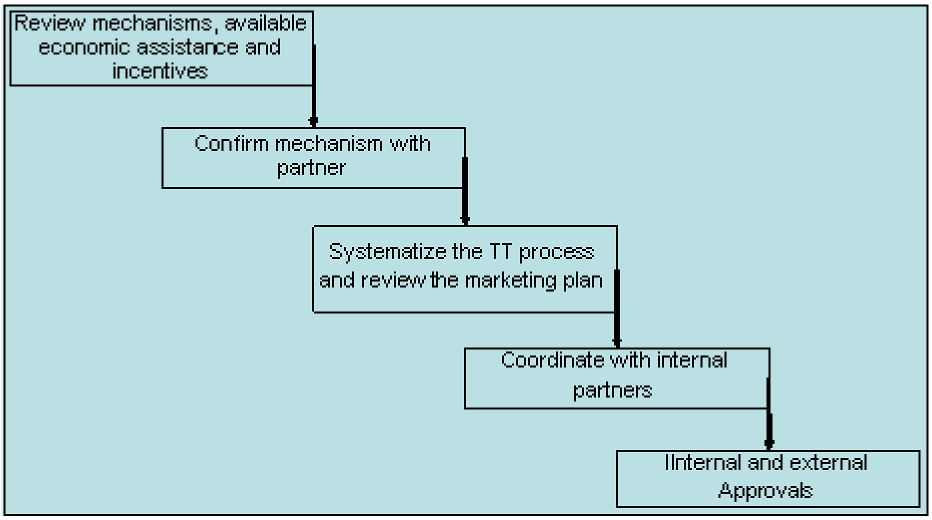

Figure 9. Vehicle identification activities

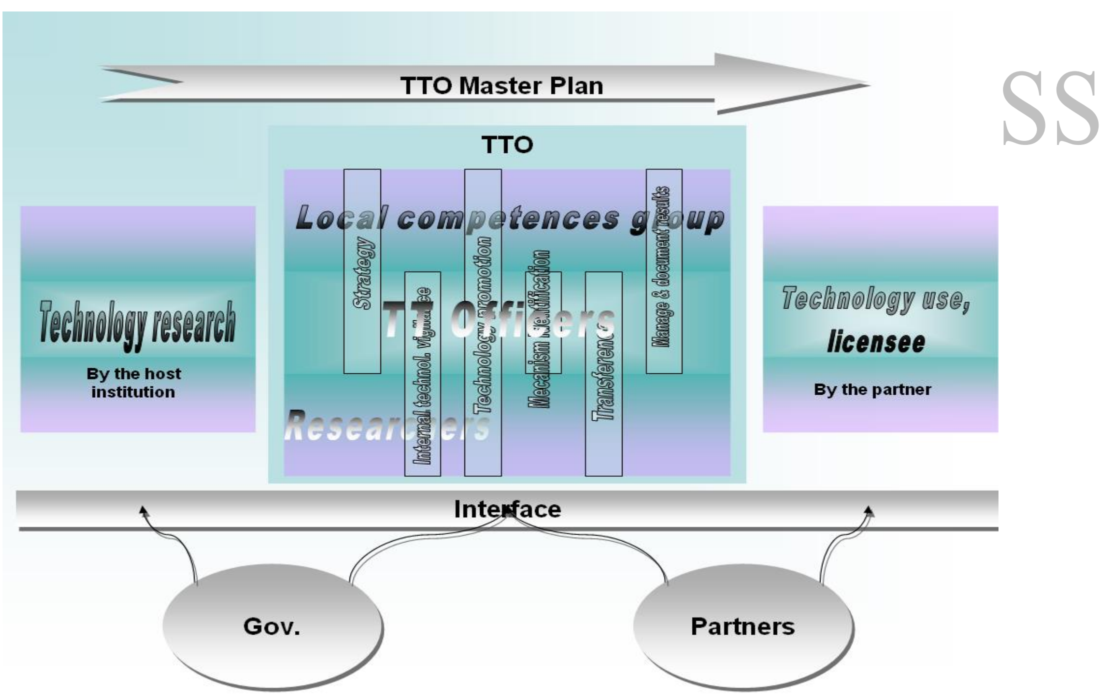

Figure 4. The Master Plan with its steps, by the institution point of view, with its interfaces and partners

7.5 KTT Needs Analysis: Case of Vietnam

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Under the light of the Master Plan to transfer knowledge and technologies, the first objective of this subchapter is to figure out the most important bottlenecks in the KTT process that should be improved and their priorities. As a specific objective, the identification of the problematic processes, procedures, and structures to propose adequate training programs related to specific subjects that could help KTT actors to hierarchically minimize the bottlenecks.

As a second objective, this document can be considered as the BTP Quick Manual for further self-assessment and evaluation of the institution's KTT unit.

The analysis approach is:

1. Fundamental analysis of the processes in the KTT flow path;
2. Identification of the structures and the actors working in the processes;
3. Find the most relevant KTT facilitators for the Institutions;
4. Show up the bottlenecks (the least implemented relevant KTT facilitators);
5. Determine the interrelationships between the most important and least implemented facilitators;
6. Evaluate the constraints to which the Institutions is subject, in order to assess the feasibility of possible solutions for improvement; and
7. Compile a set of capacity building actions that address the bottlenecks of the institutions - the weak facilitators.

In order to guarantee a diversified sample in the collection of information on the existing processes and structures, one of the components of the analysis was based on unstructured interviews carried out with actors from different departments of the institutions, with different qualification profiles and professional groups.

Based on the information obtained in these interviews and an online survey on the Facilitators present in the institutions, complemented by a study of the internal documents covering the various aspects of KTT and others that govern the institutions as a whole, the outputs of the analysis reflect the KTT processes and structures implementation levels and, from that, recommendations for the Capacity Building Programs could be set up.

Some assumptions define prerequisites to guarantee effectiveness. Briefly:

- It performs strategic decision making and is a tool for top management;
- The "task force" that applies the methodology should consist mainly of internal actors (appointed by top management) whose roles in the KTT process are extremely important; and
- Respondents are chosen by that team and should reflect most of the KTT structures and processes at all levels (operational, tactic, and strategic levels).

7.5.1 Using the TT Master Plan as a reference schema (The Group of Facilitators - GFs)

We can look at an R&D institution and its KTT management office (TTO) from the point of view of its capacity to transfer technology from its internal research groups by observing its facilitators and corresponding rules (subchapter 8.4 and Resende et al., 2010). The more well-implemented facilitators it has, the more prepared it is to transfer technology. A facilitator is well-implemented if its rules are well-implemented.

We split the Master Plan in 275 rules, that refer to 54 facilitators, into seven groups as follows:

- GF related to the institution (resources and internal culture and environment) with 6 facilitators and 35 rules;
- GF related to the institution KTT strategy with 7 facilitators and 29 rules;
- GF related to the vigilance (of new R&D results from the institution departments) with 5 facilitators and 24 rules;
- GF related to the promotion in the ecosystem (of the above R&D) with 6 facilitators and 29 rules;
- GF related to the vehicle identification (to transfer technologies to the ecosystem) with 5 facilitators and 30 rules;
- GF related to the transference (processes and resources) with 20 facilitators and 103 rules; and
- GF related to the management of documents and results with 5 facilitators and 25 rules.

The above paragraphs characterize what is supposed to measure with the tool. In other words, the institution analysis is made with the measurement of the implementation levels of its relevant facilitators (looking at the implementation of its rules).

7.5.2 Relevant Facilitators and critical Facilitators

It's important to define ***relevant facilitators***, for an institution in a given scenario, as those ones related to the most relevant structures and processes according to the observed TT strategic objectives. They are the most important facilitators for the TT from the perspective of the institution's internal actors. But it does not mean that they are well-implemented.

From the above discussion, we get an important conclusion about this tool: The ***relevant facilitators*** are the most important ones to a given institution. As better implemented these are, the more adequate the corresponding processes. When we identify the ***relevant facilitator***, we also characterize the institution and its key points for KTT, according to the master plan. The question to ask is how does one identify these facilitators?

Another question: How does one identify weakly implemented ***relevant facilitators*** – called ***critical facilitators***? We are looking for ***bottlenecks*** (in structures and processes) for every weakly implemented relevant facilitator**.**

7.5.3 Basic principles

A systematic approach is important in the analysis process so that it can help identify relevant facilitators (mapping of the TT structures and processes, of the institution and its TTO, in the facilitators of the master plan). When an institution asks for an analysis of its performance in KTT, this clearly shows its appetence for changes that could cause performance improvement. So, first of all, we need to identify the KTT strategic objectives. The processing of this information will help achieve the most relevant facilitators.

With the strategic objectives defined, the next step is to analyse KTT structures and processes, with the intention of mapping them, with those objectives, in the master plan's set of facilitators, so that we can find the relevant ones. So, it's necessary to measure the level of relevance to all facilitators discovered in the last step. We define as relevant facilitators the sub-set discovered from the master plan that are most relevant to the institution's strategic objective. From now on, the focus is only on the most relevant facilitators.

The next step is to evaluate the TT structures and processes to determine the implementation level of the relevant facilitators. The non-relevant or less relevant facilitators don't need evaluation because they don't relate to strategic objectives. We recognize as critical facilitators, those ones not present (but relevant) in the institution or weakly-implemented. This is done by measuring the level of implementation of the rules as in Figure 1.

Afterward, the critical rules will be studied and remapped into the TT processes and structures of the institution to discover ***bottlenecks*** responsible for the weak implementations.

After identifying critical facilitators, we pass to the analysis of their rules. The identification of a bottleneck means that a very important facilitator (to the objectives of the institution) do not have well implemented rules.

Dynamic tables and graphics allow visualization of associations and interdependencies between facilitators and the influence that the environment could have upon them. In other words, we will attempt to disclose which critical facilitators are influenced by others. This information allows us to identify whether there are any critical facilitators that, when modified (improved by a solution design), could influence other existing critical facilitators. In this case, that critical facilitator will be the first one to be analysed with the objective to introduce improvements in the corresponding bottlenecks.

The Capacity Building Plan will be made along the next step, which is the improvement solution planning to the most important weak points, identified in the bottlenecks, in the form of a progressive improvement plan, looking at the KTT structures, processes and procedures to identify the problems and its causes.

7.5.4 Procedures of Analysis (The procedures to assess an institution)

The proposed tool enables the identification and subsequent solution proposal for the bottlenecks related to TT management procedures, processes, and structures. This is based on the following essential questions:

- Which structures should be optimized to achieve strategic objectives as a KTT promoter?
- Which processes and procedures should be optimized to achieve the same objectives?
- Where does one start?

To answer these questions, we need to identify and hierarchically arrange the problems found in the study that follows the interviews and documental analysis, then, in the remapping phase, where these problems are remapped into the processes, structures, and TTO procedures, identify the corresponding bottlenecks, detaching the most prioritized (big concern) and those with simple and sustainable solutions.

The suggested solutions should ease the identified bottlenecks and improve the related prioritized processes, procedures, and structures.

7.5.5 The steps

Figure 2 shows a proposal for the sequence of steps we consider appropriate to the prosecution of the necessary activities.

The documental analysis, in spite of not present in Figure 2, is also very important as a huge source of institutional information. The conjugation of that information with the knowledge and information that we obtain with interviews is the "database" for the analysis procedures in this tool.

7.5.6 Identifying bottlenecks – The critical facilitators

This is the phase where the rules corresponding to the identified most relevant facilitators are analysed. At this point, the specialists that apply this tool with the internal taskforce open the meeting analysis to study the institution under the master plan light. It is the phase to verify, for each identified relevant facilitator, present or not, the rules that are important, according to the strategic objectives and their levels of implementation.

In other words, this phase studies and registers each relevant facilitator's degree of importance and level of rule implementation.

After collect and study the data for each case study, from the arrangement suggested in the spreadsheet in Figure 1, it is possible to extract the relevant facilitators with their implementation degrees, as in Figure 3 (Can Tho University - CTU case example). It shows the information in a useful form so that the necessary knowledge can be easily extracted to the next phases.

The most important bottlenecks, considering the limit (35%), are displayed in three similar graphs for the three case studies.

The CTU case is used to illustrate the critical facilitators in Figure 3. These critical facilitators cause the bottlenecks. They will be analysed with each other (as interdependencies) and in relation to their environmental influences.

The most important rules from these critical facilitators will receive a deeper analysis in the last phases – these rules are responsible for the bottlenecks.

7.5.7 Dependencies and interdependencies of the critical facilitators

We intend to use the previous information to discover the facilitators and external factors with more influence on the others. We also want to find the ones that are more influenced (dependents). After filling the matrix in Figure 4 (with the entire CTU correlation matrix as an example), we sort the rows and columns. This formats the matrix with the most influencing facilitators and external factors in the far-right column and the most influenced facilitators in the bottom row. Although this is the same matrix, the look is more adequate. The concentration of the most important critical facilitators is in the bottom-right corner.

The most incisive procedures to improve the performance of the institution will be related to those critical facilitators. The next phase is the analysis and recommendation report.

Figure 4 offers clarification. In it, the most influencing critical facilitators for CTU case study are the "Intellectual property licensing/ patents", "Information and Knowledge" and "Management Information System". Similarly, for HUST case study the most influencing critical facilitators are the "Information and Knowledge", "human resources adequacy" and "Intellectual property/Licensing/Patents", and for HU - Hue University case study are the "External vigilance", "human resources adequacy", "TT process is systematic with feedbacks during all its extension" and the "Web presence"). For all three cases, we verify that the same external factor must be considered as an issue for reflection - the "internal culture".

The next step is to remap the facilitators into the TT processes, structures, and procedures found "in the field". We determine the facilitators that are important to re-evaluate from an analysis of the most critical facilitators and external constraints identified in the previous study. The output will be the discovery of the bottlenecks and recommendations ordered by importance.

7.5.8 Capacity Building Actions Programs

The three studies can already point out a series of indicative ways and recommendations to be discussed, improving and enriching the work already done.

Based on the available proposed training actions, that is used to be taught at the European partners' universities, the next step maps those training actions with their relevance to each and all critical facilitators of all three case studies (CTU,HUST, and HU). Figure 5 shows the relevance of each training action to all critical facilitators in all three cases.

The training actions should be performed based on this information and priorities.

7.5.9 Final Notes

It is possible to analyze the efficiency and effectiveness of a TTO in its host institution by the observation of the facilitators and rules it implements. As it has better implemented (and necessary) facilitators, it will be better prepared to value-add and transfer their innovations.

Regarding the Capacity Building Actions Program, the three lists in Figure 5 show the relevance of the Capacity Building Actions in rankings. It is interesting to observe a common trend combining the three lists. A common ranking could be build denoting the priority to

- Technology Vigilance;
- IPR in a university setting;
- Technology Transfer: Building and growing a TTO;
- TT Regulation development and enforcement;
- Knowledge and Technology foresight;
- Setting up a university education program on KTT and technology entrepreneurship;
- Multilayered Collaboration between Universities: education, research AND innovation;
- Management of university networks in knowledge and technology transfer;
- Development of University-specific intervention models on KTT; and
- Incentive mechanisms for researchers.

Based on this list, one can interpret the recommendations focus mainly on Teamwork, supported by the building-up of the Entrepreneurial Culture and Innovation and Entrepreneurship Management. The replication of these cases could confirm the results to other Vietnamese regions, in spite of these actual results been restricted to the three case studies/regions.

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Analysis Procedures Images

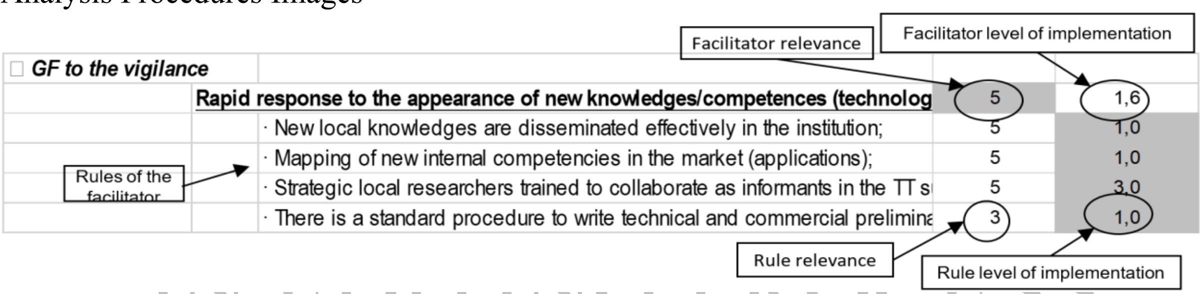

Figure 1 - Example of spread sheet with the calculus to a facilitator and the levels of relevance and implementation of their rules. Briefly, the implementation degree of the facilitator “Rapid response to the appearance of new knowledges/competences...” is 1.6 on a zero-to-five scale (where 1 means less-implemented and 5 means fully implemented). The calculation formula is: $\frac{\sum relev.\times implement.}{\sum relev.} = \frac{5\times1+5\times1+5\times3+3\times1}{5+5+5+3} = 1.6$ This value as a percentage is equivalent to $\frac{1.6\times100}{5} = 32\%$, clearly low. It characterizes this facilitator as critical – a discovered bottleneck.

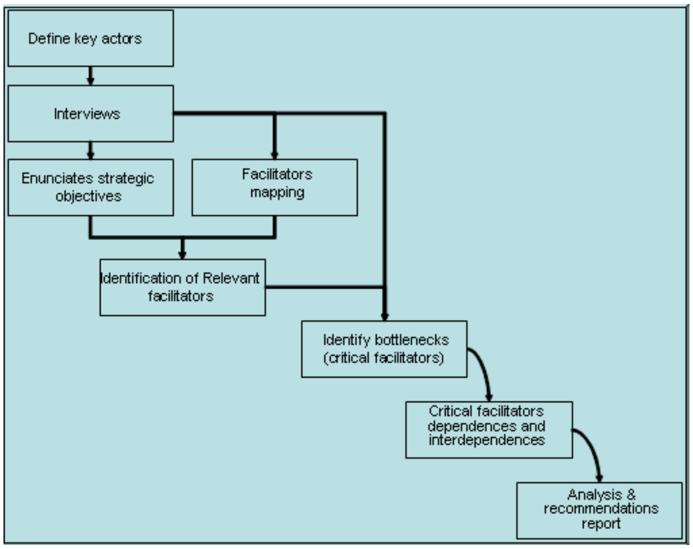

Figure 2. Proceedings of the analysis tool (Resende et al., 2013).

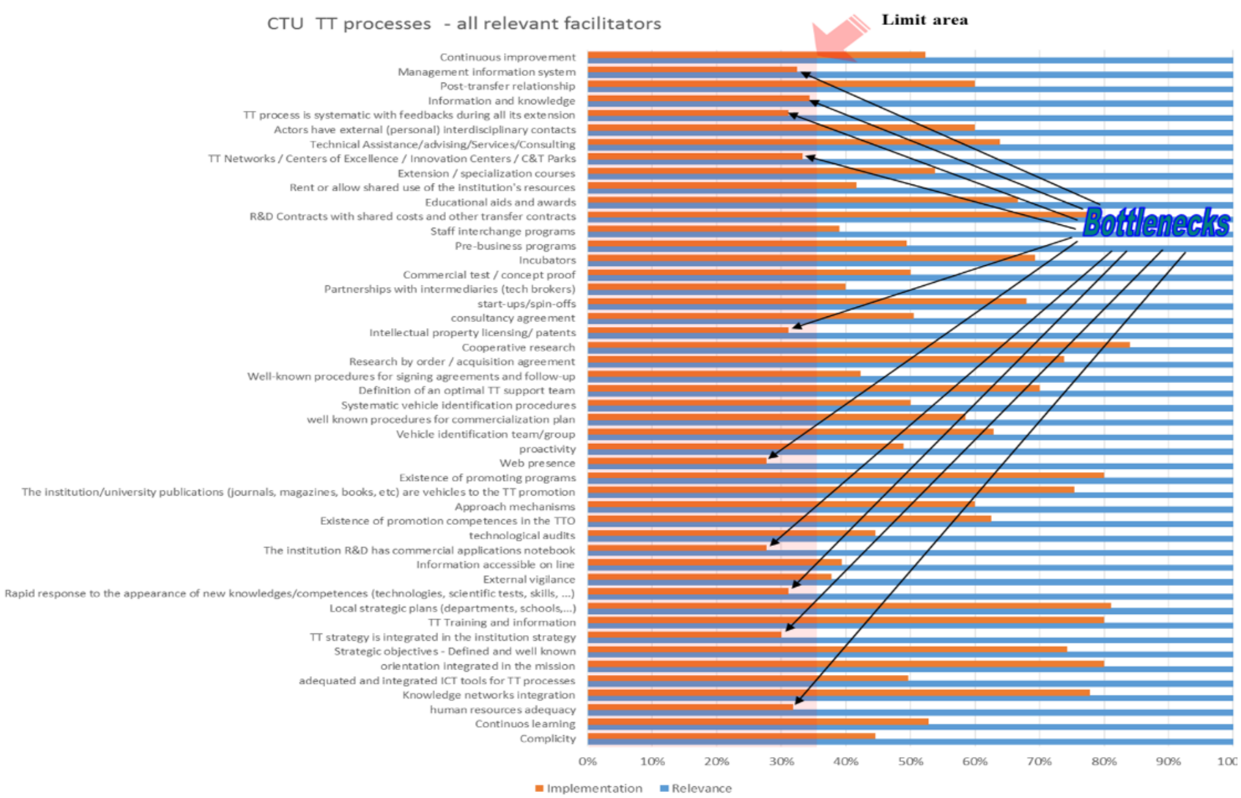

Figure 3. CTU relevant facilitators graph and their implementations. From this graph, we take off the critical facilitators (where one can find the bottlenecks). Performing the same procedure, HUST and HU show some different bottlenecks (VETEC, 2017).

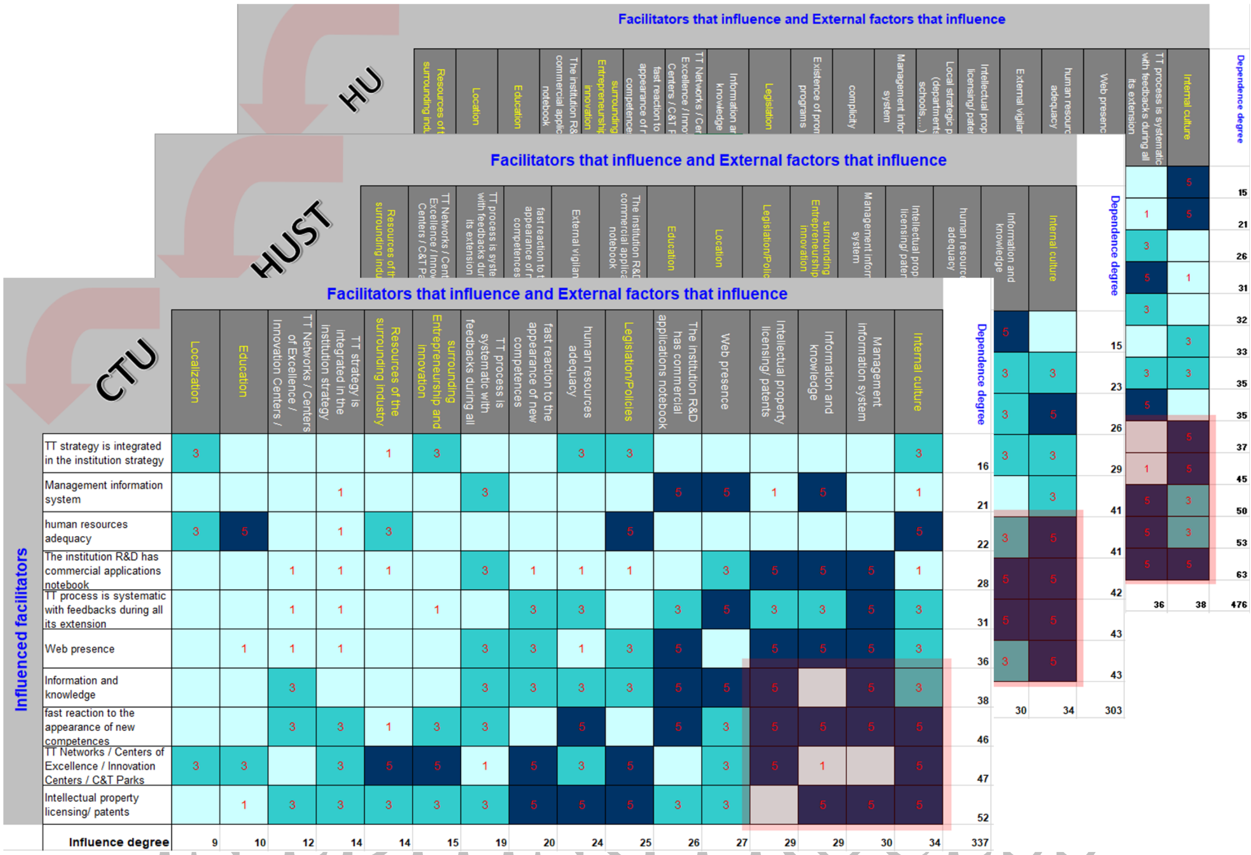

Figure 4. Correlations Matrix – influences and dependencies between facilitators and external facilitators. Rows and columns ordered and red rectangle showing focus (VETEC, 2017).

program / Facilitators - HU	complicity	human resources adequacy	Local strategic plans (departments, schools,...)	fast reaction to the appearance of new competences	External vigilance	The institution R&D has commercial applications notebook	Existence of promoting programs	Web presence	Intellectual property licensing/ patents	TT Networks / Centers of Excellence / Innovation Centers / C&T Parks	TT process is systematic with feedbacks during all its extension	Information and knowledge	Management information system	priority
Technology Vigilance - Implementing a Network of Pivots	5	5	5	5	5	5	5		5	5	5	5	5	60
IPR in a university setting	3	5	5	5	5	5	1	3	5	3	3	5	5	53
Technology Transfer: Building and growing a TTO	5	5		1	3	5	3	5	5	5	5	5	5	52
Multilayered Collaboration between Universities: education, research	5	5	3	5	3	5	5	5	1	5	1	3	1	47

program / Facilitators - HUST	Internal Culture	human resources adequacy	fast reaction to the appearance of new competences	External vigilance	Intellectual property licensing/ patents	TT Networks / Centers of Excellence / Innovation Centers / C&T Parks	Information and knowledge	priority
Technology Vigilance - Implementing a Network of Pivots	5	5	5	5	5	5	5	35
IPR in a university setting	3	5	5	5	5	3	5	31

program / Facilitators - CTU	Internal Culture	fast reaction to the appearance of new competences	Intellectual property licensing/ patents	TT Networks / Centers of Excellence / Innovation Centers / C&T Parks	Information and knowledge	Management information system	priority
Technology Vigilance - Implementing a Network of Pivots	5	5	5	5	5	5	30
IPR in a university setting	3	5	5	3	5	5	26
Technology Transfer: Building and growing a TTO	3	1	5	5	5	5	24
TT Regulation development and enforcement	3	1	5	5	5	3	22
Knowledge and Technology foresight	5	5	3	1	5	3	22
Setting up a university education program on technology transfer and	5	5	3	3	5	1	22
Multilayered Collaboration between Universities: education, research AND	5	5	1	5	3	1	20
Management of university networks in knowledge and technology transfer	5	3	1	5	3	3	20
Development of University-specific intervention models on KTT	5	1	3	3	5	3	20
Incentive mechanisms for researchers	5	5	5	3	1		19
Walk the walk: business development for a real project (own project	5	1	3	3	3	3	18
The tension field: research vs. Tech transfer	5	5	5	1	1		17
Models for knowledge and technology transfer	3	5	3	3	3		17
Business Development: from idea to spin-off	5	3	5	3			16
Introduction to Business		3	3	3	3	3	15
Launching a hi-tech business ideas contest: TBEC - Technology Based	5	5	5				15
Growth, Development and Innovation (Doctoral Programme in Public Policy)	3		1	5	3		12
Incubator mechanisms, student incubators	5		1	5			11
Technology Business Development Project	1	1	3		5	1	11
Funding mechanisms for technology transfer		1	3	3	3	1	11
Assessing Technology Transfer Offices: BTP - Best Transfer Practices		1			5	5	11
How to setup an Incubator network	3	1		5		1	10
Setting up a university seed fund	3		3	3			9
Test your idea - Business Model Canvas	3	5					8
Business Aspects of Micro-Electronics and Photonics	3	3	1			1	8
Business Aspects of Innovation in Materials	3	3	1			1	8
Business Aspects of Software	3	3	1			1	8
Entrepreneurship and Innovation	5		1		1		7
Territory, Regional Policy and Innovation (Master in Urban and Regional Plan	1		1	5			7

Figure 5. Mapping the available training programs on the critical facilitators (VETEC, 2017).

8. Infrastructure

8.1 Incubators and Science Parks: infrastructure and support for enhanced KTT

Matthias Geissler, Sophia Bittner-Zähr, Anna-Maria Kindt
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The implementation of an incubator or science park is an investment with the aim of a positive (regional) development through technology transfer from universities. The emphasis is on co-location of (newly established) firms. However, the two concepts are different as they aim to support slightly different target groups. In both cases strong financial support from public or private sources is needed for establishment. The following section outlines the two different concepts and highlight aspects of management.

8.1.1 Incubators for new business creation

Evolution and business models

Since the 1980s incubators are increasingly established as tool to support technology based business creation. From a political point of view, incubators prove openness to science and innovation and promise wealth and new jobs. In order to support technology-driven business establishments, the value proposition of business incubators changed over time from offering offices, space and resources to broader support through coaching and access to networks (Bruneel, Ratinho, Clarysse, & Groen, 2012). Additionally, access to financial resources is a central proposition nowadays with (venture) capital stemming from different sources (Zedtwitz, 2003).

Today, most incubators are unlikely to be profitable (Bruneel et al., 2012). Therefore, long-term support is often provided by public or private initiatives with profitability as a secondary goal. For non-profit incubators the supporting role is typically taken by a university or municipality (Zedtwitz, 2003). Depending on the strategic objective and competitive scope, five incubator archetypes are identified by Zedtwitz (2003): independent commercial incubators, regional business incubators, university incubators, company-internal incubators and virtual incubators. Despite the various characteristics, all incubators share similar business models (see figure 1). Key requirement is a (private or public) investor who finances incubation activities. The incubator itself is managed by a director and a management team which supports the start-ups. Their task is not limited to coaching or provision of network access, they often engage in active segmentation and collocation of entrepreneurs who face the same challenges and problems to leverage synergies (Zedtwitz, 2003). As with all founding activities only a part of the incubated businesses grow into successful firms, which makes incubation financially risky. However, Soetanto and Jack (2016) show that especially academic spin-offs benefit from the support offered by incubators underpinning their importance in KTT ecosystems. Incubators are different from “business accelerators”, which support start-ups in narrower time frames (usually three months) and set stricter criteria to the type of start-up (team of founders vs. single founders).

Incubator establishment and management

When establishing university incubators (also in developing countries) it is sensible to identify if concepts of the first incubator generation (see table 1) already exist and if they can be developed into full-fledged incubators. Evolution and growing of incubators from the first or second generation to a third generation is not as easy, because it does not simply entail a change of the service portfolio. Instead, the support and networking functions need to be assumed by dedicated staff and require elaborate planning on incubator activities. External experts become a crucial resource and adequate management practices should support the growth of new businesses in a timely manner. Zedtwitz (2003) highlights the existence of an incubation charter, day-to-day-management as well as optimizing leverage and synergy as effective practices for incubation management. Additionally, the awareness and acceptance of entrepreneurial activities under university employees and students is a crucial requirement. The latter is probably even more crucial than building or renting rooms for shared offices as the change in mindset is a long-term process.

8.1.2 Science Parks: co-location of high-technology based firms and universities

The concept

Whereas incubators are specialized on entrepreneurs in the very early stages of founding, science parks promote properties to all kinds of technology-based firms. Thereby, an incubator can be part of a science park as the provided network is a crucial resource for newly founded firms (Löfsten & Lindelöf, 2002). However, the main difference between both concepts is that science parks are a managed area in which businesses access academic knowledge and expertise through co-location (Löfsten & Lindelöf, 2002). Therefore, properties and buildings are offered, but no additional financial support or subsidies. Its aim is to create an environment in which an innovative culture fosters knowledge exchange and interactions between researchers and firm employees. Interactive spaces like sports facilities and restaurants are leverages for an innovative climate which enhances innovation and R&D efforts and is likely to create positive knowledge spill-over. Formal and informal knowledge exchange as well as the transition from employees and students to on-site located businesses are desired outcomes. Through these activities science parks reach a substantially higher rate of job growth than off-site located high-technology based firms (Löfsten & Lindelöf, 2002).

Science Park development

Science Parks can foster innovation and regional development. For building up such an area of innovative activities it is beneficial to observe if a local agglomeration of knowledge-intensive businesses around a university already exists. If this is the case, the agglomeration could be used as a basis, subsequently building the Science Park around it. However, not only properties and buildings are of importance but also a management team which offers support in business development, as well as linkages with universities and research institutes. Over time, the Science Park will change and the management will face different challenges. Especially a continuing self-renewal through newly established businesses is of importance to prohibit a fast aging and decrease of innovation (Koh, Koh, & Tschang, 2005; Tan, 2006). Sustainable growth and success of a Science Park is mainly driven by the ability to attract and create new businesses (Koh et al., 2005).

Caused by the typical transition of employees from university to businesses and between on-site located firms, intellectual property rights are another crucial aspect, which can lead to long-lasting conflicts (Tan, 2006). Therefore, it is important to have a management team which can offer support in IP related questions to ease cooperation climate and spur collective innovation activities.

Networking and the development of linkages between organizations require individuals who are open and willing to interact. Therefore, for the development of Science Parks, policy makers as well as investors and decision makers should take into account how cultural aspects could support or hinder the development of knowledge exchange. Tan (2006) observes that the Chinese culture enabled the development of rich formal and informal inter-organizational linkages between on-site located entrepreneurs. Thus Science Parks in different regions face special hurdles. However, growth mechanisms, technological capabilities and the integration in in the national as well as international markets are the main aspects which influence Science Park development (Koh et al., 2005).

Learning Questions and Discussion:

1. What is the difference between a Business Incubator and a Science Park? Do you believe your university/organization has the resources to establish or significantly contribute to the one or the other? Which activities could you probably offer to prospective founders?
2. Can you identify business supporting activities at your university/organization? Which of those might have the potential to be grown into an Incubator? What might be necessary to achieve this?
3. Which kind of supporting infrastructure relevant for your region/country would you expect from a Science Park? Which elements might be less important with regards to the customers or prospective users to be expected in your country/region?

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Table 1: Summary of the evolution of business incubation's value proposition (Bruneel et al., 2012)

	First generation	Second generation	Third generation
Offering	Office space and shared resources	Coaching and training support	Access to technological, professional and financial networks
Theoretical rational	Economies of Scale	Accelerating the learning curve	Access to external resources, knowledge, and legitimacy

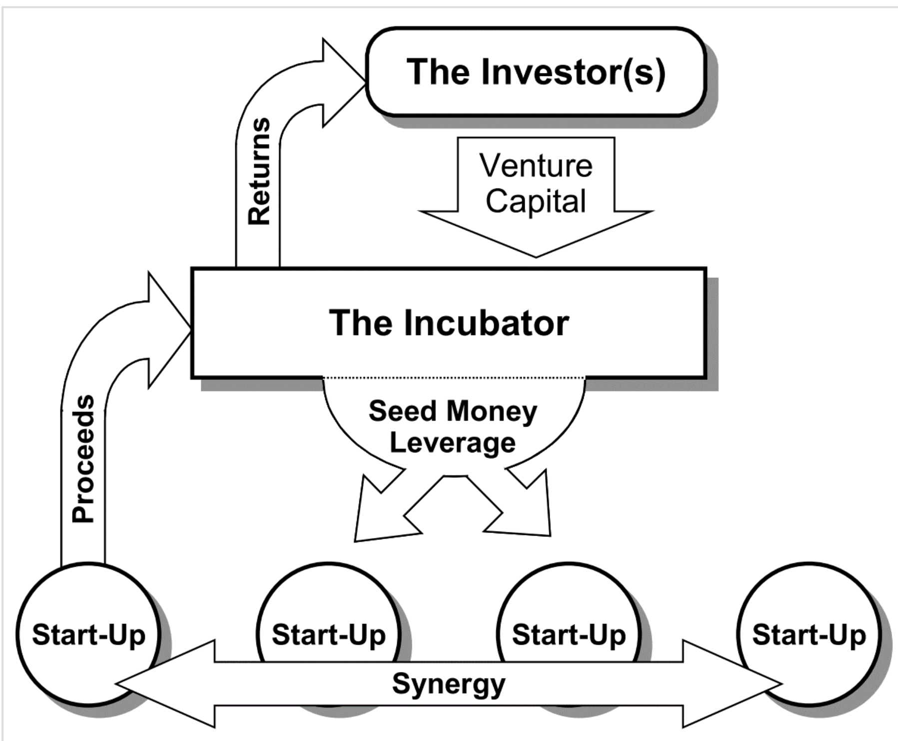

Figure 1. The generic business model of incubators (Zedtwitz, 2003)

8.2 New kinds of infrastructure: Makerspaces, FabLabs, Living Labs and Impact Hubs

Matthias Geissler, Sophia Bittner-Zähr, Anna-Maria Kindt
(TU Dresden, Germany)

The concepts described in this section complement Science Parks and Incubators (see section 9.1) as examples of more open and less formalized infrastructures in the modern KTT environment. They constitute newer developments facilitated by the Open Science and Open Innovation movements. All these institutions emphasize exchange of ideas and knowledge through the offering of an environment that is conducive to related activities. Although similar to Science Parks, Impact Hubs, for example, focus more on the support of socially and environmentally focused business models. Makerspaces and FabLabs allow everyone to realize own ideas through the use of special equipment and more or less free support. Additionally, Living Labs allow the co-creation, exploration, experimentation and testing of new products in a natural (public) environment by multiple stakeholder groups.

8.2.1 The movement towards personalized manufacturing

Makerspaces

Makerspaces are collaborative working spaces located in schools, libraries, private or public rooms. They are open to everyone willing to use the offered infrastructure for the manufacturing of individualized products, to educate herself and exchange ideas. Makerspaces are a part of the maker movement which is related to the open science movement. Its aim is to mitigate concepts in modern societies like centralization, division of labor or corporate power or, at least, to offer alternative forms of organization with an emphasis on "do-it-yourself". As a result, Makerspaces have a flat hierarchy, are open to everyone and their users share the same idea: to make things independently, following the principle of trial and error. By doing so, the users gradually evolve into true "inventors". Typical Makerspaces offer machines like 3D printers, laser cutters, and plotters. But not only machines are shared, also software and codes are available. Hackerspaces constitute a special type of Makerspace with a focus on software coding. Another subtype of a Makerspace are FablLabs (see below).

FabLabs

A FabLab (*fabrication laboratory*) is a special type of Makerspace. As part of a network, this kind of open laboratory offers computer assisted production sites as well as the needed education and support open to everyone, who wants to transfer own ideas into real world projects. Thus FabLabs allow personal fabrication.

The idea of an open laboratory was introduced by Neil Gershenfeld from the Massachusetts Institute of Technology (MIT), who held a lecture on "How to Make (Almost) Anything" in 1998. As part of this lecture, his students had the chance to use a lab in which they could work on their own ideas. Strengthened by the success of this open lab, the idea to develop a concept of open labs worldwide was born (FAU FabLab 2019). Today, a huge number of locations exist worldwide which are independent, non-profit and self-organized. However, each FabLab needs a host agency (like governmental agency, community organization, educational institution) which assumes formal ownership. Additionally, the MIT acts as an umbrella organization, regulating access and ensuring the adoption of the so called Fab Charter (see figure 1).

Each site provides different machines to its users. The use of the machines is without charge so that the users only pay for the needed materials. Additionally, they have access to support activities and workshops to plan and program their project with the needed software and also to use the machines in a safe way. Courses are usually also free of charge.

8.2.2 Approaches for enhanced interaction and knowledge exchange

Living Labs

In comparison to Makerspaces, which are part of the open science movement, Living Labs are connected to two key concepts: citizen science and open innovation. They offer "physical regions or virtual realities in which stakeholders form public-private-people partnerships (4Ps) of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts" (Westerlund und Leminen 2011). Therefore they are a new kind of infrastructure allowing for exchange between researchers, businesses and society and can be seen as expansion of Science Parks, which focus more on R&D.

The living lab concept has its roots in the 1990s and became popular in Europe through the decision of the European Commission to set up a European innovation system which is based on Living Labs (Leminen et al. 2012). Today, Living Labs can be found worldwide in the fields of energy, media, IT, mobility or healthcare. It is a place of networking between the different stakeholders and allows companies and researchers to engage in user-driven innovation. Through the integration of customers and users in the early development stages, its aim is to alleviate the risk of launching a new product, service or technology. In the end, the process of commercialization should be shortened and innovations scaled up for the introduction into global markets (Leminen et al. 2012).

Impact Hubs

So called Impact Hubs are part of a broad network of more than 100 sites worldwide. They offer shared offices, a community, startup support as well as events to entrepreneurs (Impact Hub GmbH 2019). The businesses can be mainly located in the fields of social and environmental issues, as the Impact Hub network aims at supporting the United Nations Sustainable Development Goals. In 2017 more than 16.000 persons where members of the network, which consists not only of entrepreneurs, but also of freelancers, academics, students, investors and funders, activists as well as businesses, start-up or nonprofit professionals. Through this mix of persons and their support in terms of mentoring, advice or feedback, new ideas can become real-world projects and successful ventures. Although all Impact Hubs are part of a network, each branch is founded by an entrepreneur and independent from the others. Therefore, each branch is managed differently and allows the adaption of a business model taking local conditions into account.

8.2.3 Practical Implications

As part of a university, Makerspaces and FabLabs allow students (for example in technical fields or architecture) to transfer their own ideas into prototypes. However, not only students can use such sites on their own. Also lecturers can integrate project-based learning in their teaching. In conclusion, these two concepts encourage people to educate themselves and manufacture their own products. The hosting by an educational institution is beneficial, as the modern university should be a place of learning and exchange for the broad public. However, besides the facilities, machines and staff (at least volunteers) are needed. Living Labs and Impact Hubs are characterized by the interaction of different stakeholders. They are part of a global movement and can be placed on the interface between industry, research and society.

In sum, policy makers in developing countries have to decide if maker-orientated and exchange-oriented formats can complement their innovation ecosystem in a meaningful way and if it is worthwhile to (financially) support them. For initiation of Living Labs the industry should be integrated in a very early stage. Additionally, on all continents Living Labs exist, which could act as blue-prints. Some of the concepts (Impact Hubs, FabLabs) can be initiated by private entrepreneurs, individuals or associations. However, policy makers as well as the decision makers in educational institutions should be actively supporting approaches towards the maker movement. A first starting point could be to encourage lecturers to integrate the open lab idea into project-based learning seminars. If this is successful, establishment of (small-scale) Makerspaces or FabLabs should be given some consideration.

Learning Questions and Discussion:

1. What is the difference between a Makerspace and a Living Lab?
2. Does your university/organization already offer activities typically to be found in Makerspaces? What kind of services/activities would you expect (in addition)?
3. What might be a suitable payment scheme/business model to start a small-scale Makerspace? Where would you (physically) locate it in your university/organization?
4. Is there already an “Impact Hub” located in your country/region? If not, what kind of services would you offer for your region/university/organization if you had the chance to open one (e. g., more co-working space, more focused on acquiring government funding, more accelerator type,…)?

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Table 1: Comparison of new infrastructure types

	Makerspace	FabLab	Living Lab	Impact Hub
Target group	Public, all ages (even kids), some are open for SME, too	Public	Businesses, research institutions, interested public (private-public-people-partnership)	Entrepreneurs, freelancer, academics, students, professionals, investors, intrapreneurs
Organization	Independent, mainly managed by an association of volunteers	Independent, have a host agency (gov. agency, educational institution), part of a global, share Fab Charta	Independent, global network	Sites are founded by an entrepreneur, independent, part of a global network, “users” become members
Offer	Machines (like 3D printers or laser cutter), workshops and support		Real-life environments or arenas for	Shared offices, founding support, events for knowledge exchange
Impact	Personalized manufacturing, knowledge exchange, education		User-centered innovation and research through common co-creation, exploration, experimentation and evaluation	Knowledge exchange, support of ventures in the field of sustainable development

The Fab Charter

What is a fab lab?

Fab labs are a global network of local labs, enabling invention by providing access to tools for digital fabrication

What's in a fab lab?

Fab labs share an evolving inventory of core capabilities to make (almost) anything, allowing people and projects to be shared

What does the fab lab network provide?

Operational, educational, technical, financial, and logistical assistance beyond what's available within one lab

Who can use a fab lab?

Fab labs are available as a community resource, offering open access for individuals as well as scheduled access for programs

What are your responsibilities?

safety: not hurting people or machines
operations: assisting with cleaning, maintaining, and improving the lab
knowledge: contributing to documentation and instruction

Who owns fab lab inventions?

Designs and processes developed in fab labs can be protected and sold however an inventor chooses, but should remain available for individuals to use and learn from

How can businesses use a fab lab?

Commercial activities can be prototyped and incubated in a fab lab, but they must not conflict with other uses, they should grow beyond rather than within the lab, and they are expected to benefit the inventors, labs, and networks that contribute to their success

Figure 1. The FabLab Charter (Massachusetts Institute of Technology 2012).

8.3 Vietnamese Case: BK Holdings [Model of technology transfer enterprise from university]

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BK-Holdings is the first business model established in a university in Vietnam even though this is existed over the world for long time. It ensures coherence, clarity in terms of organization, finance, mobilization of positive contributions with high responsibility from scientists.

8.3.1 Overview

Since for long time, the commercialization of research results from universities has faced to hard problems. Technology transfer activities from universities to the society are not commensurate with the potential and capacity of universities. The Management Board of Hanoi University of Science and Technology (HUST) has realized limitations that hinder the process of technology transfer such as:

- The organizational model of technology transfer activities in HUST has not motivated academic staffs to participate. There are no qualified professional organizations to accompany scientists during the technology transfer process from creating value, seeking markets to deploying into reality;
- Very few individuals/units in HUST are conscious and proactive in registering useful solutions and establishing the IPR for products/results they create. This leads to conflicts of interest between the University, scientists and industrial partners during the technology transfer process; the products/results, therefore, cannot be exploited in a sustainable and effective manner;
- The organizational model lacks transparency in the use of public assets during the implementation of technology transfer contracts, which puts University in a difficult position to explain to state management agencies when inspected and supervised.

In order to promote technology transfer activities in the University, the Rector Board thoroughly understands the necessity of an effective system of enterprises and scientific and technological services.

Hesitating the experiences of high advanced education institutions in developing countries who having effective technology transfer models, in July 2007, the Rector Board decided to set up a team in charge of research on reforming the enterprise system. In 2008, an enterprise system under the new model was officially implemented at Hanoi University of Science and Technology to replace the old company model (Bach Khoa Company)[1]. This enterprise system has the most basic difference compared to the existing model in universities:

- Separating technology transfer and production and business activities from the purely administrative management of a public training and science-technology institution;
- Transparentizing the transfer of school property into the production and business process; trying to create a mechanism for school scientists to contribute to the establishment of companies.

8.3.2 Organizational structure

BK-Holdings was established from the capital and assets of Bach Khoa Company. The public Property Management Board and the Rector, who is the Board's Chairman monitor assets (including tangible assets and intangible assets such as the facilities, technology and brand of the school, etc.) and the capital from the University transferred to BK-Holdings and vice versa[2].

The enterprise system is formed according to the group model with joint-stock companies and scientific and technological services. Initially, BK-Holdings consisted of 2 one-member limited liability companies, 4 joint stock companies, and 1 vocational college. This model of the University has been operating stably. The results show that it has brought an increase in annual revenue, contributed to the development of the University and initiated the motivation for scientists and research groups in the University.

After more than 10 years of operation, currently, the system of BK-Holdings operates in three fields and has member units[3]:

- Education (BK-Holdings Education): 4 educational institutions
- Vocational College of Hanoi University of Science and Technology
- BACH KHOA T&T., JSC
- Genetic Bach Khoa international training cooperation program
- Ta Quang Buu Secondary and High Schools
- Technology transfer: 5 institutions
- Vietnam Cleaner Production Center Company Limited
- Bach Khoa Environment-friendly Joint Stock Company
- Bach Khoa Consulting & Technology Transfer One-Member Company Limited
- Hanoi Technology and Material Technology Joint Stock Company
- Precision Mechanical Engineering Research Joint Stock Company
- Innovation and Creation:
- BKHUP Co-working Space
- Lotte Start-up Office
- Vietnam Junior Start-up
- Project on supporting the ecosystem of national entrepreneurship and innovation up to 2025 (Project 844)
- BK-eBike project: public bicycles

8.3.3 Human resource system

BK-Holdings is 100% owned by the University and the Board of Members of the System is appointed by the University. For the units under the system, BK-Holdings appoints representatives to join the Board of Members or the Board of Directors (BOD); the executive team of the units is decided by the Board of Members or their Board of Directors. Personnel in the units may be staff working at the University, but may also be other people with capabilities. In case the school's staff is appointed to the key management positions of the enterprises (Directors and Deputy Directors of the companies), the University will send a decision on secondment in the maximum time of 5 years. Payroll of staff is still under the University but income will be paid by their enterprise. During the secondment, the university's staffs can leave the management position of the enterprise and return to the University. After the secondment, seconded staff who wants to continue working at the enterprise must move completely to the enterprise.

With the priority orientation of facilitating the integration of training with scientific research and technology transfer, increasing income for staffs and students in the University, BK-Holdings can ask staffs and students of the University for the implementation of technology transfer contracts in the form of professional lump-sump contracts, consultancy contracts, or teaching contracts. Currently, BK-Holdings has a system of up to 350 employees.

8.3.4 Operational model

As a bridge between scientists and enterprises, BK-Holdings becomes a "flexible tool" to implement cooperation contracts with domestic and foreign enterprises.

If a technology is transferable, BK-Holdings - a company holding the capital of the University - will ask the relevant units to make a proposal to submit to the Public Property Management Board. The Chairman of this Board will then transfer the proposal to the Rector Board (including Trade Unions, Party Committees and School Management Board) for consideration and decision. After the consideration and decision to invest of Rector Board, the procedures for establishing a business are conducted.

Or, when a School or Research Institute needs to establish an enterprise (a joint stock company) to commercialize products to the market, the Institute will set up a proposal and complete it under the support and advice of BK-Holdings. The proposal will be submited to the Chairman of the Public Property management Board and then to the Rector Board (including Trade Unions, Party Committees and the Board of Directors) for approval. A joint-stock company will be established with shares of the University held by BK-Holdings. The remaining shares are belong to the Institute, institute's staff and outside partners. With this model of shares, the revenue/income of the parties will be associated with technology transfer activities, making the enterprise's activities strong, contributing to the school to invest in development and increase the value of assets.

Thus, BK-Holdings plays the role of the linkage between scientists (scientists as individuals or through the Institutes) as owners of scientific and technological results/products, and domestic and foreign enterprises, to commercialize research results/products into practical contributions to community and businesses.

BK Holdings' technology commercialization model consists of three components[4]:

- Research teams;
- Support services from the university;
- Enterprises who commercializes technology.

In particular, support services from the university play an intermediary role in connecting with businesses. The department of Science Management of the University provides the support and advice on intellectual property (IP), structure and method of technology transfer, pricing, payment methods, technology transfer contracts, and technology transfer implementation.

However, to really support the commercialization of technology, the model needs to hire economic, social, and financial experts to make practical requests for market research and connectivity to businesses in need. The diversity of fields of experts will create a common voice between scientists and businesses, increasing the ability to commercialize technology and enhance research value.

As the pioneer in technology transfer activities from Hanoi University of Science and Technology, BK-Holdings holds "input" and "output" aspects of technology and relations with partners. BK-Holdings is required to operate effectively under the supervision of the Rector Board.

In the past years, the system has signed and had many cooperation activities with universities, large corporations in Asia as well as in the world such as Heasung Vina Group, NISSIN Group, Company PONAST, SPOL. S R.O (Czech Republic), Prague University of Life Sciences - Czech Republic, etc.

Footnotes

1

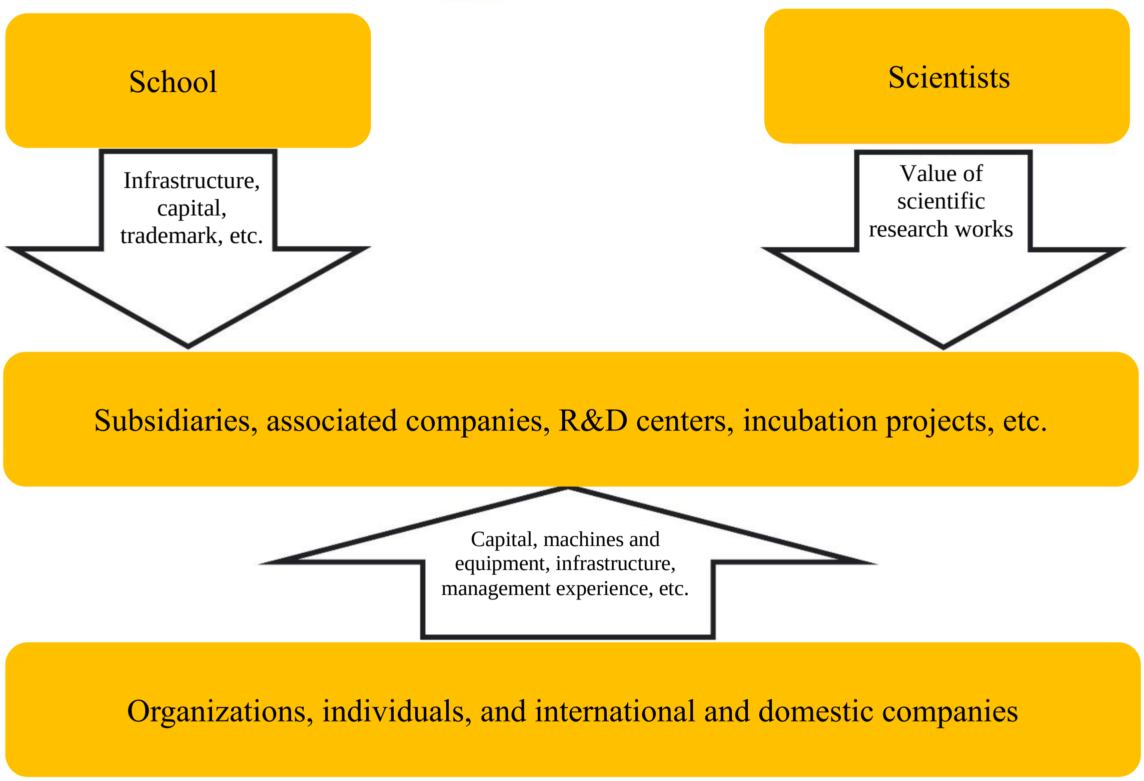

Figure 1. Relationship between units in the system of Hanoi University of Science and Technology

2

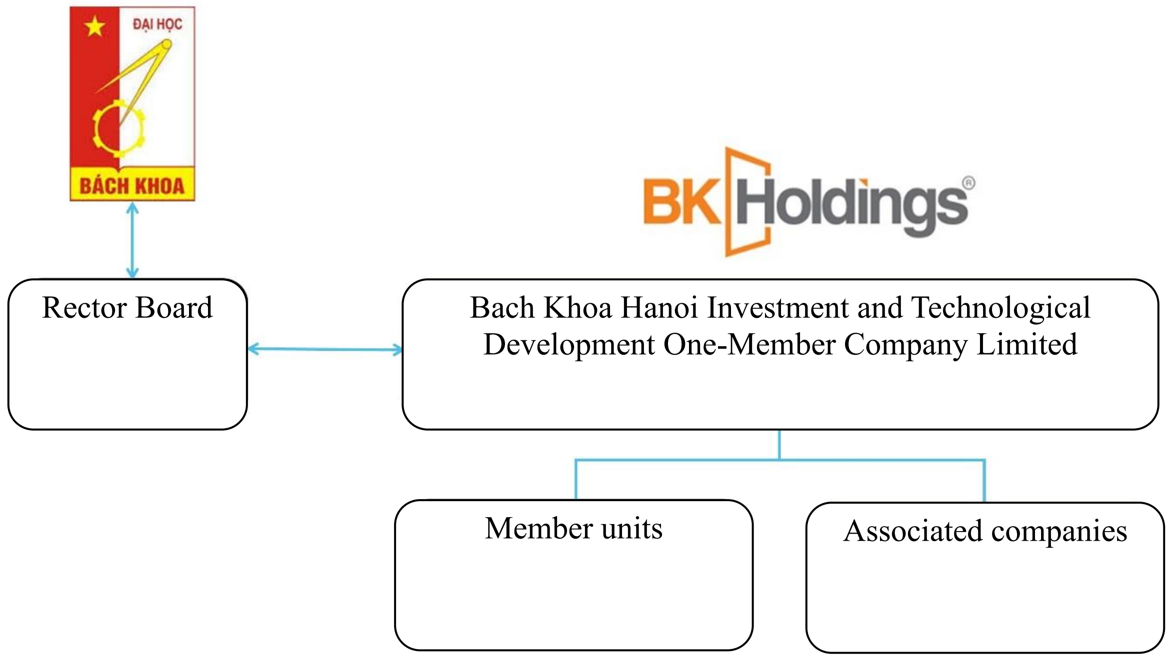

Figure 2. Management model - Relationship between Hanoi University of Science and Technology, BK-Holdings and other units

Figure 3. Enterprise system of BK-Holdings

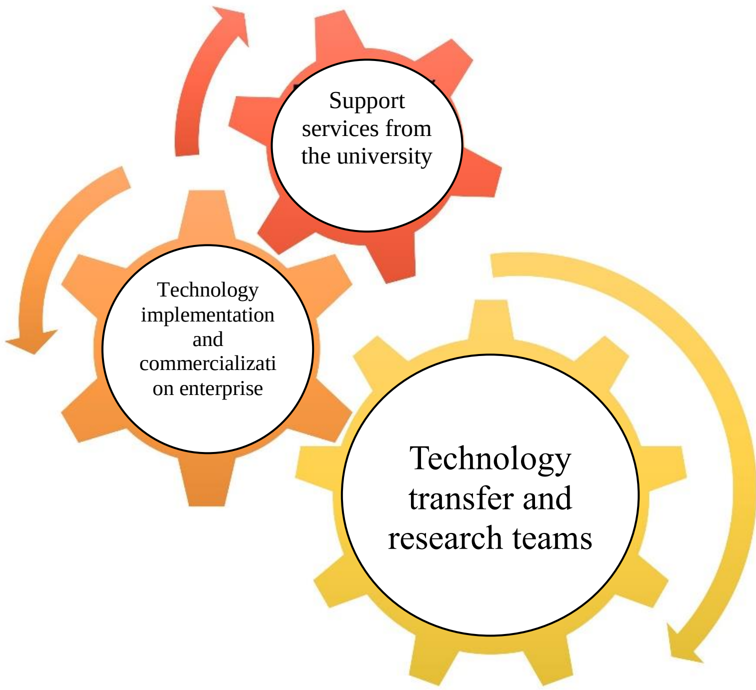

Figure 4. BK-Holdings' principles of technology transfer for commercialization