Universidade de Aveiro Departamento de Economia, Gestão e Engenharia Industrial
Ano 2015

MARCO ANDRÉ VIANA DINIZ PIMPÃO

Gestão do Risco nas cadeias de abastecimento de "commodities" – da complexidade conceptual à prática gerencial

Risk Management in Commodities Supply Chains - from conceptual complexity to managerial practice

Universidade de Aveiro Departamento de Economia, Gestão e Engenharia Industrial
Ano 2015

MARCO ANDRÉ VIANA DINIZ PIMPÃO

Gestão do risco nas cadeias de abastecimento de *commodities* – da complexidade conceptual à prática gerencial

Risk Management in Commodities Supply Chains - from conceptual complexity to managerial practice

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Engenharia e Gestão Industrial, sob exclusiva responsabilidade.

To Cristina, my lighthouse…

o júri

presidente

Prof. Doutor Mário Guerreiro Silva Ferreira
professor catedrático do Departamento de Engenharia de Materiais e Cerâmica
da Universidade de Aveiro

Prof. Doutor Virgílio António Cruz Machado
professor catedrático da Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa

Prof. Doutora Ana Paula Dias Barbosa Póvoa
professora catedrática do Instituto Superior Técnico da Universidade de Lisboa

Prof. Doutor José António de Vasconcelos Ferreira
professor associado do Departamento de Economia, Gestão e Engenharia Industrial
da Universidade de Aveiro

Prof. Doutor Alcibíades Paulo Soares Guedes
professor auxiliar da Faculdade de Engenharia da Universidade do Porto

Prof. Doutor Cristovão Silva
professor auxiliar da Faculdade de Ciência e Tecnologia da Universidade de Coimbra

agradecimentos
acknowledgments

Although I am the sole responsible for the possible shortcomings of the output of this long journey, it has not been a lonely one. Along the way, I have incurred a few debts of gratitude and have come to owe a few apologies.

I am extremely grateful to Professor Luis Miguel D. F. Ferreira (University of Aveiro) for his support and patience, his shrewd observations, his good humour in the most difficult moments and, most of all, for his open-mindedness.

I extend this gratitude to Professor António Carrizo Moreira (University of Aveiro) for his support and useful advice along the way.

As always, I must also thank my parents for their help along the years and I do hope I did not fail to meet their expectations.

This has been a long roller-coaster ride, too long and too bumpy. My greatest debt of gratitude is owed to Cristina for her support, for her companionship and for her patience. But I must also apologise to her, to Marta and Ruben for the countless ill-humoured days, after countless sleepless nights.

palavras-chave

risco na cadeia de abastecimento, gestão do risco, gestão da cadeia de abastecimento, *commodities*.

resumo

Ao longo do último par de décadas, uma longa lista de acontecimentos trouxe o risco na cadeia de abastecimento para o palco principal da literatura relativa à gestão da cadeia de abastecimento, tanto de natureza académica como profissional. Mais importante, o risco na cadeia de abastecimento é agora uma preocupação diária para gestores de cadeia de abastecimento que veem as suas cadeias de abastecimento globais exposta a uma infindável lista de potenciais causas de perturbação. Apesar de a literatura relativa à gestão do risco na cadeia de abastecimento ter aumentado consideravelmente nos últimos anos, apenas um pequeno número de investigadores abordou este tópico no contexto das cadeias de abastecimento de *commodities*. Acresce que, a maior parte da literatura que aborda o tópico fá-lo focando o risco de variação do preço das *commodities*.

A presente tese aborda a gestão do risco de abastecimento de *commodities* com vista a apurar se o risco de variação do preço é, de facto, o risco mais relevante, tal como a atenção que lhe é dada parece sugerir. Fá-lo usando o exemplo das cadeias de abastecimento de aço e tentando apurar quais os riscos mais relevantes, do ponto de vista de empresas consideradas grandes compradoras de aço.

Tendo em vista este propósito, foram levadas a cabo entrevistas em dois grupos de empresas – um grupo englobando vários sectores e um grupo de empresas grandes compradoras de aço – para apurar quais os riscos mais relevantes que afectam a cadeia de abastecimento para aquelas empresas e como estas lidam com eles. É efectuada uma análise comparativa com base naqueles dois grupos de empresas.

Tendo sido levada a cabo uma extensa revisão da literatura e beneficiando das informação recolhida com as entrevistas, esta tese sugere que a complexidade dos conceitos envolvidos na gestão do risco na cadeia de abastecimento, alguma confusão criada pelas inúmeras classificações na literatura e a falta de conhecimento relativamente a alguns aspectos com impacto no risco prejudicam a utilidade da teoria na prática, do ponto de vista dos gestores.

Tendo em conta esta preocupação, a presente tese sugere um quadro para uma gestão do risco de abastecimento sistemática, incorporando uma abordagem diferente à identificação do risco como seu primeiro passo. Pretende-se que esta seja uma ferramenta prática que possa assistir os gestores de cadeia de abastecimento no seu processo de decisão.

keywords

supply chain risk, risk management, supply chain management, commodities.

abstract

Over the past couple of decades, a long list of events has brought supply chain risk to the main stage of supply chain management literature, both academic and professional. More importantly, supply chain risk is now a daily concern for supply chain managers who see their global supply chains exposed to an endless list of potential causes for disturbances. Although the literature on supply chain risk management has increased enormously in past few years, there are only a handful of researchers who have addressed the topic in the context of commodities supply chains. Furthermore, most of the research that does address risk in commodities supply chains does so by focusing on commodities price risk.

This thesis addresses commodities supply risk management with a view to establishing whether commodity price risk is the indeed the most relevant risk, as the attention it receives seems to suggest. It does so by using the example of steel supply chains and trying to establish which risks are the most relevant from the point of view of companies that are considered major steel buyers. With that purpose in mind, interviews have been carried out in two groups of companies - a multi-sector group and group of companies that are major steel buyers – to ascertain which supply risks are the most relevant for those companies and how they deal with those risks. Using those two groups a comparative analysis is carried out.

Having carried out an extensive literature review and benefiting from the insights provided by the interviews, this research suggests that the complexity of the concepts involved, some confusion created by the different risk classifications in the literature and the lack of knowledge in important issues with an impact on risk are detrimental to the practical usefulness of theory, from a managerial point of view. With that concern in mind, this thesis suggests a framework for systematic supply risk management that incorporates a different approach to supply risk identification as its first step. This framework aims at being a practical tool to assist supply chain managers in their decision-making process.

Table of Contents

List of tables

List of images

Index of Acronyms and abbreviations

BCI	Business Continuity Institute
BCM	Business Continuity Management
BL	Bill of Lading
BRIC	Brazil, Russia, India and China
CAD	Cash Against Documents
CBP	Customs and Border Protection
CFO	Chief Financial Officer
CFR	Cost and FReight
CIF	Cost, Insurance and Freight
CIP	Cost and Insurance Paid to
C-PAT	Customs-Trade Partnership Against Terrorism
CPR	Commodity Price Risk
CSI	Container Security Initiative
DG	First Demand Bank Guarantee
DDP	Delivered Duty Paid
DHS	Department of Homeland Security
DRAM	Dynamic Random-Access memory
EUR	Euro
EXW	Ex-Works
FMEA	Failure Mode and Effects Analysis
FOB	Free On Board
HRC	Hot Rolled Coil
LC	Letter of Credit
PS3	PlayStation 3
RBT	Resource-based Theory
RDT	Resource Dependence Theory

SARS	Severe Acute Respiratory Syndrome
SC	Supply Chain
SCR	Supply Chain Risk
SCRM	Supply Chain Risk Management
SLA	Service Level Agreement
SME	Small and Medium-sized Enterprise
SPOF	Single Points Of Failure
SRM	Supply Risk Management
TCE	Transaction Cost Economics
TCO	Total Cost of Ownership
UNCTAD	United Nations Conference on Trade and Development
UNISDR	United Nations International Strategy for Disaster Reduction
USA	United States of America
USCPSC	United States Consumer Product Safety Commission
USD	United States Dollars
WTC	World Trade Centre

Part I - Introduction

1.1 - Context

The numbers are shocking, according to the United Nations International Strategy for Disaster Reduction (UNISDR, 2012, p.2), citing the EM-DAT The International Database:

> *"Between 2002 and 2011, there were 4130 disasters recorded, resulting from natural hazards around the world where 1,117,527 people perished and a minimum of US$1,195 billion was recorded in losses. In the year 2011 alone, 302 disasters claimed 29,782 lives; affected 206 million people and inflicted damages worth an estimated US$366 billion."*

Jaw-dropping as these figures might be, the odds are that these events will tend to occur more often in the future (UNISDR, 2009). The year 2011 will, indeed, linger in the memory of supply chain professionals as a year in which several events eloquently reminded them of the vulnerability of world-spanning supply chains. Little effort is needed to find, in the web published media, examples of events of different nature that have disturbed international supply chains, almost on a weekly basis. In late July of 2011, the worst floods in Thailand in the past 50 years brought havoc to the supply chains of several industries, causing losses that may have reached 20bn USD (Denton, 2011) and an estimated worldwide amount of insured losses exceeding 10bn USD, according to Munich Re (Maier and Chan, 2011). As two-thirds of the country were flooded, causing tragic loss of lives and destruction of property, several companies were forced to suspend production in their plants in central Thailand (Supply Chain Times, 2011). Still, these historical floods in Thailand were only the fourth costlier disaster ever in Munich Re's ranking of worldwide disasters, dwarfed by the staggering numbers of the losses caused by the 2011 Japan earthquake and tsunami. The floods in Thailand hit companies like Honda Motor, Toyota, Nissan, Seagate Technology or Western Digital, that experienced disruptions of their supply chains, just when many of them were still recovering from the supply chain chaos in the aftermath of the 2011 earthquake and ensuing tsunami that spread destruction in the north-east coast of Japan, causing a nuclear threat and power shutdown. Toyota alone estimated that between October 10 and November 12, the Thai floods have resulted in 150,000 units of lost production (Whipp, 2011). In 2011, Japan sustained losses amounting to 235bn USD, according to The World Bank, a number that also dwarfs the losses caused by hurricane Katrina in 2005 which amounted to

82.1bn USD, not to mention the differences in the casualty figures (Park *et al.*, 2013). A year later, companies have learned longer-term hard lessons that will hopefully help them overcome the effects of these disruptions easier, so that production is back on track much faster, even if to achieve that goal they have to withstand increased operating costs (Takahashi, 2012).

The tragic events in Japan are probably one of the best examples of the long-lasting effects that supply chain disruptions can cause and of the fact that often times those effects are not immediately noticeable. Having learned from the traumatic experience, companies often launch risk assessment programs leading to structure and process changes that are implemented several months or even years later. For instance, following the earthquake, Toyota requested the suppliers to its Japanese factories to disclose information concerning their supply chains. This request was made to about 500 suppliers and, from the information gathered from half of those suppliers concerning their sourcing network, Toyota discovered that there could be some 300 production locations at risk (Takahashi, 2012). Acting on this discovery, Toyota urged its suppliers to adopt adequate measures, such as diversifying their sourcing and incrementing buffers of parts, despite the added costs that those measures represent (Takahashi, 2012).

These 2011 natural events may seem rather extreme, but the truth is that, in the past decade or so, we have witnessed a string of events causing supply chain breakdowns across the world and there is compelling evidence that these disruptions are bound to become more frequent (Coleman, 2006, with regard to man-made disasters; Wagner and Bode, 2008). This possibility challenges the relatively low priority that companies traditionally assigned to those risks. The post-tsunami meltdown at Fukushima nuclear plant is an example of what has become a high profile risk, even tough it was usually rated as a low probability one (World Economic Forum, 2012). As the World Economic Forum stresses in its "Global Risks 2012" Report (World Economic Forum, 2012, p. 38),

> *"If realized, these risks have the potential to destabilize both economies and societies, trigger geopolitical conflict and devastate the Earth's vital resources and its inhabitants".*

The 2004 Boxing Day Asian earthquake and tsunami, hurricane Katrina, in 2005 (Kahn and Burnes, 2007; Wagner and Bode, 2006), and the 2010 Haitian earthquake are other examples of recent events with extreme consequences on supply chains (Stecke and Kumar, 2009; Thomsett, 2011). This sort of catastrophic, unpredictable natural event, simultaneously disrupt commercial supply chains and demanded swift response from humanitarian supply chains (Beresford and

Pettit, 2009).

Besides the recent natural catastrophes with worldwide impacts, over the past decade or so a plethora of events have disrupted supply chains of specific companies. In 1997, a strike of UPS workers highlighted the implications of just-in-time production models in the relationship between employers and union trades, but also exposed the vulnerability of just-in-time supply chains (Coleman and Jennings, 1998; Herod, 2000; Chapman *et al.*, 2002). In 1998, Hurricane Mitch hit South America destroying Dole's banana plantations with heavy impacts on revenue. In 2000, when supplier's semiconductor plant caught on fire, Ericsson's losses amounted to 400 million Euros (Tang, 2006a). In 2001, when all air traffic was suspended after the 09/11 attack on the WTC (Assaf *et al*. 2006; McGhee and Giermanski, 2007; Wagner and Bode, 2006), Ford closed five plants for several days. Also in 2001, following the insolvency of a supplier, Land Rover laid off 1400 workers (Chapman *et al.*, 2002; Sodhi and Tang, 2012).

In the wake of the terrorist attack on the twin towers, the reinforcement of product entry control in the United States of America with the creation of the *Department of Homeland Security* (DHS) and of *Customs and Border Protection* (CBP) - combining the *U.S. Custom Services* and *Immigrations* - brought along a number of new laws and procedures that proved difficult to cope with for exporters or importers of goods bound for the USA. This was the case of legal requirements within the scope of the *Customs-Trade Partnership Against Terrorism* (C-PAT), such as the *24-hour Rule,* and of the *Container Security Initiative* (CSI), which, despite the fact that their origin was in the U.S. Administration's policy, had a worldwide impact in companies' supply chains. On the other hand, following a number of financial scandals in the United States of America, the passage of the 2002 Sarbanes–Oxley Act resulted in added responsibility of senior executives for forecasts of performance and protection of shareholder value, thereby increasing the motivation to identify and duly manage various risks, including supply chain risks (Hendricks and Singhal, 2012). The impact of all these rules was such that it may be argued that they

> *"changed the business world and the international supply chain from a market-dominated and –oriented activity to a rules-driven activity*" (McGhee and Giermanski, 2007).

Even though these legal initiatives are a significant effort to secure supply chains, soon after those policies were enacted, for reasons that are not relevant here, some authors questioned their reach towards this goal (Rice and Caniato, 2003) and their impact on supply chain vulnerability:

"Recent Homeland Security measures—such as the Customs-Trade Partnership against Terrorism (C-TPAT), Container Security Initiative, and the 24-hour manifest rule—have served to introduce additional stages and transactions, thereby increasing vulnerability" (Stecke and Kumar, 2009, p. 203).

Be that as it may, the terrorist attack on the Twin Towers, together with the bomb attacks in Madrid's train stations in 2004, contributed to broadening the definition of risk (Cavinato, 2004) and the former has been considered a catalyst for the increasing attention given to supply chain risk management (Chopra and Sodhi, 2004; Ghadge *et al.*, 2012). The enactment of new regulation and legal requirements is one of several sources of normative pressures - along with pressures from key customers, insurance companies and corporate directives - for organizations to ensure their supply chains and thereby to ensure their business continuity (Zsidisin *et al.*, 2005). Another normative pressure results of the changes in companies' procedures as large companies develop security metrics to assess the results of their efforts to secure their supply chains. Kleindorfer and Saad (2005, p. 64) refer some examples of such measures::

"the scope of integrity of seals, continuous movement of the container, length of time in exposed areas such as foreign ports, and a number of cost metrics".

These changes in internal normative procedures show that these pressures reflect the growing concern that managers, and not only public authorities, have about securing supply chains. This concern was such that, in the early years of the XXIst century, many would rank assuring container security as one of the main challenges over concerns such as reducing inventory, reducing lead time variance or stock-outs (Sarathy, 2006).

The outbreak of the Severe Acute Respiratory Syndrome (hereinafter SARS) epidemic in the Southwest of China and Hong-Kong (in 2003), and the pandemic threat of the spread of the H5N1 virus, the so-called "bird flu" (in 2006), and of Ebola (in 2014) are only a few examples of public health threats that have taken their toll on the stability of global supply chains (Cavinato, 2004; Goentzel, 2015; Kenealy and Zolkos, 2014; Stecke and Kumar, 2009).

In 2005, a dispute between the European Commission and China over import quotas of Chinese textiles *"left 77 million Chinese sweaters, trousers and bras impounded at the EU's borders"*

(Kumar *et al.* 2007).

In 2006, Sony recalled 9.6 million lithium-ion batteries worldwide due to fire hazard with reported costs exceeding 51 billion yen and this recall affected several other makers, such as Dell, Lenovo, Toshiba, Sharp and Fujitsu (USCPSC, 2006). Another infamous recall happened in 2007 when Mattel was forced to recall almost 1 million toys due to the use of lead-based paint (Kumar *et al*., 2007). This was only one of several product recall incidents that, in the past decade or so, have put a spotlight on companies that use China as a low cost source for their inputs. This focus is supported by the data of the U. S. Consumer product Safety Commission according to which half of the 426 product recalls in 2006 concerned products from suppliers in China, contrasting the 110 cases in 2000 (Kumar *et al*., 2007). Despite this focus on eastern sourcing, in early 2013 the so-called "bogus beef" scandal in several E.U. countries, when horse meat was detected in processed meat and meals labelled as being 100% cow meat, was a loud reminder that quality risks were hardly limited to products sourced in low cost countries, stressing the importance of ensuring a proper custodial chain and traceability in supply chains. These are just a few examples of dozens of recall incidents linked to product hazards that have affected several industry sectors in the past twenty-odd years, such as aeronautics, pharmaceuticals, food, toys, automotive and electronics (Hora *et al.* , 2011).

In the summer of 2008, inbounds from China were severely affected by traffic restrictions in China, due to the Beijing Olympics (Olson and Wu, 2010) and the lessons learned motivated careful planning for the 2012 London edition of the Games to avoid repeating mistakes (Clements, 2012). Besides the already experienced risks, vulnerability due to geographic and climatic factors of supply chains with their sourcing focused in China is an example of the fact that unpredictable phenomena may cause havoc to supply chains. This will most likely be the case if, for instance, a major typhoon hits the delta of river Pearl or if the 2005 Tsunami had hit Korea (Kumar *et al*., 2007).

Another not too distant example is the series of earthquakes that hit northern Italy in 2012 and caused turmoil in the Italian's automotive supply chain by forcing automakers to shut down assembly units, due to the disruption of their local suppliers' operations (Procurement Leaders, 2012). Another earthquake has exposed the vulnerability of international supply chains due to their strong dependence on information systems. In December 2006, the earthquake in Taiwan severed undersea communication cables causing

considerable internet slowdown and one of its immediate consequences was the delay of containers in Shanghai's terminal containers due to the fact that the operation relied on information systems (Tang and Musa, 2011).

Beyond this long list of isolated events, the financial turmoil of the past few of years, introduced a new context across the world and across sectors, adding uncertainty and volatility to the markets, leaving companies across the world to live with the Sword of Damocles over their head. Throughout the first couple of years of the financial crisis, record numbers of companies were scuttled at a never before seen pace, regardless of their size and across different tiers of supply chains, triggering a debate about supply chain resilience (Jüttner and Maklan, 2011) and putting a new focus on the exposure of supply chains to risks associated to the international economy (Blome and Schoenherr, 2011).

Arguably, it should take no more than conventional wisdom to recognize that risk and performance are directly related, as Ritchie and Brindley (2007b), citing Knight (1921), recall, but this connection has in fact been demonstrated by different researches in the past. For example, the correlation between companies' financial success and the sophistication of their supply chains has been demonstrated a decade ago by a joint-study carried out by Accenture, INSEAD and Stanford University (D'Avanzo and Van Wassenhove, 2003). Moreover, the impact of supply chain disrupting events on business activity and performance has also been demonstrated. An example is the negative relation between traditional risk (i.e., simple variance) and average return across industries that has been demonstrated (Bowman, 1980; March and Shapira, 1987). With a focus on supply chain incidents, Hendricks and Singhal (2003, 2005a), based on a sample of 885 supply chain glitches announced by publicly traded firms, estimate the association of supply chain glitches with operating performance, concluding that those announced supply chain glitches are associated with a 107% drop in operating income, 114% drop in return on sales and 93% drop in return on assets. Several incidents can clearly illustrate that impact, such as the 195 million USD disruption costs caused by a 1997 fire at a supplier's plant, that forced Toyota to shut down 18 plants and lose sales of an estimated 70,000 vehicles (~325 million); or the combined effect of an abrupt demand drop and locked-in supply agreements that forced Cisco to a 2.5 billion USD inventory write-off in the second quarter of 2001 (Norrman and Jansson, 2004). The same authors, based on operating performance metrics - such as sales figures and ROA - collected through the comparison of financial statements of the year preceding a disruption announcement and the figures following that disruption, have demonstrated that such announcements have a

long-term negative effect on operating performance (Hendricks and Singhal, 2005a). In short, Hendricks and Singhal's work has demonstrated that financial markets considerably value supply chain robustness and several examples in the recent past corroborate those findings (Wagner and Bode, 2006), thereby confirming previous suggestions that managing supply chain taking risk into account could represent a competitive advantage (Hauser, 2003). Manuj and Mentzer (2008a) identify an opportunity to reduce costs or to increase revenue as typically the first step in identifying risk., but opportunities to reduce cost or increase revenue are generally seized through decisions with major strategic implications, so often difficult to reverse in the short run and with an impact that may be difficult to anticipate. Nevertheless, for crisis-prepared companies, the competitive advantage may well be translated into better odds in the struggle for sheer survival, for those companies *"fare better in financial terms"*, face less calamities and even *"stay in business longer"* (Mitroff and Alpaslan, 2003, p. 100). Thus, Mitroff and Alpaslan clearly distinguish what they call *"risk-prone"* companies from *"risk-prepared"* companies, showing what companies have to gain from proactively managing risks.

Despite the fact that the increasing global dependencies and the fast paced spread of technological innovations have increased the frequency of events with impacts difficult to identify (Munich RE, 2011), it is clear that the impact of supply chain disruptions will depend on different factors such as the nature of the event and the characteristics of the different supply chains (Belarmino *et al.*, 2012) and of the different companies and their relationships with suppliers (Lavastre *et al.*, 2014). For instance, sole supplier sourcing exposed Apple to the impact of the disruption of microprocessor chips made by IBM in New York, caused by a 2003 electric power outage in the American Midwest and Ontario, delaying the launch of Apple G5 computer by the Cupertino based company and causing considerable financial losses (Zsidisin *et al.*, 2005). The same company had already experienced a serious supply disruption in 1999, when it was faced with a shortage of DRAM chips from suppliers affected by an earthquake in Taiwan, resulting in a pile-up of customer backorders and lost sales (Tang, 2006a). Where disasters are concerned, recent research suggests that their impact depends on the disaster type, on the industry and the supply chain echelon concerned. For instance, after the 2011 Tsunami in Japan and floods in Thailand, reports suggested that

> *"the biggest, often unperceived Achilles' Heel in Japan and Thailand has been the Tier 3 and Tier 4 players which do not necessarily have the wherewithal to develop contingency plans and elaborate schemes to enable them to bounce back"* (Cooke, 2011).

The example of Boeing 787 Dreamliner's troubled development and production stages has also been referred as a case study of how *"dramatic shifts in supply chain strategy from traditional methods"* can have a detrimental effect on stock prices (Tang and Zimmerman, 2009b, p. 83), via the increased risk exposure:

> *"Although it may be impossible to identify all potential risks and create contingency plans for all eventualities before a project begins, Boeing could have done many things differently."*

Future events would prove that these suspicions were hardly pure speculation, when, in January 2013, the entire fleet of 787s was grounded following a series of technical incidents and the identification of faulty lithium-ion batteries (Reuters, 2013).

The XXIst century seems to have started with the wrong foot, as the long list of events already referred, and many others that it would be too fastidious to mention, left behind giants figures in in losses both of assets and lives. The words of the two UN officials can sum up the two aspects that are cause for concern: the huge impact of those events and the tendency for their increased frequency.

> *"A wide variation in the number and intensity of natural hazards is normal and to be expected. What we have witnessed over the past decades, however, is not nature's variation but a clear upward trend"* (Former UN Secretary-General Kofi Annan, cited by Stecke and Kumar, 2009, p. 202)

> "*In the wake of the global financial crisis, disaster risk stands as a new multi-trillion dollar class of toxic assets of unrealized liabilities. The catastrophic economic losses from the Japan earthquake/ tsunami, floods in Thailand and the destructive Super Storm Sandy show clearly the extent of what is at stake*" (UNISDR Chief, Margareta Wahlström, The United Nations Office for Disaster Risk Reduction, 2013).

The overwhelming impact of those catastrophic events and the added frequency of their occurrence have fuelled the interest of researchers on supply chain risk as it will be further explained in the literature review herein. However, throughout these two first decades of the XXIst century, there has been scarce research focusing on risk in commodities supply chains. In

fact, as a preliminary literature survey had suggested and the extended literature review has confirmed. This scarcity of research, will be further explained within the context of the subsection on the motivation for this thesis, is aggravated by the fact that most of the few research texts on risk in commodities supply chains focus on commodity price risk, which seems to suggest that this is clearly the most relevant risk in commodities supply chains. However, even if one accepts, until demonstrated otherwise, that this is indeed the most relevant supply risk in the case of commodities, it seems doubtful that all other risks are irrelevant to point of being totally absent on previous literature. Obviously, this absence lacks the confirmation that only the literature review might or might not provide.

On the other hand, as it will also be further discussed herein, at a later stage, there is an extreme profusion of different concepts in the literature on supply chain risk management and these concepts are seldom given the same meaning by different authors. Despite the significant growth of knowledge that this abundance of interpretations represents, the result is, more often than not, a great deal of terminological confusion that thwarts the practical usefulness, from a managerial point of view, of that generated knowledge. Hopefully, this thesis will shed some light on this often forsaken field of research and represent a humble contribution to a better understanding of risk management in commodities supply chains, with a manager-friendly approach, so to speak.

1.2 – Structure of the Thesis

This thesis is organized in 7 parts, the first of which is the Introduction (Part 1), which includes a description of the present context of global supply chains from the point of view of risk. Focusing particularly on the period up until the early days of this research, but also giving some more recent examples, this description of context affords a considerable number of events that, throughout the past few years, have put the subject of supply chain risk under the spotlight. A plethora of risks that materialized in the first decade on the XXIst century highlighted the urgency of the subject of supply chain risk, which until not too long ago was hardly the hot topic that it has become. At the end of this context introduction the subject of this thesis is briefly introduced. Part 1 also includes this outline of the thesis' contents.

Part 2 begins by explaining the motivation for the present research. It does so, essentially, by suggesting a few frequent shortcomings of supply chain risk analyses in the literature and by focusing, particularly, on some risks that, it is submitted, are too often neglected, despite the fact that they can have a considerable impact on the organizations affected. A special reference is made to the case of commodities due to the fact that, historically, some of the documented cases have indeed involved commodities. Finally, Part 2 also includes a sub-section that enunciates the research questions that are the starting point for the research and expresses the intention to contribute to managerial practice by suggesting a model for supply chain management, focusing particularly on the identification of risks, based on the existing literature but suggesting the necessary options to, hopefully, deal with the difficulties that the analysis of the information gathered might expose.

The first sub-section of Part 3 is a more detailed perspective of supply chain risk throughout the past couple of decades. It explains how of supply chain risk has become a high profile topic, both in research *fora* and in managerial practice. In its second sub-section, Part 3 analyses the previous literature on supply chain risk management and does so by identifying several aspects that are considered fundamental in the literature and that are considered in the sub-sections of this section. As an introduction to the review of previous literature, an account of the increasing attention to supply chain risk management in the past couple of decades is provided, highlighting factors that contributed to this added attention and some of the most relevant important contributions in this period. Then, a description of the literature selection and analysis processes is made, followed by the identification of the main supporting theories of supply chain risk management research. Part 3 includes a sub-section 3.4 that reports on the most relevant contributions in the literature towards supply chain risk management systematization. The following sub-section deals with concept complexity in this field of study by highlighting the main contributions in the literature regarding a number of fundamental concepts. Hence, sub-section 3.5 addresses a number of concepts discussing different proposals in the literature and enunciating the meanings adopted, for the purpose of this thesis, for a list of relevant concepts. Part 3 also includes a reference to different frameworks and models for supply chain risk management and classifications of risk mitigations strategies proposed in the literature. Bridging the subject of supply chain risk management and the commodities trade, Part 3 includes a subs-section that demonstrates that the literature often recognizes the need to adopt a contextual approach to the subject of supply chain risk. The last sub-section in Part 3 introduces

the subject of risk in commodities supply chains, including the reference to the existing literature, identifying gaps in the existing literature and explaining the reasons for the focus on the steel supply chain. Some introductory information pertaining to the global steel trade are also included in this sub-section.

Part 4 addresses methodology-related issues, explaining the methodology adopted and the reasons for its adoption. Focusing on the case study approach, a reference is made to the most relevant literature that discusses and supports this approach. This reference is made with the main concern of seeking guidance for the remainder of the research work, in order to try to avoid, as much as possible, the pitfalls of this type of approach. This part also includes a sub-section that explains the thought process behind the selection of the cases used and shortly describes the method of information collection.

Part 5 is divided into 3 sub-sections. The first starts by introducing the organizations in the first group of interviews and the interviewees whilst keeping both companies and managers anonymous. Then it reports on and discusses the findings in the first group of interviews. The focus is on the risks that the interviewees identify in their supply chains, without any special focus on a single product, although specific examples might be relevant. This sub-section also reports on the interviewees' experience regarding their practice in coping with different risks. The second sub-section mimics the first one in so far as the information collected refers to the same aspects. However, on this second group, the focus is on steel supply chain and an effort was made to keep the interviews within this strict boundary to isolate the experience that concerns steel alone. Sub-section 5.3 in Part 5 makes a comparative analysis between the two realities in the previous sub-sections, based on the information collected and on further information gathered from the literature and from steel market information. The final sub-section in Part 5 highlights the reasons that have lead to the suggestion of a supply chain risk management framework, with special focus on the risk identification stage.

Part 6 purports to contribute to supply risk management knowledge and, particularly, aims at achieving relevant managerial implications. It does so by suggesting a supply risk management framework that builds on the existing literature but also includes a fundamental suggestion for an alternative approach for risk identification. This proposal is submitted based on the insights afforded by the extremely rich experience of the interviewees, the discussion of their solutions and their difficulties, and, at times, the shortcomings of their knowledge. The proposal

for a complete framework focuses particularly on the risk identification stage but it also suggests implications that the approach submitted for the stage of risk identification has on the following stages. A fundamental concern in this proposal is to keep it usable from a managerial point of view striving, therefore, to ensure simplicity and clarity of the meaning of each step.

Part 7 includes the conclusion of this research, an acknowledgement of its shortcomings, of the limits of its conclusions, which, simultaneously, lead to suggestions for future research.

Part 2 - Motivation and research objectives

2.1 - Motivation

> *"Consider cookery. The first rule of good cookery is to use the best ingredients. No amount of culinary expertise can cover up for substandard raw materials. You can't, as the saying goes, make a silk purse out of a sow's ear"* (Barrat and Whitehead, 2004, p. 16)

Despite how obvious the caveat above might seem, too often the discussion surrounding the purchase is focused on price alone, but this is not surprising as so often the lowest purchasing price is the lever for the organization's competitiveness. In fact, competitiveness is, ultimately, the goal of comparing products and suppliers (Cavinato *et al.*, 2000). The buyer, obviously, will seek to ensure that he gets the best deal possible, i.e. the best price that will grant him, in the end, the desired competitiveness. However, one must consider what qualifies as "the best price". An easy answer is that the best price is the lowest, but this is an answer that no 4th grader will accept, let alone a professional. Indeed, anyone will immediately ask where does quality come in? Just as it is plain to see that cheaper may imply lower quality it is also clear common sense that a higher price alone does not ensure greater quality. These are simple obvious observations that aim at highlighting another obvious idea: the best price will be the one that ensures that I receive more for less, whilst still receiving everything that is essential for me. An obvious statement and yet the decision is often much more complex than just comparing price tags. Total cost of ownership (hereinafter TCO[1]), bundled prices, trade-offs that the decision holder must consider, these are some of the terms that come to mind when one refers to procurement decisions (e.g. Bowersox *et al.* , 2006, pp. 83–84) and that immediately remind us that, as it happens with many difficult questions, the answer to the question "what is the best price?" will often be "it depends". The Total Cost of Ownership framework for purchasing decisions deals with the complexity of this analysis as

[1] There are several different definitions of TCO in the literature and it is beyond the scope of this work to discuss the concept of TCO. For a short yet informative discussion of this concept see (Zachariassen and Arlbjørn, 2011). For the purposes of this thesis the rather straightforward definition in Degraeve and Roodhoft (1999, p. 6 *apud* Zachariassen and Arlbjørn, 2011, p. 450) suffices, with added benefit to clarity: TCO is an attempt *"to quantify all of the costs related to the purchase of a given quantity of products or services from a given supplier"*.

"(it) requires that the buying firm determines which costs it considers most important or significant in the acquisition, possession, use and subsequent disposition of a good or service" (Ellram, 1995, p. 4).

The complexity of this analysis is a consequence of all the cost factors that may have to be carried to the manager's spreadsheet as parcels of the TCO calculated. This complexity can be anticipated by considering the major categories for the components of TCO considered by Leenders and Fearon in Figure 1 below (Leenders and Fearon, 1997 *apud* Bowersox et al., 2006, p. 85).

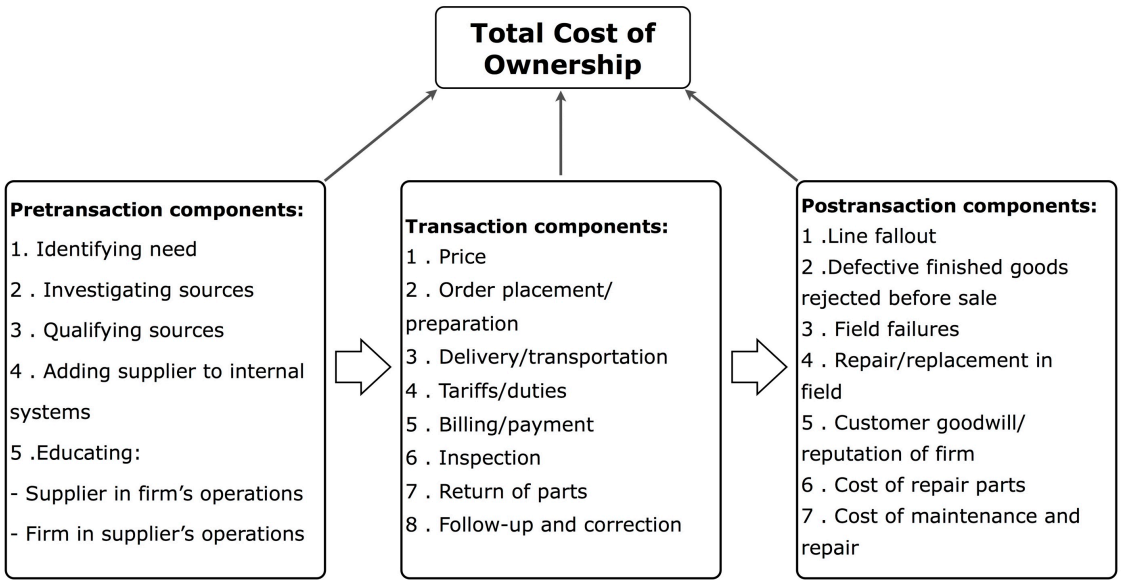


Figure 1 - Major categories for the components of Total Cost of Ownership (source: Leenders and Fearon, 1997 *apud* Bowersox et al., 2006, p. 85)

Within the broad spectrum of possible TCO components for a given product, the weight that each TCO component has can vary wildly, depending on all sorts of factors and there is a good example, albeit an extreme one, given by Burt (1996, p. 39) whilst discussing requirement trade-off analysis

"airplane bolts must have 100% reliability (...) The unit price per bolt is not critical, given the total cost of the aircraft and the potential cost of an accident."

One such factor that may have great implications on TCO is risk. In fact, the very example of airplane bolts shows the impact of risk. However, the importance of risk may not be obvious in the list of major categories for the components of TCO considered suggested by Leenders and Fearon (1997). Moreover, it is not uncommon for earlier articles focusing on TCO approaches and frameworks to lack a single express reference to risk as it is the case, for example, of several often cited research papers by Ellram of components of TCO: investigating sources, delivery/transportation, tariffs/duties, inspection, return of parts, defective finished goods, field failures, to mention but a few.

Arguably, as a consequence of the numerous supply chain disruptions throughout the last couple of decades, some of which have already been referred herein, and of the subsequent increasing relevance of risk in the context of supply chain management, risk may finally make its way into the literature on TCO (e.g. Zachariassen and Arlbjørn, 2011), reflecting the impact that it may have on the performance of the organization, as Borge (2002, p. 3) warns:

> "*Since good risk management can mean the difference between wealth and poverty, success and failure, life and death, it is worth some of your attention*".

Despite the relevance that risk currently has in supply chain management literature, there are several aspects that tend to be forsaken by supply chain managers. This probably happens, it is submitted, for one of four reasons: either due to the fact that they do not recognize them as relevant or strategic; or because they feel that they lack the knowledge necessary to delve into those aspects; or because, due to lack of human resources, they just cannot afford to take the time to consider such issues; or simply out of sheer ignorance. One of the underlying arguments in the present research is that the lack of attention to some issues that are linked to risk is not the result of an option but of contextual aspects, of idiosyncrasies of the decision holders and of researchers, and of other reasons, some arguably undesirable. Previous research carried out on the subject of supply chain risk management (Pimpão and Ferreira, 2012) and the a preliminary survey of the literature showed that there is a considerable number of risk and of risk sources classifications and taxonomies suggested in the literature and the literature review to be carried out will have to have these in mind. However, it also led to the belief that there are important realities that are constantly left out of those analyses, such as other risk sources and risks. Furthermore, some of those hidden/despised risk sources and risks may have a devastating

impact on the organization and yet they are grossly ignored. Risk associated to the contractual solutions adopted by companies in the international supply markets, to solutions adopted for purchases, for contracts of carriage, for payment terms and other aspects instrumental to the purchase is often beyond the grasp of supply chain managers who often lack the skills to understand them. This fact triggered the interest in analysing the way that companies deal with supply chain risk, in order to understand whether there is an adequate perception of the relevant risks and how companies deal with the risks that they do identify.

Should these doubts be relevant, they could be more so in the case of commodities. Indeed, when we consider, for instance, the possibility of risk associated to the contractual solutions that may expose the company to the risk of fraud, or to risk associated to transportation, we must anticipate the possibility of these risks materializing in cases where the impact is enormous. If we picture the case of a bulker with a cargo of grain on her holds contaminated and if we imagine the loss to the inadequately insured buyer holding the risk, we can easily anticipate the impact of such loss. If we consider a case such as the infamous Solo Industries case[2], in which a shady business man running a Dubai-based smelting company, we might start to have a glimpse of a reality that is totally beyond the knowledge of many supply chain managers, bearing in mind that he managed to leave behind him a

> *"merry-go-round of debt, mostly on the back of discounting L/Cs which would never be drawn (with a) $300 million shortfall in Dubai and between $600 and $700 million in India"* (MacNamara, 2001, pp. 73–74),

The Solo Industries case, truth be told, is of a different nature as it concerns trade frauds in which the international banking system was the victim of its own want of due diligence and, consequently, it is referred here solely for the purpose of illustrating the amounts can be on table in the international trade of commodities, exposed to its risks. However, there are countless examples in International Trade case law of incidents that resulted in great losses as a consequence of events such as containers that were lost overboard, cargoes that were stolen, ships that were lost at sea or deviated to an unknown port, simple delivery delays, or payment

[2] Madhav Patel, the said shady business man, is said to have scammed several banks with a complex network of letters of credits to finance cargoes that were mostly fictitious or of much less value than what they were financed for. For a short but informative description of the facts in this case see MacNamara (2001, pp. 70–75) and the 2003 UNCTAD report "A primer on new techniques used by the sophisticated financial fraudster" (UNCTAD, 2003, pp. 7–10).

arrangements that went wrong. Frequently, such losses could all have been avoided if adequate precautionary procedures had been observed. Unfortunately, it is not unlikely that, in many cases, managers were probably concerned with the wrong risks for different reasons, such as: the fact that they had insufficiently knowledge regarding risks linked to the articulation between carriage arrangements and sales contract terms; they lacked the necessary awareness of all the relevant risks involved in their day-to-day operations and of the tools and strategies to cope with those risks; they were poorly instructed, based on the existing faulty procedures; or they just simply lacked the time because the organisation was understaffed.

One might labour under the misconception that such risks are relevant only in one-off transactions but not in an operation that has been going on for years in trouble-free fashion. However, there is support in the literature for the belief that risk awareness is very much influenced by the experience of previous problems or the lack thereof (e.g. Harland *et al.*, 2003; Oke and Gopalakrishnan, 2009) and a manager must not forget that the fact that there is no history of incidents does not mean that risk is not lurking around the corner, just as he must not trust that for low-probability events with potentially high-impact lower attention levels suffice (Chopra and Sodhi, 2004).

It is possible that the existing literature is somewhat focused on the risks faced by an organization with a supply chain that operates with some degree of integration, with a limited number of organizations with recurring transactions between them. In this context, it is arguably expectable for managers' attention and researchers' work to be focused on risks that are more readily anticipated as fitting the label "supply chain risks", such as

> *"delays, disruptions, forecast inaccuracies, systems breakdowns, intellectual property breaches, procurement failures, inventory problems and capacity issues*" (Chopra and Sodhi, 2004, p. 53).

However, supply risk management is not just about long-standing inter-firm relationships and recurring transactions. In many cases companies do not have steady relationships with suppliers and rather buy in spot markets. Even companies with stable buyer-supplier relationships may occasionally buy in spot markets for different reasons, and in those occasions there may well exist other risks beyond those that are commonly identified by those firms.

The roots of the motivation for the present research lie where the knowledge of tools to manage risks that are well known in international trade (yet seem to be rather obscure for many supply chain managers and researchers) meets the existing knowledge on supply chain risk management[3]. Being well aware of the importance that risk management has in the day-to-day concerns of supply chain managers, this research hopes to bridge those different perspectives, enriching the discussion on supply chain risk management both from a theoretical point-of-view and a practical one.

Most studies that deal with supply chain risk mitigation tend to suggest risk mitigation strategies without linking the different strategies to different risks (Oke and Gopalakrishnan, 2009). However, from a managerial point of view, this link might be essential in order to add operational usefulness to the knowledge on both risks and mitigation strategies. In practice, arguably, neither is of any use without the other: extensive knowledge on risks and on mitigation strategies without establishing such links can be interesting for academics but little more than a boondoggle from a practitioner's point of view. There might be a dash of boldness in this suggestion, but there is support in the literature for the idea that this is insufficiently investigated as, for instance, the following remark by Oke and Gopalakrishnan (2009, p. 169):

> *"There is also a need for more empirical studies on this aspect of supply chain risk research. As such our second research question is: What are the mitigation strategies required to manage different types of supply chain risks?"*

Consequently, an effort will be made to identify the relevant risks but also to try to establish such links whenever they can be either conceptually justified or detected in the practice of supply chain managers. Hopefully, should this be achieved, this research might be a little more than misplaced academic bravado and might make a contribution, albeit a modest one, for managerial practice.

[3] Although the expressions "supply chain risk" and "supply chain risk management" are both used herein, the distinction is made between supply risk management and demand risk management (Tang, 2006a; Kern *et al.*, 2012) and the analysis in this research concerns risks associated to supply management alone, as discussed in the literature review.

2.2 – The research objectives and the research questions

Based on a preliminary scrutiny of the literature it seems arguable that literature focusing on risk management in commodities supply chains appears to be almost exclusively concerned with the price volatility of primary commodities, whereas discussions regarding supply chain risk in general focus several other types of risks beyond price volatility. Furthermore, as it has been explained in the motivation for this research, commodities' trading is an activity that involves specific risks that are well known and discussed in other *fora* and that are relevant to supply chain management even though they seem to be left out in the literature on supply chain risk.

Through the literature review, the present research will try to ascertain whether risk associated to price volatility of primary commodities is in fact given almost exclusive attention by the literature on commodities supply chain risk. If this is the case, it will also try to ascertain whether price volatility is also of utmost importance in the case of other commodities (other than those traded in financial markets) or whether there are other risks that are potentially just as relevant. Should the findings of the research corroborate the idea that other risks are somewhat neglected, this research will aim at understanding the reasons for that. The same effort will be made if the information collected confirms the paramount relevance of price risk. It will also investigate whether there is a biased perspective that results in that focus on price risk and, if so, what can explain that bias. The exclusive focus on price risk and the strategies that, according to the preliminary literature analysis performed, seem to be suggested and/or used may lead companies to misdirect their attention from where the sources of the uncertainty are, thereby reducing their odds on the fight against uncertainty. The present research will endeavour to ascertain whether this is true.

These efforts will be focused on the steel supply chain. Steel is known to be a commodity that it is exposed to price swings in the international markets and this is expected to cause managers to pay considerable attention to its price. On the other hand, the price of steel is particularly affected by different exogenous factors and it is anticipated that it might be exposed to other sorts of risks. These are the ingredients for potential complexity, which leads to the belief that there might be more to price volatility than meets the eye. Truth be said, the influence of external factors on price is most likely common to most or even all commodities. However, based on preliminary readings and on previous knowledge, it is anticipated that the international

steel trade involves several different risks that could probably be worthy of attention by supply chain managers. Finally, the relevance of price volatility risk will probably depend on the volume purchased, which means that the investigation should focus on companies that can be considered relevant steel buyers. The fact that steel is an extremely relevant commodity for a number of important companies in the Portuguese region of Aveiro has made this choice also a compelling one, but further reasons for this decision will be further explained later.

Based on a preliminary literature review combined with previous knowledge, as explained above, the starting point for the present research is the possibility of the existence of a gap in the literature on commodities supply chain risk management that results in price risk being considered the most relevant risk and, arguably, in the fact that other important risks are neglected. In order to ascertain whether this is true, this research will start from a set of research questions:

1 - Which are the most relevant risks that companies that are large steel buyers face?
2 - What are the causes for those risks?
3 - How do these companies deal with the risks they face?
4 - Are there relevant differences in the risks experienced by companies that are large steel buyers?
5 - Is the risk associated to price volatility particularly relevant in the case of these companies?

Despite its theory-oriented nature, this research aims at affording some help for managers of commodities supply chains in setting up a comprehensive approach to supply chain risk management. Based on previous analyses of the literature on supply chain risk management, it is believed that there is considerable confusion in the terminology used in the literature and that most supply chain risk management frameworks are too complex to be adequate for managerial guidance in the day-to-day efforts to manage supply risks. Consequently, the present research also aims at contributing to increase managerial supply chain risk management knowledge and skills. With this goal in mind, it will aim at simplifying the risk identification process from the point of view of managers. In its Part 6, having addressed those research questions, this thesis suggests a framework built from contributions of the existing literature and offers some guidance for its use. This suggestion of a framework arises from the fact that, throughout the interviews carried out, it became obvious that there is indeed a need to simplify the risk identification process avoiding the use of classifications that can be rather obscure from a managerial point of view.

Hence, a proposal for a different approach is made. However, bearing in mind that the focus of this research is limited to risk and strategies identification, the discussion of the application of that framework will also focus on these aspects of the supply chain risk management framework, admitting, from the outset, that this discussion will not cover the whole framework with equal depth. Despite this limitation, this framework will, hopefully, be a useful tool for managers in their risk management decision-making process, assisting them in their efforts to build a comprehensive supply risk management policy, to detect the lack of visibility over the sources of risk, and to anticipate the necessary knowledge and skills for risk management, and, consequently, the need for further training.

Part 3 - Previous research on Supply Chain Risk Management

3.1 - Supply chain risk – from neglected to its high profile

In the early years of the XXIst century, Jüttner *et al.* (2003, p. 197) considered that

"despite increasing awareness among practitioners, the concept of supply-chain vulnerability and its managerial counterpart supply-chain risk (was) still in their infancy."

That reality was translated in the outcome of a survey in which only about one third of the more than 200 responding firms from North America and Europe stated that they paid due heed to supply chain vulnerability and risk mitigation actions (Poirier and Quinn, 2004). However, a decade later, these are truly challenging times for global supply chains, as a consequence of all sorts of incidents but also of the volatility of markets, with abrupt price and availability swings as fast pace growing demand in emergent economies puts pressure on the availability of materials, on fuel and on freight rates (Christopher and Holweg, 2011). On the other hand, due to rapid changes in information and communication technologies, the very nature of modern supply chains has become increasingly dynamic and even unpredictable – the "amorphous" supply chain, in the words of Ritchie and Brindley (2000) – and lean supply chains repeatedly suffer from their lack of agility (Christopher, 2000).

To cope with the constant challenges that the organization faces, internally and externally, supply chain managers must make decisions on a daily basis, often breaking away from established practices, and most of these decisions have a degree of risk attached to them, in the words of Ellegaard (2008, p. 426):

"(a)s boundary spanners, purchasers and supply chain managers are required to make a range of risky business decisions".

Besides the conscience of the risk attached to decisions inherent to the supply chain manager's role, the fact that supply chains face challenging times is also widely acknowledged and managers have become increasingly aware of the potential impact that catastrophic phenomena may have on modern supply chains (Knemeyer *et al.*, 2009). However, companies often do little more than dealing with the consequences, trying to close the stable door after the horse has

bolted. This can usually be explained by the fact that unplanned events that may occur in the supply chain and disturb the expected flow of materials or components are not taken into account on the day-to-day inventory management and production planning (Svensson, 2000). Even among those managers and companies who try to anticipate supply chain disturbances, there seems to be a tendency to focus the attention on the factors that they are most familiar with and that they believe that they can influence (Arntzen, 2009). This belief was expressed by Chopra and Sodhi (2004), when the authors argued that most companies had plans to face recurrent low-impact supply chain risks but neglected low likelihood risks with potentially high impact. Although there are conflicting views regarding this valuation of risks by managers (for a discussion of these conflicting views see Knemeyer et al., 2009), the same idea is supported by the conclusion by Tang (2006). Having reviewed various models for managing supply chain risks, this author concluded that those quantitative models were designed to manage operational risks primarily *("inherent uncertainties such as uncertain customer demand, uncertain supply, and uncertain cost"*, at p. 453), not disruption risks *("major disruptions caused by natural and man-made disasters such as earthquakes, floods, hurricanes, terrorist attacks, etc., or economic crises such as currency evaluation or strikes"*, at p. 453), even though, as the author adds, in most cases, the impact of disruption risks in business is much greater than that of the operational risks.

Now, the series of catastrophic events in the past decade or so, some of which have been mentioned above, has brought added attention to the low likelihood risks with potentially devastating effects, justifying the argument that they tend to become more frequent - as mentioned above (Coleman, 2006; Wagner and Bode, 2008) – and forcing companies to plan for catastrophic disruptions. Stecke and Kumar (2009) demonstrated that between 1993 and 2003 the number of terrorist attacks may not have increased, but 62% of total attacks had targeted business interests. On the other hand, the same authors state that in the last 100 years, mostly in the last quarter of the 20th century, the frequency of natural catastrophes reported has increased over 40-fold, an impressive number even if the increasing numbers also reflect the added geographical spread of human presence and the reach of information technology, hence the added attention given by research to environment linked risks (Stecke and Kumar, 2009; Ghadge et al., 2012).

A 2013 joint report by PwC and the UNISDR also states, based on evidence, that extreme weather phenomena are expected to become more frequent, stressing the importance of going beyond the past experience when it comes to assessing risks:

"It is also widely expected that climate change will lead to significant shifts in the frequency, intensity and geographical distribution of extreme weather events. Not only will businesses become increasingly more exposed to weather-related hazards, but if their risk assessment tools and strategies are based on historical experience only, they will become increasingly more unprepared and unresilient" (PwC and UNISDR, 2013, p. 5).

Historical experience, however, can result in the same type of risk being anticipated in some cases whilst totally forsaken in others. For instance, whilst for many companies the risk of being affected by an earthquake is too remote for them consider it, the risk of an earthquake in California may be clearly recognized by other companies despite its uncontrollable nature (Harland *et al.*, 2003). Hence, a company's supply risk strategy is, in fact, often determined by the past experience, awareness and expertise of the company or its managers:

"Observation fields are typically circled around already known sources of risk and the most critical and vulnerable areas of the supply chain" (Kern et al., 2012, p. 64).

Therefore, the ability of the organization to manage sudden changes will depend on different endogenous factors, such as whether the organization has effective management structures that perceive and respond to external change signals adequately (Ritchie and Brindley, 2000).

Furthermore, the way that managers deal with risk is often also influenced by their own objectives. Managers, in general, accept risk taking as a inevitable part of their role as decision-makers placed before uncertainty (March and Shapira, 1987), but most managers are usually assessed by reference to performance targets and those performance goals can lead managers to become more risk averse or risk prone when their performance is above or below the stipulated targets - *"In "bad" situations risks would be taken"* (March and Shapira, 1987, p. 1409). As March and Shapira (1987) argue, the lack of understanding, or trust, that managers have of probability estimates, is the reason why they seem to ignore low probability risks, regardless of their possible large impact:

"(w)here low prior probability is combined with high consequence, as in the case of unexpected major disasters or unanticipated major discoveries, the practice of excluding very low probability events from consideration makes a difference. In a world in which there are a

very large number of very low probability, very high consequence possible events, it is hard to see how an organization can reasonably consider all of them" (March and Shapira, 1987, p. 1411)

Unfortunately, the literature is considerably divided regarding this view on whether managers will pay too little or too much attention to the low probabilities and high consequences associated with catastrophic events. For instance, according to standard economic theory, as Lovallo and Kahneman (2003) refer, failure rate is easily explained by the fact that rewards of success are alluring and, consequently, entrepreneurs and managers knowingly accept the odds:

"In the long run, the gains from a few successes will outweigh the losses from many failures" (Lovallo and Kahneman, 2003, p. 58).

However, these authors further suggest that managers tend to decide under the illusion that they are in control of the situation when, in fact, the high number of business failures is due to poor decision making, or, using the authors' words it is *"the result of rational choices gone wrong"*, choices made by managers affected by *"delusional optimism"* (Lovallo and Kahneman, 2003, p. 58). Moreover, there are psychological studies of individual decision-making processes that suggest that managers tend to overweight low probabilities, particularly when they are associated with devastating events (Knemeyer et al., 2009).

Be that as it may, beyond that lack of uniform views, March and Shapira (1987) also refer the relevance of performance goals on the risk attitude of managers, who tend to focus on those targets, thus recognizing a risk prone attitude on managers who are eager to meet the performance goals yet out of reach and are, therefore, on the lookout for gain opportunities but not for the dangers ahead. As much as they measure performances, managers establish aspirations as benchmarks and aspirations that fail to be met are strong drivers for manager behaviour change (Miller and Leiblein, 1996). On the other hand, as behavioural theory of the firm suggests, when performance objectives are achieved organizations avoid the costs and uncertainty of seeking alternative strategies (Miller and Leiblein, 1996). Furthermore, formal incentive schemes frequently reward achievers regardless of their want of due caution in risk management, thereby encouraging bold risk taking, even though traditionally a *"good manager is seen as "taking risks" but not as "gambling"* (March and Shapira, 1987, p. 1413). This is all the more

problematic when behavioural theorists have also argued that poor performers are more prone to engaging in risky strategies than high performers (Miller and Leiblein, 1996). This impact that performance metrics have on managerial behaviour, as Zsidisin (2007) suggests, can be used for prioritizing business continuity planning, ensuring that people are accountable for the adoption and management of business continuity planning, benefiting from the fact, as the author suggests, that people tend to perform those activities that will be measured. Thus, the risk-averse or risk-seeking nature of the decision maker can have a dramatic impact on risk management decisions. Besides the risk-seeking nature of the manager or his stakes on the decision, sheer optimism may also be in the root of added risk exposure caused by the decision maker (Lovallo and Kahneman, 2003, p. 145):

> *"When forecasting the outcomes of risky projects, executives all too easily fall victim to what psychologists call the planning fallacy. In its grip, managers make decisions based on delusional optimism rather than on a rational weighting of gains, losses, and probabilities. They overestimate benefits and underestimate costs. They spin scenarios of success while over-looking the potential for mistakes and miscalculations."*

Due to the often ill-founded management decisions discussed thus far, risk management should be the field for employing a team-based approach (Manuj and Mentzer, 2008b) for reasons that Knemeyer *et al.* (2009, p. 151) clearly explain:

> "*The implementation team should be cross-functional because the consequences of catastrophic events cut across the supply chain. If, for instance, a facility is lost to a catastrophic event, the consequences affect supply chain operations, financial flows and possibly also information flows. It may additionally impact relationships with customers and suppliers. As a result, a wide spectrum of functional expertise is needed to foresee potential catastrophic risks and evaluate their likely consequences. Clearly, as firms exhibit varying degrees of exposure to the various types of catastrophic events, a corresponding breadth of expertise is needed.*"

Although the team-based approach can be fundamental for the ability to identify and manage risk, there are counteractive interests that should be taken into account to avoid having a biased risk management team (Manuj and Mentzer, 2008b, p. 212):

"*Team members bring different perspectives to solving a problem. Hence, team composition becomes an important determinant of the quality of risk identification and management. However, for the team to effectively and efficiently reach a decision, it is important to understand the trade-offs and counteractive forces that may exist in a group*"

With the same preventive purpose, Ritchie and Brindley (2007b, p. 304), stress the urgency of *"developing appropriate performance measures and metrics to evaluate, educate and direct the operational and strategic decisions"* and Manuj and Mentzer (2008b) suggest, based on the literature and on the interviews carried out in their research, different measures of supply chain performance that should be assessed to evaluate a risk management strategy holistically.

The lack of risk and gain sharing between companies across a supply chain is also a cause for added risk exposure, as companies tend to focus on their own interests, forsaking the benefits to the whole supply chain, for lack of an holistic view (Lambert and Cooper, 2000; Narayanan and Raman, 2004; Simatupang and Sridharan, 2005; Norrman, 2008). The fact that performance measures are often directed at cost reductions, rather than at enhancing the performance of the supply chain, results in disintegrated performance measures. These disintegrated performance measures within the organizations and between companies across the supply chain result in strategies biased towards personal objectives of managers and companies, rather than towards common goals (Simatupang and Sridharan, 2002). As measures are often connected to cost reduction, companies frequently focus their efforts in shifting costs to other members of the supply chain rather than truly reducing them (Simatupang and Sridharan, 2005b). Self-absorbed companies, operating driven by incentives that are misaligned along the supply chain, result in added risks and aligning incentives often proves difficult to achieve. Narayanan *et al*. (2004) suggest three reasons for this difficulty: first, they argue that it is difficult for companies to persuade other firms to act in the best interest of the supply chain when they cannot see the other companies' actions; second, the authors suggest that the fact that one company has information that the others do not have has a detrimental effect on incentive alignment; finally, simple poor incentive design is also responsible for misalignment of incentives along the supply chain. Recognizing the importance of this, the need for promotion of goal congruence is one of the managerial implications that Zsidisin *et al.,* (2004) extract from the analysis of the cases in their research. The other two implications that those authors refer are the need to obtain information to verify supplier activity and to reduce outcome uncertainty. This uncertainty is in the roots of the chain of factors that can cause the infamous "bullwhip" effect, through panic and

chaotic reactions, herd mentality and stampede behaviour, resulting in unnecessary costs (Childerhouse *et al* 2003). The lack of confidence leads to rogue behaviour, with individual decisions in supply chain management that shatter any chance of inter-organizational alignment, increasing the exposure to risk (Christopher and Lee, 2004). Lacking mutual strategic objectives, incentive alignment and information sharing, supply chains lack important *"antidotes to discontent"*, as Simatupang and Sridharan (2005b) call them. Those *"antidotes"* glue the whole supply chain together, and their want causes losses due to inefficiencies - such as stock-outs, high logistics costs or excessive stock - and jeopardizes trust between the supply chain partners (Simatupang and Sridharan, 2005b).

Although risk management has been extensively addressed in the financial activities for decades, with respect to supply chain management risk has become under the spotlight rather recently. Bearing in mind the extreme importance that efficiency and reliability of supply chains have in the effort to ensure the necessary competitive advantage to thrive on increasingly competitive markets, one should not be surprised by the increasing importance that supply chain risk has these days. Yet, this high profile of supply chain risk is indeed quite recent as it is a consequence of repeated catastrophic losses in the past decade or so, some of which have already been mentioned above. These disruptions have had their impact magnified by the characteristics of modern supply chains as their evolution, throughout the past few decades, has lead to their added vulnerability and to greater impact of disruptions. These characteristics of modern supply chain have become risk drivers and they have been clearly identified in the literature

> *"... a focus on efficiency rather than effectiveness ... the globalisation of supply chains ... focused factories and centralised distribution ... the trend to outsourcing ... the reduction of the supplier base"* (Jüttner, et al. 2003, p. 205).

This model, with its focus on efficiency, has proved its merits over the years, but it is now clear that it depends on a stable market and it often struggles to cope with the challenges of today's volatile markets (Christopher, 2004; Kleindorfer and Saad, 2005). For instance, the reduction of the supplier base to the extreme of having a single supplier adds obvious risks loudly flagged by different episodes in the past. One such episode was the bankruptcy of UPF-Thompson, the sole chassis supplier of Land Rover for the Discovery, exposing the carmaker to threats by the bankruptcy receivers (KPMG) to halt supply with the consequences referred, *inter alia*, by

Christopher and Peck (2004a). This reduction of the supplier base is a consequence of the quest for utmost efficiency. Organized as networks of companies, modern supply chains aim at reducing financial and technological risks and creating a competitive advantage through added specialization, but this strategy entails specific risks that can be associated to

> *"... the network's resistance towards changes, new technologies, practices and members, as well as to problems and risks that may arise in network management or the setting up of appropriate development activities"* (Hallikas et al., 2004, p. 49).

Inter-organisational networking is, thus, not only a strategy for added efficiency but also a factor that increases risk exposure. In fact, it has been argued that risk exposure of large companies increases with this networking and that having small and medium-size enterprises (SMEs) as partners in the supply chain increases risk exposure for those large companies, just as the risk exposure of the SMEs is increased by being a link in those supply chains (Finch, 2004).

In the context of in-house production, prior to the outsourcing trend, with local supply and sales directly to customers, supply chain complexity was at a minimum and risks were easier to control (Harland *et al.*, 2003). From the 1990s onwards, the present market context, with fierce competition in the global market, with shrunken margins, where price and service are inseparable, the constant struggle for competitive advantage in the market has driven organizations to adopt strategies focused on relentless cost reduction and supply chain efficiency is seen as fundamental to this cost reduction effort (Turnbull, 1990; Zsidisin *et al.*, 2000). Applying best practices and supply chain management concepts is a fundamental key to achieve lean supply chains and the desired efficiency, but this efficiency implies that supply chains do not have the resources to cope with glitches, as they have neither the headcount nor the surplus assets to give them the slack they need to cope with unpredictable supply and demand variations (Norrman and Jansson, 2004). Another major factor to succeed in this battle for competitiveness is extreme efficiency in sourcing and purchasing, with considerable focus on lowering total cost of ownership, a goal that is often pursued through outsourcing and global sourcing. A clear example of this evolution is mentioned by Souter (2000, p. 26):

> *"Hewlett-Packard Co.'s business has undergone radical changes over the past 10 years, said Ellen Pfeiffer, business risk manager of the computer equipment company in Palo Alto, California. In 1990, the company fully owned all of the units that produced its equipment. By*

the mid- 1990s, however, HP's computer equipment was produced by a mix of in-house units and third- party suppliers. Today, 95% of the manufacturing is outsourced to third parties, she said.

"We are now a research and development, marketing, and supply chain management company," Ms Pfeiffer said."

However, it is not unusual for companies to adopt global sourcing lured by its promise of cost reduction, relying on it as a best practice but ignoring the pitfalls that may be associated to this strategy (Jin, 2004). These new risks exist for both larger and smaller organizations, and these companies will have to gain added risk management skills to cope with risks associated to a greater number of sources (Ritchie and Brindley, 2000). An example of the importance of these skills is in the suggestion by Holweg *et.* al (2011), with this concern in mind, of a total cost model to assess the costs and risks inherent in global sourcing scenarios, in order to ensure that sourcing decisions are adequately informed. As there is inherent uncertainty in estimating some of the parameters for the risk and cost assessment of a sourcing option, the use of such a support tool in the early stages of this assessment is deemed important as a way to separate likely from unlikely candidate solutions (Holweg et al., 2011).

Supply efficiency strategies often result in longer pipelines, through the generalized use of offshoring of manufacturing (Christopher and Lee, 2004), and added complexity (Danese *et al.*, 2004). Globe-spanning modern supply chains are more complex and this added complexity challenges these new supply chains. Their increasing complexity has different sources, such as increasing product or service complexity, e-business, outsourcing and globalization, and risk visibility is reduced by the supply chains' increasing "virtual" nature (Harland et al., 2003; Cucchiella and Gastaldi, 2006). On the other hand, this added complexity also determines an increasing number of sources of uncertainty within the supply chain (Cucchiella and Gastaldi, 2006), thereby having an impact on delivery performance, lead times, production lot sizes and other outcomes (Vachon and Klassen, 2002). The occurrence of a single risk, even if seemingly trifle – e.g., a labour dispute or an IT blackout – can spread havoc in the whole supply chain (Kern *et al.*, 2012) and the simple fact that a given product has to be moved across the whole world means that there are added exposure points (Stecke and Kumar, 2009, p. 203):

"(…) the probability of disruptions from causes such as bankruptcies, worker strikes, and accidents may depend on the number of hands (ownerships) a product passes through."

Therefore, reducing complexity is one of the key activities in the challenging implementation of risk management strategies (Freedman, 2003).

To cope with the challenge of added complexity modern supply chain must develop two characteristics: agility that can be defined, in the context of supply chain management, as the ability to survive in a dynamic environment *("it is all about customer responsiveness and mastering market turbulence"* - Hoek *et al.*, 2001, p. 127); and flexibility, which is determined by speed and flexibility of sourcing, manufacturing and delivery (Prater *et al.*, 2001; Harland *et al.*, 2003). Reduced flexibility leads to added vulnerability to disrupting factors, both internal and external (Yuva, 2008). Conversely, it has been demonstrated that firms that have achieved higher levels of flexibility outperform their competitors with less flexibility, which indicates that flexibility translates into competitive advantage (Fawcett *et al.*, 1996; Tang and Tomlin, 2008).

Multi-tier just-in-time supply chains linking hundreds or even thousands of organizations become complex networks with reduced flexibility. Consequently, those supply chains face added risk (Braithwaite and Hall, 1999; Svensson, 2000; Prater *et al.*, 2001; Jüttner *et al.*, 2003; Danese *et al.*, 2004; Masson *et al.*, 2007) and the above mentioned trend towards outsourcing as a strategy to achieve, among other advantages, agility, cost-efficiency and technological advantages (G. A. Zsidisin et al., 2000), increases the number of actors along the supply chain. This has an obvious detrimental effect on visibility and control, as the case of Boeing's 787 Dreamliner has eloquently shown (Tang and Zimmerman, 2009; Monczka *et al.* 2011; Machowiak, 2012), due to the lack of a proper view of the different risks that supply chains face, or the fact that the perception that companies have is limited to the closest tiers of their supply chain. This lack of visibility is in the roots of the lack of confidence that leads to different sorts of reactions across the supply chain that lead to inefficiencies, higher costs increasing the "chaos" risks (Christopher and Lee, 2004). Supply chain confidence, as Christopher and Lee (2004) demonstrate, benefits from added visibility. Therefore, added information sharing is a condition for supply chain stability and efficiency, by reducing uncertainty, thus enabling companies to keep lower safety stock levels and to be more responsive to market swings. Willingness to share information, however, has not been the traditional stance of companies but rather believing that sharing information diminishes their power (Christopher and Lee, 2004). Increased visibility is a condition for adequate risk identification, assessment, management and business continuity planning and these tasks must be a common endeavour of the firm and its suppliers, extended

throughout the several tiers of the supply chain, based on formal contractual requirements (Norrman and Jansson, 2004). Sharing information is fundamental for collaborative learning which is a source for competitive advantage and a potential way to reduce risks (Hallikas *et al*, 2005). Furthermore, in the era of complex supply chains, the simple concept of organizational learning does not ensure constant fit of the company's strategies to the demands of its operating context. The demand for added flexibility, resilience, commitment between supply chain partners and other conditions for the desired business outcomes can only be achieved through inter-organizational learning (Manuj and Mentzer, 2008a).

Despite the widely recognized need for collaboration, information sharing and joint risk management (e.g., D'Avanzo and Van Wassenhove, 2003) and the role of collaboration and integration in risk reduction (Kern et al., 2012) and performance enhancement (Huo, 2012), collaboration also introduces new risk factors (Hallikas et al., 2005; Cheng and Kam, 2008). The way companies frequently take advantage of their bargaining power to pressure their suppliers, increases risk levels in their supply chains due to misalignment of objectives and conflicting interests (Simatupang and Sridharan, 2005b), and this often happens in the context of what those companies call a partnership. This is especially noticeable in cases where large retailers with considerable market dominance exert strong pressure over their first and second tier supply base, contributing to the deterioration of their financial condition. Together with the trend of supplier rationalization, this is an important source for added risk (Cavinato, 2004). In 1998, Smeltzer and Siferd suggested that proactive purchasing through activities such as reducing the supplier base, developing long-term alliances, achieving early supplier involvement and outsourcing would benefit risk management and the entire organization. Nowadays, despite the fact that they are still commonly identified as best practices to reduce risk, it has become clear that those best practices can also result in exposure to new risks and the lack of shared gains can sow the seed of risk in the form of discontentment, as Narayanan and Raman (2004, p. 96) put it:

> *"(...) the fates of all supply chain members are interlinked: If the companies work together to efficiently deliver goods and services to consumers, they will all win. If they don't, they will all lose to another supply chain. The challenge is to get all the firms in your supply network to play the game so that everybody wins. The only way you can do that is by aligning incentives."*

Product related factors also put added pressure on modern supply chains stability. Market

competition is fierce and in many sectors there is a somewhat artificial need for new product development or the update of the existing ones. As the pace of new product launches increases, product life cycle is dramatically shortened, time-to-market is compressed and there is a faster increase of demand in the early stage of products' life cycle, which coupled with inaccurate demand and supply planning exposes companies to added risk (Norrman and Jansson, 2004). In their analysis of factors that breed vulnerability, Stecke and Kumar (2009) summarize (Table 1) the relevant supply chain practices and their effect on vulnerability causing factors.

Table 1 - Supply Chain Practices and Their Effect on Vulnerability Causing Factors (source: Stecke and Kumar, 2009)

	Vulnerability causing factors			
Supply chain management practices	Increase in the number of exposure points	Increase in distance/time	Decrease in flexibility	Decrease in redundancy
Globalization	X	X		
Decentralization	X	X		
Outsourcing	X	X		
Sole sourcing			X	
JIT			X	X
Product/process complexity	X			
Litigation	X			

A leaner supply chain represents potential benefits that most businesses cannot ignore. However, the effort to achieve a lean supply chain must not imply that supply chain risk is forsaken and managers must keep in mind that such lean systems are becoming increasingly more fragile and dramatically more exposed to sudden changes and unanticipated disruptions (Zsidisin et al., 2005). Supply chain management has been based on the underlying principle that establishing control of the end-to-end process contributes to the seamless flow of goods along the supply chain. Reality has changed, though, and the days when the goal of relative stability was feasible are gone. With this new reality in mind, Christopher and Holweg (2011), among others,

question the traditional approach to supply chain management, arguing that most current models for supply chain management were carved on a reality that no longer exists. Mastering the era of turbulence calls for

> *"(…) structural flexibility which builds flexible options into the design of supply chains"* (Christopher and Holweg, 2011, p. 63).

An increased awareness of the disturbances that an organization might face, and of their origins, can represent a major improvement in the preparedness of the organization to cope with those causes for vulnerability (Svensson, 2000). As far back as at least the year 2000, it was already stressed that companies should focus on risks in all links of their supply chains rather than simply focusing on their own risks (Souter, 2000). However, as the consequences of events of all sorts, man-made and natural, in disparate parts of the globe rippled across the oceans, the fragile nature of modern supply chains was repeatedly exposed. This caused not only long-term stock price effects but also loss of reputation and even loss of life and assets (Sodhi *et al.*, 2012). The consequences of those events seem to demonstrate that Mitroff and Alpaslan (2003) were right when they stated, based on a 20-year study on the crisis readiness of *Fortune 500* companies, that only 5 to 25% of those companies were prepared to cope with crisis or disruptions.

Besides several catastrophic events, the economic turmoil of the past few years, first with the subprime mortgage crisis in the U.S. and later with the sovereign debts crisis in Europe, tore down companies at a never before seen pace, irrespective of size or sector and across different tiers of supply chains. This tidal wave of bankruptcy triggered the debate about supply chain resilience (Jüttner and Maklan, 2011) and put the exposure of supply chains to risks associated with the international economy under the spotlight (Blome and Schoenherr, 2011). Consequently, there is now wide consensus that managing risk in the supply chain is a critical capability in order to compete in the present business environment and this consensus exists both in the scientific community and among practitioners (Colicchia and Strozzi, 2012). It is clearly understood that taming supply risks is critical to the paramount concern of supply management – ensuring the availability of critical materials and components from the supply base, at competitive cost (Kraljic, 1983) – and it is widely accepted that supply chain risk management is critical to the organization's competitive stance in the market (Colicchia and Strozzi, 2012). Consequently, supply chain risk has stepped up to the top of the agenda, Supply Chain Risk Management has become a hot

topic in supply chain discussions in workshops, in conferences and in specialized internet *fora* across the world. It has also become under scrutiny in an increasing number of studies on the subject (Natarajarathinam *et al*., 2009; Rao and Goldsby, 2009). The spotlight is now on concepts such as supply chain agility, flexibility (Harland *et al*., 2003; Jüttner *et al*., 2003) – or *"dynamic flexibility"* (Christopher and Holweg, 2011) - and resilience (Jüttner and Maklan, 2011). These concepts are nowadays considered of foremost importance to the stability of supply chains and the recognition of this relevance is a clear sign of their impact in the performance of organizations (Ritchie and Brindley, 2007; Wilson, 2007) and, consequently, in stock price (Hendricks and Singhal, 2003b, 2005a, 2005b; Kilgore, 2004).

Notwithstanding the impact that supply chain risk management has on the performance of companies, a more systematic and structured approach to conceptualizing vulnerabilities and supply chain risks can only be found in the literature from the last year of the XXth century onwards (Jüttner *et al*., 2003), with the work of authors such as Zsidisin (2000), Svensson (2000), Christopher (2000), Harland and Brenchley (2001), Chapman *et al* (2002) and Harland *et al*. (2003). Since the days of those earlier researches focused on supply chain risk management to the present, the topic has climbed to the top of the agenda and this can be seen in the increasing number of studies on the subject and the added attention given, in the last few years, to the management of crisis in the supply chains (Natarajarathinam *et al*., 2009) and in the number of practitioner conferences focusing supply chain risk management (Brindley, 2004; Rao and Goldsby, 2009). Hence, it is not too much of a stretch saying that supply chain management has become supply chain risk management oriented (Norrman and Jansson, 2004) and that SCRM – *"the risk management response primarily to supply chain risks"* (Wu and Blackhurst, 2009) - has had its profile raised.

The practical nature of the concerns that fuel the increasing attention given to SCRM can be seen in the fact that several approaches to this issue have put considerable effort into designing workable frameworks and tools for risk management (e.g., Hallikas et al., 2005; Pujawan and Geraldin, 2009; Ritchie and Brindley, 2007b). However, as Colicchia and Strozzi (2012) refer (citing, among others, Kleindorfer and Saad, 2005 and Tang, 2006), models and strategies developed in the literature focus mainly on supply chain operational risks and not on disruption risks, even though the context and characteristics of modern supply chains seem to increase the likelihood of supply chain disruption episodes, as mentioned before.

From a managerial point of view, the long string of events that disturbed supply chains across the planet, some of which have been recalled above, should be enough to compel managers to implement supply chain risk management strategies to cope with disruptions. However, as Kiser and Cantrell (2006, p. 12) comment:

> *"(...) too often supply management professionals are focused only on negotiating the best bargain for their materials. They forget that a seemingly great bargain could be prone to a catastrophic disruption in supply and result in a costly halt to production."*

These catastrophic events, some of which will linger in our collective memory, have indeed put supply chain risk on the spotlight as one of the main concerns for researchers and practitioners. However, most of the factors contributing for the added supply chain vulnerability lack novelty and have, in fact, been listed for quite some time. An example can be seen in the 2002 report of Cranfield University (Cranfield University - School of Management, 2002, p. 3) that already listed most of those factors:

> *"- A focus on efficiency rather than effectiveness*
> *- The globalisation of supply chains*
> *- Focussed factories and centralised distribution*
> *- The trend to outsourcing*
> *- Reduction of the supplier base*
> *- Volatility of demand*
> *- Lack of visibility and control procedures".*

3.2 - Previous literature selection and analysis processes

A thorough analysis of the existing literature on the subject of supply chain risk management is essential to understand the practical needs and the theoretical development in supply chain risk management. With this goal in mind, a perusal of articles selected mostly from business review journals, operations management journals, as well as management science or

operations research was carried out. Other possible sources were not excluded, whenever a cross-reference drove the analysis towards a particular article. This analysis began with a preliminary search for relevant articles using academic multidisciplinary databases - mainly Web of Science, Scopus and Academic Search Complete - through the use of combinations of keywords such as "supply risk", "supply chain risk", "Supply risk management", "risk mitigation" and "strategies". At a later stage, new keywords were added to directly lead to the relevant articles concerning specific aspects focused on this research. In particular, the sets of keywords used included "commodities" and "steel" but also keywords related to methodological issues or related to the theoretical background. Thus, the literature review also encompassed the analysis of the most relevant articles and books concerning methodological and theoretical background issues. The first effort to uncover the development of supply chain risk management was focused on the period between 1980 and 2010, in the first stages of this investigation, but it was systematically updated throughout the research until its final stage in the present year, in order to ensure that recent relevant literature was not left out. Although the impact factor, whenever it was known, was born in mind during the analysis of the articles retrieved, it was purposefully not a condition for any article to be excluded, as long as its title, abstract, keywords or a cross-reference suggested that it could afford some insight into a relevant issue.

Throughout the whole process almost 1000 articles on supply chain risk issues, 40 on methodological aspects, and a few others on different subjects were filtered and classified by analysing their abstracts, summaries and keywords, as a result of the abovementioned use of keywords and of cross-references. Of the long list of articles on supply chain risk matters, over 500 articles that had been classified as being "risk management related" were further analysed and a final short list was put together. As the literature perusal progressed this short list received further additions as a result of cross-references and ended up with circa 120 titles. These articles have been published in 57 different journals, most of which have supply chain management as main scope. However, there were also a number of journals on operations management, management science and business review journals, among others, in the list. The literature review was focused on these articles and the relevant information was gathered, for future reference, both by systematically extracting the reference data and by keeping a log with notes and quotes associated to each article. An effort has been made to systematically extract, form the selected articles, information useful to add some coherence to the analysis. Among the aspects extracted were: the focus of the article, the journal and its field of knowledge or activity, the industry or industries that the articles focused, the type of paper (whether conceptual, empirical, literature

review, etc.), the methodology identified and whether it suggested some framework or model for supply chain risk management.

A further group of articles and books concerning risk management in commodities supply chains was also analysed in order to extract the relevant information for the purpose of this research. Beyond these main groups of references, several other secondary groups of articles and books have been identified regarding parallel issues that surface along the research such as methodology related literature and supply chain management related.

The results of the literature analysis will be reported addressing the following aspects:

- Reference to the main supporting theories identified for supply chain risk management literature;
- An account of the most relevant efforts towards a systemization of supply chain risk management through the creation of supply chain risk models or frameworks;
- A scrutiny of the most relevant proposals interpretations in the literature of fundamental concepts with a view to a clarification of their meaning;
- A reference to sector-based approaches to supply chain risk management;
- The supply chain risk management process as proposed in the literature – a reference to the most significant proposals;
- Risk management in commodities supply chains, which will incorporate a brief reference to the context of the international trade of commodities and a reference to previous research on Commodities Supply Risk Management.

3.3 - Supporting theories

Different organizational perspectives have been offering theoretical support for different research approaches in the literature on supply chain risk management. Throughout the literature review that was carried out, real options, transaction cost economics, resource dependence theories, network theory, agency theory and behavioural approaches were the most commonly theoretical foundations identified. However, the complete list of theoretical perspectives identified is longer, even though identifying the theoretical support for every single research article proved impossible in many cases, whenever none was expressly acknowledged by the authors nor was it possible to undoubtedly identify any. Therefore, despite the efforts made to

keep track of this information in all the articles shortlisted, there were too many cases that could not be associated to a specific support theory. Having said that, a reference to the most relevant theories identified is due as well as to examples of research in the literature to which they lend conceptual support.

Understanding the strategic choices and decisions of companies and of their consequences from the point of view of performance is an important issue in the context of strategic management (Rumelt *et al.*, 1994). In increasingly uncertain and complex contexts, such as those of modern supply chains, there is value in keeping a range of options open and, the greater the uncertainty, the more valuable it is to be able to react to new circumstances by choosing between options in the future (Smith, 2002). To cope with this uncertainty, real options, in the context of supply chain management, give the firm the right to exercise the operational and managerial flexibility, changing the supply chain's network structure whenever it proves necessary, taking advantage of the supply chain's inherent flexibility (Smith, 2002). Real options theory draws an analogy between real options and financial options, applying the techniques developed in financial options theory to the analysis of non-financial, or real, assets (Reuer and Leiblein, 2001). By definition, a financial option gives its holder the right to buy or sell the asset concern, but it does not involve an obligation: he will have the right to buy or sell, should he wish to do so, at the specified price on or before the expiration date (Brach, 2003). Derived from the financial options theory of economists Black and Scholes (1973) and Merton (1973), the notion of real options was developed by Myers (1977) and emphasizes that firms' discretionary investments create follow-on opportunities that they can later opt to exploit or simply pass:

> *"The central premise of real options theory is that managerial decisions revolve around creating and then exercising or not exercising certain options"* (Hult et al., 2010, p. 436).

Consequently, this theory focuses on real options as investments in real assets - from the Latin *realis*, which refers to fixed, permanent, or immovable things (Brach, 2003) – highlighting value that is preceded by earlier investments (Reuer and Leiblein, 2001). Decisions made by supply chain managers regarding supply chain risk management strategies involve both uncertainty and potential financial impact, ergo it is not surprising that some authors consider real option theory relevant:

"Given the potential dollar value involved in these decisions, an understanding of how these supply chain decisions are made is of significant theoretical and practical importance. Real options theory, with its focus on decision making under conditions of uncertainty, is an appealing theoretical lens for this endeavor. In essence, real options theory asserts that managerial decisions center on creating and then exercising or not exercising certain opportunities". (Hult *et al.*, 2010, p. 435)

Real options theory recognizes the value that flexibility can provide because a real option is the opportunity to choose to make, or not to make, a particular decision. From a real options perspective,

"supply chain decisions that keep the most options open will normally be preferable to those decisions that shut options down" (Christopher and Holweg, 2011, p. 76).

Table 2 - Common real options (source: Chevalier-Roignant and Trigeorgis, 2011)

Real option type	Description	Relevant industries
Deferral or waiting option	Management can wait before making the investment to see how the market unfolds.	Resource extraction industries, real-estate development, capital-intensive industries.
Staging or time-to-build option	When a managerial decision takes time or is done in stages, management can default if market prospects prove worse than expected.	Technology-based firms (R&D), long-development capital-intensive industries (e.g., electric utilities), startup ventures.
Expand or extend option	If the project turns out better than expected, management can spend more to *expand* the project scale or it can *extend* the project's useful life.	Natural-resource industries (e.g., mining), real-estate development.
Contract or abandon option	If the market prospects are worse than expected, managers can contract or abandon it for salvage.	Capital-intensive industries (e.g., airplane manufacturers), new product introductions.
Switching option	Management can select among the best of several alternatives, e.g., inputs, outputs or locations, under the prevalent market conditions.	Multinational firms with production facilities in different currencies, platform strategy in the automotive sector.
Compound option	If investment takes place in stages, the first project can be valued in view of the future growth options it creates.	High-tech, R&D, industries with multiple product generations, strategic acquisitions.

Different authors suggest lists of real options strategies. For instance, Chevalier-Roignant and

Trigeorgis (2011) suggest the set of common real options in Table 2.

In the literature on SCRM reviewed for the purpose of this research, real options theory could be identified in a short number of articles. Among those, Cucchiela and Gastaldi (2006), building on previous research on real options theory (e.g., Clemons and Weber, 1990; Trigeorgis, 1996), suggest a list of options for supply chain network management: defer, explore, outsource, abandon, growth and compound. Having done that, the authors match uncertainty sources, risks and real options types (Table 3).

Table 3 - Mergers among real options and supply chain risks (source: Cucchiella and Gastaldi, 2005)

Uncertainty sources	The principals risks resulting from the selected uncertainty source	Real option types								
		Defer	Stage	Explore	Lease	Outsource	Scale down	Scale up	Abandon switch	Strategic grow
Internal sources										
Available capacity	Financial capacity: the project is not realizable of the excessive financial exposure	X		X	X	X				
	Production capacity: the project is too much great or complex		X	X	X	X				
	Structural capacity: the network does not have the necessary infrastructures		X	X			X		X	
Customs regulations	Development from the consumers of a own product	X		X			X		X	
	Not usability of product without right regulation		X	X	X	X			X	
Information delays	Lack of information necessary for the right definition of product characteristics		X	X	X	X			X	
	Lack of information necessary for the definition of the right moment of product emission on the market	X		X		X			X	
Internal organization	Not cooperation among the actors	X	X	X					X	
	Low ability to adopt the new technologies		X	X			X		X	
External sources										
Competitor action	Competitor actions can delete the achieved advantage	X	X	X	X		X		X	
	Detention from competitors of a competitive advantage	X		X						
Manufacturing yield	Low consumer demand of products	X	X	X	X		X		X	
	Consumer demand of products superior than forecast	X		X				X		
Political environment	An excessive demand of the consumer could make the mature product	X		X	X	X	X	X	X	
	Not forecast of the possible actions of the vigilance authority	X			X				X	X
	Changes in the reference context can modify the type of demand products			X					X	X
Price fluctuations	Not coverage of the costs sustained by the network due to product price fluctuations	X	X	X	X	X	X		X	
Stochastic cost	A new technology on the market could make obsolete the product	X			X				X	
Supplier quality	Not availability of specific skills required to the suppliers	X	X	X	X	X				

Recognizing the costs associated to three decision phases in the application of real options (discovery, selection and monitoring), the authors suggest a theoretical framework enabling the

selection of possible options to protect the firm against the risk originating from every source of uncertainty

Despite the fact that there seem to exist few empirical tests of real options, preliminary field studies show that managers do intuitively recognize them (Tiwana *et al.*, 2006; Tiwana *et al.*, 2007). In fact, Hult *et al.* (2010), who also focus their attention on a real options perspective of supply chain risk management decisions, refer several well-known cases of supply chain management strategies that the authors consider to be real options theory in practice, particularly a few well-known examples of postponement strategies such as the case of Benetton, of Whirlpool and of HP printers.

According to Cohen and Huchzermeir (1999), most models that research in the field of Real Options has generated are impractical and difficult to implement. Moreover, these authors consider that the literature on analytical approaches to global supply chain management strategy and planning lack coherence and further development. Reuer and Leibnein (2001) also voice their view aligned with the general criticism regarding the majority of the reported models which are considered inherently impractical. Furthermore, as they do not incorporate the underlying complexity of a global supply chain network, nor do they account for international market dynamics, they would be difficult to implement. However, these authors consider that, should companies indeed seek to manage risk through investments in real options, they should make sure that they have a good grasp of their implications, which is often not the case (Reuer and Leiblein, 2001).

Whereas, throughout the literature review, real options theory was seldom identified in express references in previous literature, transaction cost economics (hereafter TCE) seems to have frequently provided theoretical support for research on supply chain risk management. TCE, *"the underpinning for make-or-buy decisions"* (Harland *et al.*, 2005, p. 833), is an approach that explicitly considers the implications of an organization's choice to perform a transaction or activity internally or in the market. When it performs that transaction internally it is a case of vertical integration and when it does so externally, in the market, it integrates horizontally or outsources the transaction (Williamson, 1985). Over the years, TCE has become a prominent support for frameworks addressing the problem of firms' decisions and has attracted considerable interest in the field of strategic management (Mellewigt and König, 2009). The origins of TCE are traced back to the seminal work of Coase (1937), later developed by

Williamson (1975, 1981), and its most basic premise is that a company's activities are based on minimizing costs at every stage of its operation (including hidden costs, Fayezi *et al.*, 2012) and, with that purpose, it

> *"(…) focuses on the relationship between attributes of transactions and characteristics of the governance structures used to accommodate these transactions*" (Noorderhaven, 1996, p. 105).

Minimizing costs at every stage implies viewing the passing of product between different stages of the production system as transactions and transactions with a cost. In short, Conner (1991, p. 130) refers to TCE using the expression *"Firms as Avoiders of Costs of Market Exchange"*. Firms do this by choosing between two options: integrating that phase (process) into their production, or contracting it to another firm. Hence, Williamson (1981) sees the problem of organizing as essentially a contracting problem, and a contracting problem that seeks to add efficiency to the firm's operations, reducing both operation costs and transaction costs, and the solution that minimizes these costs sets the limits for the company's decision (Williamson, 1975). This solution is achieved, according to the same author, by coordinating the three strategic options for a firm to organize its structure and its relationships with other actors: market, hybrid and hierarchical.

In the context of supply chain management, the literature review identified a few cases in which the authors found theoretical support on TCE. Although the express reference to TCE in the context of supply chain management is not abundant, it is arguably an adequate support for theory in this field of research. In fact, as Cucchiella and Gastaldi (2006) mention, while TCE focuses on the variability of outcomes, on the unknown distribution of potential outcomes and on the lack of control of outcome attainment (Zsidisin, 2003a), supply chain management (and one might add, supply chain risk management) is also concerned with uncertainty regarding potential outcomes, such the reliability of as supplier's performance. The outcome potential is precisely one of the dimensions of risk, which adds to the pertinence of TCE for supply chain risk research. Bearing in mind the type of decisions that supply chain risk management involves, the suitability of TCE is, arguably, not surprising since, in the words of Mellewigt and König (2009, p. 37):

> *"TCE is the dominating theoretical lens that is being adopted to investigate governance decisions of firms."*

As it has been mentioned above, the literature review in this research identified some examples of express reference to TCE in the context of supply chain risk management. For the purpose of this research it suffices to refer some examples of the most prominent texts that do expressly refer TCE as theoretical support to explain inter-firm relationships and supply chain management strategies. Hallikas *et al*. (2002) consider the theoretical support offered by TCE for their analysis of risk management in the context of complex supply networks. However, the authors end up favouring the network approach over the alternatives of insourcing or outsourcing, reminding the fact that both network-based and TCE approaches focus on explanations of inter-firm collaboration and that the former is often adopted within the latter's environment. Harland *et al.* (2005) is another example of reference to TCE to explain the motivations of outsourcing and Ellram *et al.* (2008) explore the rationale for offshore outsourcing in a multiple case study analysis, using the framework of TCE to develop an understanding of how firms manage the costs and risks of offshore outsourcing of professional services. Finally, in the aftermath of the steep increase of insolvencies and of some high-profile bankruptcies (Lehman Brothers, General Motors, Chrysler, to name only a few), Blome and Schoenherr (2011) use TCE as the theoretical anchor for their analysis of SCRM in the context of financial crises.

Peck (2005) highlights the fact that TCE theories consider the existence of opportunism between firms – i.e. the

> *"self-interest seeking with guile (…) the incomplete or distorted disclosure of information, especially to calculated efforts to mislead, distort, disguise, obfuscate, or otherwise confuse"* (Williamson, 1985, p. 47) -

thus questioning the principles behind integrated approaches to supply chain management. In fact, TCE theories even challenge the idea that organizations can be orchestrated to act as one, due to the fact that opportunistic behaviour is often seen even in relationships of so-called partnership. This is the case, for example, of firms leveraging their bargaining power *vis-à-vis* less powerful partners, pressing them into contractual arrangements that push risk associated with inventory management, technology or new product development to the weakest part who is, so to speak, between a rock and a hard place. Peck (2005) draws on network theory and complex

systems perspectives and suggests a conceptual model of a supply chain as an interactive adaptive system. Moreover, the author concludes that, since inter-organizational networks, embedded within an environment, are characterized by many uncontrollable forces, it must be accepted that

> *"complexity and limited managerial control are facts of life for supply chain managers"* (Peck, 2005, p. 225).

TCE theories, as mentioned before, rest on the assumption that opportunism exists, but they also rely on another behavioural assumption: bounded rationality. As Tiwana *et al.* (2007) explain, to make their strategic assessment managers must integrate a variety of information. Challenged to perform cognitively demanding tasks, they need to consider a broad range of facts and further examine subsets of facts. At some point, they are constraint by the limits of their bounded rationality, i.e. their *"rationality is bounded when it falls short of omniscience"* (Simon, 1979, p. 502). Falling short of omniscience is a consequence of the limits of the ability of managers to process and interpret, in their decision-making process, a large volume of pertinent information (Simon, 1979). This sort of behavioural consideration is present in strings of supply chain risk literature concerning research, that has incorporated a behavioural perspective (Ellis *et al.*, 2011). Lovallo and Kahneman (2003) suggest several explanations for poor decision making adopting a behavioural perspective. Harland *et al.* (2003) adopt a behavioural perspective when they include risk perception and attitude to risk in their holistic view of risk assessment and management. Zsidisin (2003b) focuses on managerial perceptions of supply risk and how the supply characteristics affect those perceptions. Wagner and Bode (2006), in their investigation on the relationship between supply chain vulnerability and supply chain risk, reveal that behavioural aspects influence supply chain characteristics such as a firm's dependence on certain customers and suppliers, or reliance on global supply sources that are relevant for a firm's exposure to supply chain risk. Manuj and Mentzer (2008a) propose a comprehensive risk management and mitigation model for global supply chains, bringing together the concepts, frameworks, and insights from several disciplines, including considerable input from behavioural considerations. The authors' goal is to equip managers with a step-by-step procedure to identify, assess, and manage risks in their global supply chains. The same authors, elsewhere (Manuj and Mentzer, 2008b), analyse the applicability of a set of supply chain risk strategies in context – i.e., bearing in mind the environment conditions – and the relevance of three moderators to risk management outcomes: supply chain complexity, inter-organizational learning, and team composition.

Recalling contributions by other authors (e.g., Chopra and Sodhi, 2004), the authors stress the relevance of behavioural issues in this context.

Another major perspective of industrial organization economics is that it is in terms of resources, rather than of products, that firms are defined. Conner (1991, p. 132) expresses this idea by saying that at the heart of this resource-based theory (here RBT) is *"the neoclassical view of the firm as input-combiner*". Resources, in this context, means *"all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm"* (Barney, 1991, p. 101), both internal and acquired or complemented through partnerships (Conner, 1991). This theory recognizes that there are significant consequences of the way that each company combines its resources, opportunities and competences into unique sets. These distinctive characteristics are difficult to emulate and, consequently, the competitive advantage derives from how those resources are exploited, through the particular resource configuration adopted. Connor highlights a particular difference between TCE and RBT arguing that

> *"the resource-based embraces the (positive) value-creating potential of the firm as at the heart of the theory of the firm, rather than avoidance of the (negative) effect of opportunism"* (Conner, 1991, p. 143).

Beyond the possible differences, the fact is that resource and capability-based arguments are now commonly seen as the main pillars in the explanation of firm-level sustainable advantage (Penrose and Pitelis, 2009, Introduction p. xxxi).

The relevance of resources also derives from the fact that the need for them - be that financial, physical or information resources - makes the organizations prone to potentially depending on external sources for those resources (Pfeffer and Salancik, 2003, p. xii). The resource dependence theory (hereinafter RDT) is, hence, another theoretical support for research on the field of supply chain management. It has its origins in Penrose's view of the firm:

> *"the primary economic function of an industrial firm is to make use of productive resources for the purpose of supplying goods and services to the economy in accordance with plans developed and put into effect within the firm"* (Penrose and Pitelis, 2009, p. 13).

Pitelis, in his introduction to Penrose's "The Theory of the Growth of the Firm", summarizes this

author's major ideas, the first of which is her view of firms as

> *"(…) bundles of resources, under internal direction, for production of goods and services, sold in markets for a profit"* (Penrose and Pitelis, 2009, Introduction p. xix).

Consequently, as Daft (2010) explains, for resource-dependence theory a firm's success comes by way of achieving independence and autonomy. To do so, the organizations will try to minimize their dependence on other organizations for the supply of important resources and influence the environment to make resources available.

Even though the interest in the resource dependence view in supply chain management research has been sparse, RDT has been used to complement the transaction cost approach. This is the case, for example, of Smeltzer and Siferd (1998). These researchers analyse risk management, from the point of view of purchasing management, within the context of TCE and RDT.

Agency theory was frequently identified throughout the literature review. It has been used, since the 1960s and 1970s, in a considerable number of fields of research notwithstanding the controversy that surrounds it (Eisenhardt, 1989a). The focus of this theory is on problems associated to the delegation of work to the agent by the principal (Zsidisin and Ellram, 2003). The literature on the genesis of Agency theory focused on risk sharing problems among individuals or groups, describing the problem as one that arises when attitudes before risks are different between cooperating parties (Eisenhardt, 1989a). In the words of Rumelt (1994, p. 28)

> *"Agency theory concerns the design of incentive agreements and the allocation of decision rights among individuals with conflicting preferences or interests".*

Agency theory focuses on resolving two typical problems within agency relationships: issues that derive from the fact that principal and agent have conflicting goals and it is difficult for the principal to verify that the agent is acting as intended by the relationship (to " *reduce the threat of top managers' moral hazard*" - Aureli and Salvatori, 2012, p. 308); the problem of risk sharing when the parties' attitudes toward risk differ (Eisenhardt, 1989a). Jensen and Meckling (1976, p. 308) define the concept and summarize the problem in straightforward terms:

"(…) a contract under which one or more persons engage another person (the agent) to perform some service on their behalf which involves delegating some decision-making authority to the agent. If both parties to the relationship are utility maximizers, there is good reason to believe that the agent will not always act in the best interests of the principal. The principal can limit divergences from his interest by establishing appropriate incentives for the agent and by incurring monitoring costs designed to limit the aberrant activities of the agent".

It is thus clear that the interests of principal and agent may clash and that the principal must keep an eye on the agent due to the expectable *"tendency to shirk when not being observed"* (Mudambi and Ricketts, 2002, p. 3). Therefore, the literature on agency is mostly concerned with the design of those contractual incentive solutions that ensure the desirable efficiency in the relationship principal-agent,

"(…) to induce a suitable degree of effort from one party (the agent) even where there are costs of monitoring and enforcement" (Mudambi and Ricketts, 2002, p. 3).

That is not to say that there are no other possible causes for dysfunctional agency relationships beyond inadequate incentive agreements, such as poor management skills (Rumelt et al., 1994). Despite the frequent use of Agency theory in different disciplines along the past four decades, there is little literature analysing its use to explain inter-firm relations within a supply chain (Fayezi *et al.*, 2012). Yet, some say that the application of Agency theory can arguably offset the shortcomings of TCE in explaining the dynamics of inter-firm relations in general (Williamson, 1988) and also in the particular case of supply chain relationships (Fayezi et al., 2012). Reinforcing this idea, Stock thoroughly identifies a long list of theories that can be applied in Logistics research and in that long list the author identifies Agency theory. Furthermore, the author specifies some of its potential applications in this field:

"- Defining and understanding inter- and intra-firm organizational relationships.
- Developing and maintaining strategic alliances and partnerships with vendors, suppliers and logistics service providers.
- Investigation of the nature and scope of relationships with suppliers.
- Supply chain management issues such as risk sharing, capital outlays, power and conflict between channel intermediaries and the determination of costs and benefits of supply chain integration" (Stock, 1997, p. 527).

The literature reviewed included a few examples of research that adopted Agency theory as theoretical support. One such case was Ritchie and Brindley (2007b), where the researchers adopted the terms principal and agent to describe the interactions and relationships within the supply chain. According to the authors, employing an Agency theory, in the articulation of the main strands of risk management within the supply chain, amplified the processes, the procedures and the different perspectives and relationships from different vantages points within the supply chain (Ritchie and Brindley, 2007b). Ergo, using the Agency theory highlighted the dynamics between the interests of the parties within the supply chain. Cheng and Kam (2008), adopting a network perspective of the supply chain, draw on the Agency theory to provide a conceptual framework for analysing supply chain risk. The effect of the performance goals on the risk attitude of managers, as explained by March and Shapira (1987) or Miler and Leibnein (1996), and referred elsewhere herein, is a typical discussion of the central issues in the agency theory from a behavioural point of view. One final example is the work of Rao and Goldsby (2009) who, drawing on Agency theory and citing Fama (1980), identify the relationship between managers and the firm owners as a typical agency relationship. Consequently, the authors identify agency uncertainty as one of their sources of firm-specific uncertainties.

A final mention to the industrial network approach is necessary. This approach has its focus of analysis on inter-firm relationships rather than firms isolated and sees them as the coordination of activities between companies (Riemer and Klein, 2006). To address the need to sustain on-going coordination efforts among network members, network management aims to establish structures and mechanisms that are needed to cope with the complexities inherent to a network (Johnston and Vitale, 1988). There are examples of research adopting this approach to analyse different issues such as: network coordination; interests, objectives and strategies alignment between the members of the network (Narayanan and Raman, 2004); management of networks of suppliers (Dubois and Fredriksson, 2008); network efficiency (Mizgier *et al.*, 2013); uncertainties and risks with focus on dependency (Hallikas *et al.*, 2004); and supply chain network vulnerability and resilience (Peck, 2005; Pettit *et al.*, 2013). Some of the most relevant consequences of networks are also the focus of different approaches. The concern with transaction and production costs that a network organization produces is typically a concern for transaction costs economics and the opportunities to create value created by the pooling of resources within the network is a typical concern for the resource-based theory.

3.4 –Supply chain risk management systemization

Concerns with risks involved in specific supply chains are not a novelty of the XXIst century but trying to identify pioneer research on the subject of risk management specifically concerning supply chains - emerging within the broader field of business risk management - can be a painful task. Having said that, one can identify, throughout the last few decades of the past century, relevant research giving added notoriety to the subject. For example, Wright (1980) argued that there was strong evidence that there the need for senior executives in procurement operations to make strategic evaluations of their supply markets, to evaluate the risks involved in particular supply channels and to be able to relate these to their company's marketing objectives, was generally ignored. Consequently, the author highlighted the need to consider purchasing as a risk-taking function. From that long gone year of 1980 to the present, a long string of research literature has put an increasing focus on supply chain risk management. Just a few years into the XXth century, Tang (2006a) suggested a framework for classifying articles on supply chain risk management, which is a clear sign that there was already enough research on the field for such a classification to become necessary. Tang identified several different categories even though the author did not review articles addressing issues such as, among others, risk identification, risk assessment, risk avoidance. An account of the most relevant contributes to the development of knowledge in this field throughout the last thirty-odd years can throw some light on the evolution of theory concerning supply chain risk management.

Since the late 1950s, particularly with the breakthrough contribute of Forrester (1958), it has been recognized that the internal systems of supply chains can lead to oscillations in demand and inventory as orders pass through the system, originating wild swings of demand and subsequent inefficiencies in stock levels (Wilding, 1998). By the end of the XXth century, organizational risk management, particularly corporate risk management, had already been addressed by the researchers, as it was, for example, the case of Miller (1992) who developed a framework for categorizing the uncertainties faced by firms operating internationally, adopting an integrated risk management perspective. However, it was mostly from the early 1990's onwards that researchers turned their attention to supply chain risk management specifically. Smeltzer and Siferd (1998) focused their attention on purchasing management identifying risk management as

one of its essential components. This is by itself hardly new to the literature on purchase management, as the portfolio-based approaches to strategic purchase management already revolved around the risk dimension in supply management (e.g. Kraljic, 1983; Turnbull, 1990; Olsen and Ellram, 1997). However, the authors analysed risk management in purchase management within the context of transaction costs theory and the resource dependency model, arguing that proactive supply management is qualitatively different from reactive supply management due to its concern with risk. Their work is also noteworthy for providing examples of risk management through proactive purchasing activities. Wilding (1997, 1998) discussed the implications for supply chain strategy and manufacturing logistics of uncertainty within the supply chains, focusing his attention on deterministic chaos and parallel interactions as sources of uncertainty. Christopher (2000) suggests that the key to cope with supply chain risk is in agile supply chains, which means that managers must thrive to ensure supply chain responsiveness. This need for supply chain agility and responsiveness as been widely recognized since then (Braunscheidel and Suresh, 2009; Christopher and Peck, 2004a; Gligor *et al.*, 2013; Li *et al.*, 2009).

In the beginning of the present century, the idea that managers for companies that depend on other companies should be focusing their attention beyond their companies' walls had already been adopted by many large corporations. Souter (2000), for instance, refers the example of companies such as HP and Amazon to urge risk managers to adopt a supply chain perspective when it comes to risk identifying, mitigating and monitoring. This was one of the many different perspectives that have been addressed by the literature as a result of the increasing awareness of the impact of supply chain.

Other researchers have focused on different aspects such as: supply chain vulnerability (Svensson, 2000); causes for supply chain disruptions (Kleindorfer & Saad, 2005); the severity of these disruptions (Craighead *et al.*, 2007); supply chain resilience (Sheffi and Rice, 2005; Ponomarov and Holcomb, 2009); the consequences of supply chain disruptions (Hendricks and Singhal, 2003, 2005a, 2005b; Wilson, 2007b, focusing on transportation disruptions); and business continuity (Zsidisin *et al.*, 2005; Zsidisin, 2007; Sheffi, 2009; Blos *et al.*, 2010). Some of those efforts aimed at proposing frameworks or models, thus hoping to offer some structure to guide future researchers and practitioners. Throughout the last decade of the XXth century, some researchers developed frameworks with the purpose of categorizing uncertainties challenging companies and supply chains (*inter alia,* Miller, 1992; Wilding, 1998). However, it was mostly in

the first decade of the present century that several researchers aimed their endeavours at suggesting frameworks for the analysis and management of supply chain risk. The list of frameworks in the literature is long and diversified, but reference must be made to some of the most relevant frameworks and models suggested in the literature.

Svensson (2000, 2002) analysed the concept of vulnerability, which he considered to be unexplored in the literature, and suggested a conceptual framework for the analysis of vulnerability in supply chains, based on establishing sources of disturbances and categories of disturbances.

Das and Teng (2001) suggest a comprehensive and integrated framework of the constructs of trust, control and risk. These authors identify risk as either relational risk or performance risk, trust as goodwill trust or competence trust, and control as behaviour control, output control or social control. Furthermore, the authors suggest a number of risk reduction approaches and discuss trust-building techniques and control mechanism aiming at risks reduction.

Hallikas *et al.* (2002) describe a conceptual framework of risk analysis and assessment from the point of view of subcontractors. The author's efforts aimed at illustrating how small and medium-sized enterprises could assess and analyse business risks related to networking. Although their research was based on the concept of assessment of risks as the conversion of qualitative data into a quantitative form, the authors acknowledge that in this task

> *"(…) a qualitative analysis should not be neglected, because it provides information concerning the factors pertaining to the estimation and it provides a deeper understanding of the process" (Hallikas et al., 2002, p. 52).*

Moreover, these authors stress that the primary goal of their model is not to provide an absolute value of risk, since the estimation of the probability and the effect of the risk are based on subjective estimation, but rather to provide direction and support in the decision-making process, for instance by establishing a prioritization of risks. Hauser (2003, p. 64) calls this *"risk-adjusted supply chain management"*, and explains that this means the

> *"(…) adoption of a strategy that optimizes supply chain performance by analysing supply*

chain risk and extracting from this analysis the information needed to make sound business decisions."

With this purpose, the author suggests a business case framework to assess and manage risk in an organization. The framework consists of different steps: process/risk identification, identification of vulnerabilities, redefinition of the model, creating a complexity/risk portfolio, finalized model, developed initiatives, and performance measurement.

Lee (2002) suggests that supply chain strategies need to be matched to the right level of demand and supply risks encountered, further suggesting an uncertainty framework that specified the two key uncertainties faced by a product: demand and supply.

Kleindorfer and Saad (2005) also provided a conceptual framework reflecting the joint activities of risk assessment and risk mitigation. Building on the existing risk management literature, this framework addresses the effect of alternative design options on the effectiveness and robustness of the supply chain before different sources of disruption. The authors refer two main categories of risks affecting supply chain design and management – risks derived from difficulties in coordinating supply and demand, and risks arising from disruption of normal activities – but they focus their analysis on the second category. Hence, the authors focus on risks arising from natural *"disasters, strikes and economic disruptions, and from acts of purposeful agents, including terrorists"* (Kleindorfer & Saad, 2005, p. 53). This last group of risks arising from terrorist acts jumped to the top of the agenda with the 9/11 attack on the twin towers and, as referred elsewhere herein, induced the creation of a plethora of measures and legislation that, by itself, introduced new risks to global supply chains, some having immediate impact by interrupting supply flows and stopping production lines (Sheffi, 2001, refers a number of examples), others with a long-lasting impact affecting particularly container-based trade (Kleindorfer and Saad, 2005).

Another example of an effort to create a framework is in Peck (2005), where the author develops a multi-level framework for the analysis of the different levels at which sources and drivers of supply chain risk operate. This author identifies the following four different levels: value stream/product or process; assets and infrastructure dependencies; organisations and inter-organisational networks; and the environment. Peck suggests this framework as the basis for a model to explain the scope and dynamic nature of supply chain risk.

Hallikas *et al.* (2005) suggest a risk-based classification of supplier relationships, and considered the differences across supplier clusters in collaborative learning and risk management. This framework suggests three relationships clusters:

> *"(…) non-strategic relationships, in which the mutual dependency and risks are relatively low; strategic relationships, in which the mutual dependency and risks are high; and asymmetric relationships, in which the suppliers' dependency and risks are high and the buyer's dependency and risks are low"* (Hallikas et al., 2005, p. 80).

Cucchiella and Gastaldi (2006) suggest a theoretical framework for supply chain risk management with the purpose of enabling real options to face risks arising from every source of uncertainty. Identifying and understanding these sources of uncertainty is the first stage proposed by the authors, with a view to individualizing the most correct way to reduce each uncertainty. Citing Van der Vorst *et al.* (1998), the authors identify three clusters of uncertainty sources in supply chains, namely, order forecast horizon, input data and decision processes. The number of uncertainty sources, however, increases as the complexity of supply chains also increases and the framework suggested by Cucchiella and Gastaldi (2006) aims at reducing the impact of such sources of risk by suggesting those real options. In their work, the authors divided supply chain risks into categories of internal risks, such as capacity variations, regulations, information delays, and organizational factors, and external risks such as market prices, actions of competitors, manufacturing yield and costs, supplier quality, and political issues.

Also based on the distinction between internal and external types of risks, Wu *et al.* (2006) identify a list of inbound supply risk factors and create a hierarchical risk factor classification. Based upon this classification, these authors propose an integrated methodology to classify, manage and assess inbound supply risks that aims at reinforcing inbound supply chain risk management. Furthermore, they suggest an analytical hierarchy processing method to rank the inbound supply risk factor associated to different suppliers.

Gaudenzi and Borghesi (2006) use an analytical hierarchy process (AHP) to assess risk in a supply chain, from the perspective of customer value, and prioritize supply chain objectives, identifying risk indicators, as well as assessing the potential impact of negative events and the cause-effects relationships along the chain. Furthermore, the authors suggest that supply chain

risk management can be considered as a process that supports the achievement of supply chain management objectives and call for the involvement of key decision makers.

In the same year, in an article published on Supply Chain Management Review, Kiser and Cantrell (2006) added a practitioner's point of view by suggesting their own six-steps process for a comprehensive and company-customized risk management plan, which will be referred with greater detail further below.

Based on literature review and through discussion with supply chain experts for SMEs, Faisal *et al.* (2006b) identify 11 variables that can impact risk management in the supply chain. Those variables, or "risk mitigation enablers" as the authors name them, are:

- Information sharing
- Agility in the supply chain
- Trust among supply chain partners
- Collaborative relationships or partnerships
- Information security in the supply chain
- Corporate social responsibility
- Aligning incentives and revenue sharing policies
- Strategic risk planning
- Risk sharing in the supply chain
- Knowledge about various types of risks in a supply chain
- Continual risk analysis and assessment

These authors aim at presenting an approach to effective supply chain risk mitigation by understanding the dynamics between various enablers that help to mitigate risk in a supply chain. Using interpretive structural modelling the research presents a hierarchy-based model and the mutual relationships among the enablers of risk mitigation.

Highlighting the interconnection between risk and performance, Ritchie and Brindley (2007b) develop a framework to explore the application of the concepts underpinning risk management. These authors suggest five major components to a framework in managing supply chain risk: risk context and drivers; risk management influencers; decision makers; risk management responses; and performance outcomes. Building on a five risk sources lists proposed by Ritchie and Marshall (1993, *apud* Ritchie and Brindley, 2007b), the authors suggest

seven risk sources: environment characteristics, industry characteristics, supply chain configuration, supply chain members, organization's strategy, problem specific variables, and decision making unit. Differentiating systematic and unsystematic risks, the authors further introduce the term driver

> *"(…) to differentiate those factors likely to have a significant impact on the exposure (i.e. likelihood and consequences) to undesirable performance and risk outcomes, or possibly providing the opportunity to improve performance, albeit with increased risk" (Ritchie and Brindley, 2007b, p. 309).*

Despite the fact that their research suggests risk management strategies that they consider effective, these authors also suggest the need for future research to develop more refined frameworks to categorize risk sources, risk drivers and causal pathways. They conclude that there is a need for research to develop a more diverse set of risk management tools and approaches to effectively address the diversity of issues and contexts (Ritchie and Brindley, 2007a).

Based on agency theory, and on the precepts of inter-organizational transactional relationships in a network environment, Cheng and Kam (2008) formulate an alternative typology of risk in network systems. Building on the above-mentioned framework suggested by Peck (2005), these authors suggest a network-based conceptual framework that provides a structured approach for identifying and assessing risk dynamics and their differential impacts on different levels of supply networks. Their research highlights the fact that the dynamics of risk in network systems depend on other factors beyond the typology of networks, showing the impact of the functional role of each collaborator inherent in the network through agreements on supply and incentives, and supply performance. Beyond the commonly referred dimensions of probability and loss, Cheng and Kam refer two further dimensions of risk to explicate the concept of risk in global supply chains, namely speed and frequency.

Manuj and Mentzer, in two often cited papers published on the same year (2008a, 2008b), also highlight these two dimensions of risk, saying that

> *"(…) speed and frequency together determine the losses that happen per unit of time" (Manuj and Mentzer, 2008b, p. 197).*

These researchers identify three major gaps in previous literature on risk management in supply chains. The first gap the authors refer is the lack of a definition that adequately takes into account the unique dimensions of risk and risk management in a global supply chain. Secondly, they consider that there is a lack of attention to the antecedents of supply chain risk management strategies – i.e. the reasons why managers choose between different strategies – and their consequences. Finally, the authors argue that there is insufficient research on the moderators of the risk management process. In order to bridge these gaps, the authors developed a risk management and mitigation model which they intended to be a comprehensive model and one suitable for its use, as a step-by-step procedure, by global supply chain managers to regularly identify, assess, and plan for risk. In their research, Manuj and Mentzer explore the phenomenon of risk management and risk management strategies in global supply chains, addressing the applicability of six risk management strategies that they identify (avoidance, postponement, speculation, hedging, control, and transferring/sharing risk), bearing in mind environmental conditions and the role of three moderators: team composition, supply chain complexity management, and inter-organizational learning.

Knemeyer *et al.* (2009), building on a previous conceptual framework (Cohen and Kunreuther, 2007), suggest a framework linking risk assessment and risk perceptions in order to develop risk management strategies that must ultimately be evaluated for effectiveness. The authors do so by incorporating a methodology used by the insurance industry to quantify the risk of multiple types of catastrophic events on key supply chain locations. Through an integration of diverse research streams related to the management of risk, they propose a proactive planning process for addressing catastrophic risk in supply chains, through an integration of diverse research streams related to the management of risk. This planning process consists of four steps that the authors refer to as: to identify key locations and threats; to estimate probabilities and estimated loss for each key location; to evaluate alternative countermeasures for each key location; and to select countermeasures for each key location. As the authors stress, their conceptual framework can only be converted into a proactive planning process if a motivated cross-functional implementation team embraces this task. The role of the team formation, of leadership and of motivation is thus recognized by Knemeyer *et al.* (Knemeyer et al., 2009), as it has been previously referred herein.

Oke and Gopalakrishnan (2009), based on the case of a large US retailer, investigate the types and management of risks faced within the supply chain. According to these authors,

previous research that addressed mitigation of risks in supply chains tended to propose strategies without an effort to separated mitigation strategies for different types of risk. Consequently, their work categorizes risks into inherent or high frequent risks and disruption or infrequent risks, investigating mitigation strategies for dealing with these risks and identifying generic strategies that could handle most risk types, as well as specific strategies for handling particular risks.

A different approach is adopted by Pujawan and Geraldin (2009). These authors suggest a model for risk quantification based on the house of quality (HOQ) model and on the Failure Mode and Effect Analysis (FMEA). In their research they identify a list of risk events through the breakdown of major business processes (Plan, Source, Make, Deliver, Return) into sub-processes and then asking the question of "what can go wrong?" (Pujawan and Geraldin, 2009, p. 958). The outcome of their work is a framework to proactively manage SC risks that the authors call "house of risk". With a similar concern in their catastrophe focused classification framework, Stecke and Kumar (2009) also try to match different types of catastrophes to a variety of infra-structural components of supply chains and to appropriate risk mitigation strategies.

Focusing on the concept of resilience, Ponomarov and Holcomb (2009) carry out an extensive integrative review of the literature in a number of disciplines, in order to present an integrated perspective on resilience. Their integrated perspective of supply chain resilience offers itself as the basis for developing a conceptual framework of the dimensions of supply chain resilience, its antecedents, and its consequences, considering the relationship between logistic capabilities and supply chain resilience.

Olson and Wu (2010) review cases and models applied in supply chain risk management research to identify classifications of types of risks, a list of risk mitigation strategies, cases, and models. These authors further identify a generic framework and compare categorisations of risks.

In Pettit *et al.* (2010), the authors' endeavours concentrate on providing a complete framework that encompasses the wide breadth of issues internal and external to the supply chains. Based on the literature review carried out and on insight provided by focus groups on a case study, the authors suggest a conceptual framework, which is the basis for several propositions regarding the concept of supply chain resilience. Those propositions stem from the assertion that balanced resilience will result from a fit between the vulnerability factors and the capability factors (which the authors designate the Zone of Resilience) and revolve around

different balances of degrees of vulnerabilities and degrees of capabilities, resulting in different measures of resilience. Beyond that Zone of Resilience, according to the authors, no firm is expected to be viable in the long-term. The authors identify vulnerability factors and capability factors, developing taxonomies for those factors and suggest that their Supply Chain Resilience Framework can provide a useful managerial tool for improving performance. Building on their Supply Chain Resilience Framework, the same authors (Pettit *et al.*, 2013) develop a tool (the authors call it SCRAM™) to provide direction for a supply chain to improve its resilience. With this goal the tool is designed to assess supply chain resilience, creating a measurement instrument that helps managers implement the Supply Chain Resilience Framework.

Tummala and Schoenherr (2011) address the scarcity of conceptual frameworks - identified *inter alia* by Manuj and Mentzer (2008a) - providing a clear meaning and normative guidance for supply chain risk management. The authors suggest that supply chain risks can be managed more efficiently through the use of Supply Chain Risk Management Process (SCRMP) that their research suggests, a framework that affords practitioners some assistance, to be used as an audit tool (Figure 1). The structured approach suggested is divided in the following stages:

Phase I - risk identification, risk measurement and risk assessment;
Phase II - risk evaluation, and risk mitigation and contingency plans; and
Phase III - risk control and monitoring.

Based upon the work of previous researchers (namely, Chopra and Sodhi, 2004 and Schoenherr *et al.*, 2008), the authors also suggest a list of supply chain risks and their respective triggers. Furthermore, the authors identify two sets of risk drivers, using the distinction between internal and external drivers. Despite the fact the merits of the authors' suggestion and of the usefulness of their framework as an analysis tool, it is arguably too complex for immediate use in managerial practice, as it requires a considerable effort of interpretation. However, this framework will be a relevant reference for the present research.

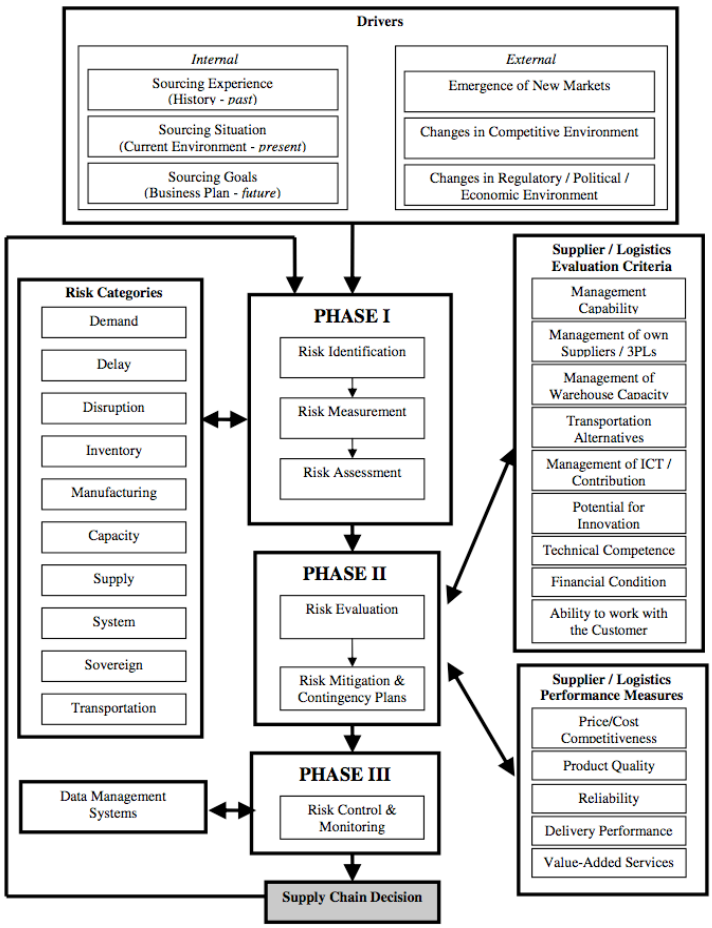


Figure 2 - Supply Chain Risk Management Process suggested by Tummala and Schoenherr (2011)

The most original aspect of their proposal, arguably, is the fact that Tummala and Schoenherr (2011) suggest categories and indexes for the severity of hazards based on the Military Standard MIL-STD-882C, of the US Department of Defense[4]. The authors consider these classifications useful to assess quantitatively the consequence severity of hazards when objective information is not available. Where risk assessment is concerned– *"the determination of likelihood of each risk factor"* (Tummala and Schoenherr, 2011, p. 10) - and no objective information is available, the

[4] Military Standard, MIL-STD-882C (1993), *System Hazard Analysis, System Safety Program Requirements*, Department of Defense, USA, January 1993, superseded by MIL-STD-882D (10 February 2000) and by MIL-STD-882E (11 May 2012).

authors suggest the use of techniques such as the Delphi method and focus groups of experts *"to aid in the derivation of probabilities"*, or the use of probabilities categories as suggested by the above mentioned Military Standard MIL-STD-882C.

Blackhurst *et al.* (2011), using systems theory and the resource-based view of the firm as the theoretical underpinnings, provide a systematic investigation of supply resiliency. Based on empirical generalizations extracted from a multiple case-study research, these authors identify sets of supply resilience enhancers and of supply resilience reducers, suggesting a framework that the authors consider useful to assess the level of resiliency in a supply base. The concept of supply chain resilience will have to be further discussed at a later stage herein and then their research will be worthy of further mention.

It is beyond the purpose of this analysis to report on all the contributions in the existing literature that have suggested frameworks or models for supply chain risk management in general or for some particular purpose within the broader context of supply chain risk management. However, the usefulness of frameworks has been championed by a long string of research articles and the effort herein to refer the contributions that have been deemed most relevant is a token of the recognition of that usefulness. Nevertheless, it is important to stress the instrumental nature of these frameworks and the limitations of their applicability. Tummala and Schoenherr (2011) highlight this idea with their cautionary note on the use of their Supply Chain Risk Management Process (SCRMP) as they stress that the framework cannot be applied blindly and it is a mere tool that does not make decisions for the supply chain manager, nor does it replace intuitive judgment and tacit knowledge of the unique situation.

3.5 – Supply chain risk management concepts in the literature

3.5.1 - The need for concept clarification

In the context of supply chain risk management the conceptual basis for discussion has been significantly increased in the first decade of the current century. However, despite significant academic efforts to clarify this conceptual basis, the field of supply chain risk management is a

rather "*chaotic and somewhat disorganised*" one (Trkman and McCormack, 2009, p. 247). Even though managers seem to be rather indifferent to such conceptual distinctions (Peck, 2005), concepts such as "risk", "disruption", "risk driver", "risk source", "risk consequences", Risk mitigation strategies", among others, are been given different meanings by researchers. The clarification of these concepts is relevant to the definition of the very concept of supply chain risk management. Jüttner et al. (2003), for instance, identify the distinction of four basic constructs as relevant in defining the very concept of supply chain risk management: supply chain risk sources, risk consequences, risk drivers and risk mitigating strategies. Understanding the difference between concepts such as risk sources, risk drivers and supply risks is a condition to tackle risks adequately, through effective risk management strategies devised by companies on the basis of specific knowledge of those concepts (Chopra and Sodhi, 2004). Likewise, prior to delving into the research problem, it is important to analyse the most important concepts involved in supply chain risk management in order to clarify their meaning or, at least, the meaning adopted herein.

3.5.2 - Risk and supply chain risk

The roots of the modern concept of risk can be traced to the Hindu-Arabic numbering system (Bernstein, 1996). Systematic efforts to understand risk, however, began, as Bernstein also refers, in the Renaissance, in the seventeenth century, with Pascal and Fermat's attempt to crack Paccioli's puzzle that led to the discovery of the theory of probability - *"the mathematical heart of the concept of risk"* - as they tried to apply mathematics to gambling. The advances that took place between 1654 and 1760 are behind most tools for risk management that are used today (Bernstein, 1996).

Every form of life is exposed to risk, as risk is inherent to life. Likewise, every company is exposed to a degree of risk, as risk is inherent in every link within a firm's supply chain (Svensson, 2000). Business risk has been defined as the level of exposure to uncertainties that the enterprise must understand and effectively manage as it executes its strategies to achieve its business objectives and create value (Dani, 2009). Risk management is "*a way to gain more power over events that can change your life*" (Borge, 2002, p. 3) and this concern with taking control of the unknown has been a human quest throughout the history of mankind, one in which some

achievements can be claimed:

> *"(the) gods are still so unkind as to deny us knowledge of what the future holds, but we have made two giant strides: first, we now understand a great deal about the likelihood of unpleasant surprises; and, to a far greater extent, we are learning how to manage the consequences of unpleasant surprises when they do occur*" (Bernstein, 2000, p. 5).

In classical decision theory, risk is commonly conceived as reflecting variation in the distribution of possible outcomes, their likelihoods, and their subjective values, thus including positive and negative variations (March and Shapira, 1987). Risk Management is a term traditionally used in the world of finance to describe the vulnerability of investments, justify hedging policies and to support the decision to contract insurance (Sørensen, 2004). In an increasingly unstable world, companies are forced to tackle risks affecting their pressure sensitive global supply chains as much as they are forced to tackle other business risks (Wagner and Bode, 2008) and behind this demand for risk management is the increasing number of risks (Bernstein, 1996). Thoroughly assessing the sources of risk allows companies to understand the risks they are exposed to, thereby being able to take a proactive, long-term view for reducing and managing that risk (Zsidisin et al., 2004). This, however, is a challenging endeavour and, even though they do not directly refer to them, the words of Bernstein eloquently translate the difficulties and dilemmas that companies face in their struggle to try to reduce their risks:

> "*The issue boils down to one's view about the extent to which the past determines the future. We cannot quantify the future, because it is an unknown, but we have learned how to use numbers to scrutinize what happened in the past. But to what degree should we rely on the patterns of the past to tell us what the future will be like? Which matters more when facing a risk, the facts as we see them or our subjective belief in what lies hidden in the void of time? ... In this sense, risk is a choice rather than a fate. The actions we dare to take, which depend on how free we are to make choices, are what the story of risk is all about*" (Bernstein, 1996, pp. 6 and 8).

Although the concept may seem easy to grasp, there is not a widely accepted definition of risk (March and Shapira,1987). Furthermore, the very concept of risk is prone to confusion with other concepts and, despite their different meanings, risk is often used interchangeably with terms such as risk source and uncertainty (Colicchia and Strozzi, 2012). For example, in the context of insurance, risk can be defined as

"(…) the probability of an uncertain event, causative of economic loss" (Thoyts, 2010, p. 5),

but the fact that it is often confused with hazard[5] and with peril[6] shows that its correct meaning is not easy to grasp. Likewise, the concept of supply chain risk in itself is not a straightforward one, as Tang and Musa (2011) refer in their analysis of research advancements in supply chain risk management. As these authors refer, in the context of supply chain operations it is not clear to distinguish risk and uncertainty:

> *"Risk sometimes is interpreted as unreliable and uncertain resources creating supply chain interruption, whereas uncertainty can be explained as matching risk between supply and demand in supply chain processes"* (Tang and Musa, 2011, p. 26).

Moreover, the term risk is frequently used to refer to both risks and their consequences (Jüttner e*t al*., 2003; Manuj and Mentzer, 2008b), but risk should be separated from 'risk sources' and 'risk consequences'. Risk sources are

> "*(...) the environmental, organizational or supply chain related variables that cannot be predicted with certainty and that affect the supply chain outcome variables*" (Norrman and Jansson, 2004, p. 436).

In short, the concept of risk has a multi-faceted nature and the scope for understanding it differs according to industry (Jüttner e*t al.,* 2003; Li and Barnes, 2008). This is a field of study in fast development, involving several disciplines, but still in its early years. As such, it is prone to be the field for great variety of definitions, but as Zsidisin and Ritchie (2009a, p. 2) explain, most of these definitions *"are generally considered to be consistent and complementary*".

Risk in the supply chain has been present on research for a few decades and an example

---

[5] In the context of insurance, a hazard *"(…) is something that affects the probability of a risk occurring. Something that a layman would regard as 'dangerous' is indeed almost certainly a hazard. For example, if a car has defective brakes, it is self-evident that the probability of a collision is increased. However, if a car is fitted with an ABS braking system, this will also affect the probability of a collision, in this case making it less likely. This is also a hazard" (Thoyts, 2010, p. 5).*

[6] In the context of insurance, *"(…) if a risk is seen as the broad threat, a peril is the precise means by which the risk could come about. Therefore, if the risk is physical damage to a building, then fire, storm, flood and earthquake are all perils" (Thoyts, 2010, p. 5).*

of that is the fact that risk can be found in early literature concerning logistics and, particularly, concerning purchasing. In fact, more than three decades ago, Wright (1980, p. 50) warned that

> "*(t)here are two important needs of supply management: firstly to develop a management capability that can provide the needed inputs to an organisation's corporate strategy and corporate planning activities for the formulation of supply strategies; secondly, to monitor trends and changes in the supply market and the effectiveness of the organisation's supply network with the purpose of providing an early warning system when the future supply of essential inputs can no longer be assured*".

Since then, the concept of risk has been scrutinized in the literature in different fields of research and risk in the supply chain is by no means a novel issue in the literature either. One such field is portfolio analyses where risk has had a fundamental role since at least Markowitz's (1952) model of equity investment portfolio analysis (Dubois and Pedersen, 2002). The first comprehensive portfolio approach for purchasing and supply management introduced by Kraljic (1983) - *"a major breakthrough in the development of professional purchasing"* (Gelderman and Van Weele, 2003, p. 208) - has risk as a core aspect. The same can be said of other prominent portfolio-based approaches to strategic purchasing (among others, Turnbull, 1990; Nellore and Söderquist, 2000; Gelderman and Van Weele, 2003). For instance, Kraljic's analysis had a first dimension in which products were classified based on their impact in profit and on the supply market complexity (Olsen and Ellram, 1997). This market complexity was the perspective in which Kraljic discussed risk, incorporating in his perspective of risk, *inter alia,* supply scarcity, the pace of technology, entry barriers and the existence of monopolies or oligopolies (Zsidisin, 2003a). The assessment of both the product's impact on profit and the risk associated to the respective supplier determined the attractiveness of that supplier and conditioned the supply management options. Caniëls and Gelderman (2005; 2007), among others, stress the relevance of risk in this model and the scrutiny of the several portfolio-based approaches shows that they aim at detecting products or categories of products that may cause difficulties or risk of dependence (Gelderman and Semeijn, 2006), with a view to improving supplier management (Nellore and Söderquist, 2000). This scrutiny also allows the conclusion that they generally evidence an increasing attention given to risk in the context of supply chain management.

Even though it is arguable that approaches to risk management have been implied in supply chain management for quite some time, only recently has an effort for a coherent and

logical study on this subject become visible (Ritchie and Brindley, 2007b). Balancing supply and demand has always implied risk considerations, but different factors, several of them already mentioned, have increased the risk levels across the supply network (Jüttner *et al.*, 2003) stimulating the discussion around the subject. An often-cited definition sees risk as *'the variance of the probability distribution of outcomes"* (March and Shapira, 1987, p. 1404), but, from a managerial perspective, risk usually represents the downside of risk, the magnitude of possible losses and the act of risk taking, and risk as a concept that cannot be captured with a single number (Zsidisin, 2003a). In discussions on the subject of risk, two meanings of risk are frequently considered: risk as purely danger and risk as danger but also opportunity. From this perspective, risk management has twofold function, as Borge warns:

"*Risk management can help you to seize opportunity, not just to avoid danger*" (2002, p. 3).

In traditional decision theory, in the words of Wagner and Bode (2008, p. 309), the deviations around the mean expected value of a measure are proxy for risk, which is thus linked to variance, encompassing both positive and negative values or, in other words, a potential "downside" and "upside". Despite the possibility of risk being translated in both "positive" or "negative" variations, in the field of supply chain management risk is usually relevant as such only from the "negative" perspective. Hence, the concept of risk is often given only this negative nature but, as Miller (1992, p. 311) summarizes,

"*(w)ith either the variance or negative variation understandings,* "*risk*" *refers to variation in corporate outcomes or performance that cannot be forecast ex ante.*"

In so far as the literature on supply chain management is concerned, we can also find that "negative" perspective. This is the case, for example, in Harland *et al.* (2003, p. 52) where risk is defined as *"a chance of danger, damage, loss, injury or any other undesired consequences"*. As Jüttner and Maklan (2011, p. 246) refer, the focus of supply chain risk management is *"on the identification and management of risks for the supply chain in order to reduce its vulnerability"*, therefore risk in the context of supply chain management is considered in its "negative" meaning, associated to some loss, be that a quantitative loss, such as lost revenue, or a qualitative one, such as reputation damage (Manuj and Mentzer, 2008b). Zsidisin (2003a, p. 218) had already highlighted (citing March and Shapira, 1987 and Shapira, 1995) that few managers view risk as *"the variance of the probability distribution of outcomes"*, but that they rather identify:

"(1) the downside of risk, (2) its magnitude of possible losses, (3) the act of risk taking involving the use of skills, judgment and control, and (4) risk as a concept that cannot be captured with a single number."

Wagner and Bode (2008, p. 309) reinforce that view asserting that risk as purely negative outcome is what corresponds best to supply chain business reality, hence defining risk as

"*the negative deviation from the expected value of a certain performance measure, resulting in undesirable consequences for the focal firm. Hence, risk is equated with the damage or loss resulting from a supply chain disruption.*"

Throughout the first decade of this century numerous researchers have contributed to the development of the concept of supply chain risk by addressing the field of supply chain risk management with focus on different topics and perspectives such as: supply chain risks (Rao and Goldsby, 2009); risk management strategies (Christopher and Lee, 2004; Jüttner *et al*., 2003; Manuj and Mentzer, 2008a, 2008b); procurement and supply (Wu *et al*., 2007; Zsidisin and Ellram, 2003; Zsidisin, 2003; Zsidisin *et al.,* 2004; Zsidisin *et al*., 2008); supplier selection (Hallikas *et al*., 2004, 2005; Levary, 2007); performance implications of risk (Ritchie and Brindley, 2007a; Wagner and Bode, 2008; Wieland and Wallenburg, 2012); and supply chain risk financial impact (Hendricks and Singhal, 2003, 2005a, 2005b; Papadakis, 2006). As a consequence, there is considerable diversity in the meaning given to the concept of "risk" and even in the terminology used but one of the most often cited definitions of supply risk is the one provided by Zsidisin (2003a, p. 222), who defines it as

"(…) the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety".

Risk is measured in terms of probability and severity of negative business impact, the two dimensions of risk that several studies have highlighted (Hallikas *et al*., 2004; Harland *et al*., 2003; Li and Barnes, 2008; Peck, 2005; Zsidisin *et al*., 2004), two dimensions that are implied in Zsidisin's definition above. Different authors have used a matrix model to demonstrate graphically the risk level that a be established by crossing those to dimensions. One example is

the proposal in Thun and Hoenig (2011, p. 244) that the authors use to extract adequate courses of action (Figure 3).

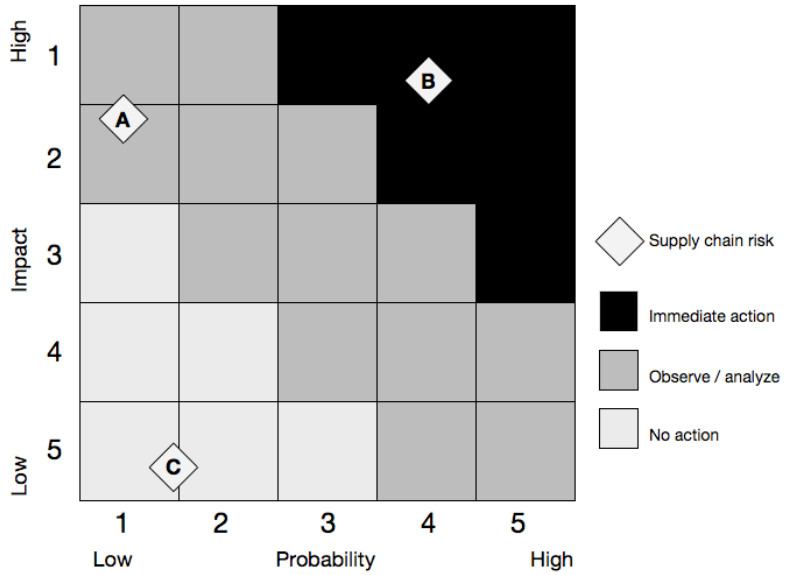


Figure 3 - Probability-impact matrix (source: adapted from Thun and Hoenig, 2011, p. 244)

Jüttner *et al.* (2003, p. 200) define supply chain risk as *"the variation in the distribution of possible supply chain outcomes, their likelihoods, and their subjective values"*, highlighting the same two dimensions of risk - impact and likelihood of occurrence – and including in this concept *"any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user"*. These dimensions are implicit in the questions that are the basis for a risk analysis:

> "*(i) what can go wrong, (ii) how likely is it to happen, and (iii) what are the consequences*" *(Asbjørnslett, 2009, p. 29).*

Manuj and Mentzer (2008b, p. 196) define risk as

> *"the expected outcome of an uncertain event, i.e. uncertain events lead to the existence of risks. We call these uncertain events "risk events"*

and, building on the definition suggested by Zsidisin (2003a), they define supply risk as

> "*the distribution of outcomes related to adverse events in inbound supply that affect the ability of the focal firm to meet customer demand (in terms of both quantity and quality) within anticipated costs and time, or causes threats to customer life and safety*" (Manuj and Mentzer, 2008b, p. 197).

Although they acknowledge those two dimensions of risks (likelihood and impact), these authors add two new dimensions: speed and frequency. Speed of risk refers, on the one hand, to the rate at which the risk event unfolds and, on the other, to how long it takes for the risk event to be noticed. Frequency refers to how often a given type of risk event happens. Bearing in mind the characteristics of global supply chains - longer lead-times and their added variability, longer transportation legs, diminished supply chain visibility and control, among others – Manuj and Menzer consider these two further dimensions of risk especially important in global supply chains. In spite of these differences, most definitions of risk incorporate three dimensions: likelihood, impact (both already referred) and *"the causal path leading to the event"* (Ritchie and Brindley, 2007b, p. 305).

Risk, as enunciated above, is a concept with many facets. It includes sources of risk and its impact, and the scope for understanding supply risk differs according to industry (Zsidisin, 2003a). Jüttner *et al.* (2003, p. 204) also stress that *"the systematic differences in the risk concepts could be dependent on the specific supply chain and/or industry context"*. Hence, supply chain strategies must be canvassed bearing in mind the characteristics of the product, as asserted by Christopher *et al.* (2006), and among these characteristics risk is of utmost importance, an importance that is reflected on how frequently the word "risk" appears in these authors' arguments. Meulbrook (2000), for example, states that supply risk "adversely affects inward flow of any type of resource to enable operations to take place; also termed as 'input risk"' a definition that is referred and adopted by Harland et al. (2003). Jüttner et al. (2003, p. 200), define supply chain risks as "any risks for the information, material and product flows from original supplier to the delivery of the final product for the end user" or simply "the possibility and effect of a mismatch between supply and demand".

As an effort to differentiate supply chain risks, several authors suggest different

classifications of risks (among others, Svensson, 2000; Jüttner *et al*., 2003; Chopra and Sodhi, 2004; Christopher and Peck, 2004; Hallikas *et al*., 2004; Wagner and Bode, 2008; Rao and Goldsby, 2009). Establishing risk categories benefits risk identification and improves communication between those involved in the risk management process. In fact, some authors consider that the definition of risk categories is the most important stage of a risk assessment process, prior to impact and probability assessment (Blackhurst *et al*., 2008). However, these authors also stress that, when it comes to establishing risk categories,

> *"(…) firms adopting a supplier risk assessment and monitoring methodology will need to define risk categories based upon their own needs, industry type, supply chain type, etc. In other words, there is no "one size fits all" approach to assessing risk"* (Blackhurst *et al*., 2008, p. 148).

Although this caveat seems to make good sense, the fact that there are no consistently accepted dimensions of supply chain risk and that there is a significant number of typologies or taxonomies, contributes to a considerable conceptual confusion and the conclusion of Oke and Gopalakrishnan (2009, p. 1) that *"there is yet to be a consensus on which framework(s) best captures different types of supply chain risks"* still holds true. The following excerpt from Jüttner *et al*. (2003, pp. 199–200) clearly conveys this idea, as it refers that "risk"

> *"is used to refer to uncertain internal or external, environmental variables that reduce outcome predictability. In this sense, "risk" actually refers to a source of risk and uncertainty, such as "political risks" and "market risks" or, from a supply chain view, "the volatility of customer demand". On the other hand, the term risk is also used when referring to the consequences of risks, i.e. to the potential outcome indicators. In this sense, the terms "operational risks", "human risks" or "risks to customer service levels" are consequences of risks becoming events."*

The same sense of confusion results, for example, from comparing the classification in Wagner and Bode (2008) and the classification in Tang (2006a). On the one hand, the first authors mention that the categories of supply chain disruptions are often labelled "supply chain risk sources" and enumerate five distinct classes of supply chain risk sources: demand side; supply side; regulatory, legal and bureaucratic; infrastructure; and catastrophic. On the other, Tang (2006a) suggests a distinction between operations and disruption risks, arguing that the business impact associated with disruption risks is much greater than the business impact of operational

risks. According to this classification, disruption risks are caused by major disasters (natural or man-made) or by economic crises such as currency devaluation or strikes; operational risks are associated with inherent uncertainties such as uncertain customer demand, uncertain supply, and uncertain cost. Comparing the two classifications it seems that the meaning of disruption in Wagner and Bode (2008) is much wider than in Tang (2006a). Moreover, it has also been argued that many of the existing risk classifications focus only on disruptive events and on their anticipation, neglecting root causes of uncertainties:

> *"Frequently, only disruptive events (such as bankruptcy, natural disaster or the possibility of a terrorist attack) are included, whereas continuous changes due to a turbulent environment (e.g. a change in customer tastes, technology shifts or supplier priorities) are ignored*" (Trkman and McCormack, 2009, p. 247).

Establishing an *a priori* list of risk events could prove a cumbersome task, as the list in Wu *et al.* (2006, p. 353) suggests. More than a daunting task, it may well be a useless effort due to the fact that, notwithstanding all the effort put in it, the list would most likely be far from comprehensive. However, the above-mentioned conceptual and practical benefits of establishing risk categories seem undisputed, in spite of the difficulties referred. Consequently, it is important to mention some of the most relevant classifications in the literature as a step of the effort towards the selection of a supply chain risk classification for this research.

A frequently used classification is based on the distinction between "internal risks" and "external risks" (e.g., Christopher and Peck, 2004; Wu *et al*., 2006; Blackhurst *et al*., 2008). Building on a framework originally suggested by Mason-Jones and Towill (1998), Christopher and Peck (2004a) further explore the distinction between internal and external risks. These authors refer three categories of risk sources ("Internal to the firm, "external to the firm but internal to the supply chain network"; and "external to the network") further sub-divided into different risks. Environmental risks are the only sub-category identified within external risks. These environmental risks include risks that can affect the supply chain, both upstream and downstream, and they can also affect the marketplace. As risks internal to the firm, those authors identify "process risks" and "control risks". The former group concerns disruptions to the processes of the firm, the latter concerns *"the assumptions, rules, system and procedures"* that the company has adopted or implemented to control processes (Christopher and Peck, 2004, p. 5). Hence, a process risk is the misapplication of any of the forms of process control that companies

use, such as order quantities, batches sizes and safety stock policies, as exemplified by these researchers. Among the "external to the firm", the authors consider "demand risks" and "supply risks". Demand risks are defined by these authors as potential or actual disturbances to the flow of product, information or cash within the network, while supply risk is defined as those potential or actual disturbances to that flow of product or information but from within the network upstream (Christopher and Peck, 2004). An example of a proposal that rests on this distinction is the suggestion in Tang (2006a) of four different approaches to mitigate the impact of supply chain risks: supply management, demand management, product management, and information management.

This distinction between "supply risks" and "demand risks" is the basic distinction of a different classification also frequently referred (Hallikas *et al.*, 2005; Wagner and Bode, 2006; Sodhi and Lee, 2007; Oke and Gopalakrishnan, 2009, in the context of retail supply chains) that considers risks in the supply chain as being either risks associated with product demand or risks associated with product supply (Johnson, 2001). Demand risks result from disruptions that occur in downstream supply chain operations, whereas supply risks derive from disruptions that occur upstream of the company's supply chain. Downstream disruption can occur, for instance, in the physical distribution to warehouses or clients, with problem associated to transportation or warehousing, but it can also be associated to *"a mismatch between a company's projections and actual demand as well as from poor supply chain coordination"* (Wagner and Bode, 2008, p. 310), as a consequence of seasonal imbalances, introduction of new product adoption, short product life cycle among other causes (Johnson, 2001). Manufacturing and logistics capacity limitations, long and unpredictable lead-times, supply disruptions, quality problems, currency fluctuations are all examples of typical upstream disturbances (Johnson, 2001). Distinguishing risks specific to supply from risks specific to demand (Manuj and Mentzer 2008a) we can distinguish, with the same reasoning, mitigation strategies that address supply risks whilst others are suitable for demand risks (Tang, 2006a). Accepting these distinctions, we can also accept the distinction in Tang (2006a) between supply and demand management, from the point of view of risk management, therefore distinguishing supply risk management and demand risk management (Kern *et al.* 2012). The analysis in this thesis concerned risks associated to supply management alone.

Also considering the distinction between internal and external risks, Wu *et al.* (2006) create a *"hierarchical inbound risk classification"*, focusing on inbound supply risk analysis and taking

into account both the internal or external nature of the risks and the degree of control that the company can hope to be able to exert over those risks. This classification considers risks to be:

> *"•"Internal Controllable" refers to the internal risk factors that originate from sources that are most likely controllable by the company. Examples are the quality and cost of the product.*
> *•"Internal Partially Controllable" refers to the internal risk factors that originate from sources that are partially controllable by the company. For example, fire accident in the company.*
> *•"Internal Uncontrollable" refers to the internal risk factors that originate from sources that are uncontrollable by the company.*
> *•"External Controllable" refers to the external risk factors that originate from sources that are most likely controllable by the supplier company. For example, selection of the next tier suppliers.*
> *•"External Partially Controllable" refers to the external risk factors that originate from sources that are partially controllable by the supplier company. For example, customer demand can be partially impacted by company's promotion plan.*
> *•"External Uncontrollable" refers to the external risk factors that originate from sources that are uncontrollable by the supplier company. Examples are nature disasters such as earthquake, tsunami."* (Wu *et al*., 2006, pp. 352–353)

The authors consider this a useful classification to help managers get a clear idea about risk location and to adequately adopt the right strategies to cope with each risk, to avoid it or mitigate it. According to the authors, breaking down the existing risks into these categories will enable supply managers to identify the group of factors that contributes the maximum level risk and to classify each group of factors according to their importance. As Harland *et al.* (2003) the likelihood of a given event happening depends on the extent of the exposure to risk and on the likelihood of a trigger, but Wu *et al.* (2006) also refer that the power that an organization or individual have may put them in a position to partly or fully influence the realization of risk. Hence, whether a given risk is *"controllable"*, *"uncontrollable"* or *"partially controllable"* will depend on the organization concerned and a less powerful organization may be unable to do more than just cope with and react to the circumstances (Manuj and Mentzer, 2008a).

Kleindorfer and Saad (2005) classified supply chain risks into one of two broad categories: risks arising from the problems of coordinating supply and demand, and risks arising from disruptions to normal activities. Qualifying the first category as *"normal supply-demand coordination*

risks", these authors focus their attention on the second category, which they consider to be less explored in the literature although receiving increasing attention in recent years. These researchers base their classification in four premises derived from theory and practice: (1) to manage risk the nature of the underlying hazard giving rise to this risk must have been previously identified; (2) the risks identified must be quantified through a *"disciplined risk assessment process"*; (3) to adequately manage risk the options made *"must fit the characteristics and needs of the decision environment"* (Kleindorfer and Saad, 2005, p. 54); and (4) risk management options must be integrated with continuous risk assessment and in coordination across the supply chain. Within their framework, the authors identify three main tasks that are the basis of risk management: specifying sources of risk and vulnerabilities, risk assessment and risk mitigation.

From a different perspective, considering the different nature of risk sources, the existing literature occasionally distinguishes systematic risks and unsystematic risks (Ritchie and Brindley, 2007b), as it has been referred before. This, however, is a distinction that will frequently lead to different classifications in cases that one could expect to see risks having the same classification. For instance, although problem specific risks tend to be unsystematic (as opposed to, for instance, environment risks - Ritchie and Brindley, 2007b) the same risk can be systematic in a given supply chain context, or become systematic with the passage of time. The logic behind the distinction between operations risks and disruptions risks has some resemblance with the one behind the previous classification referred: operations risks are associated with uncertainties inherent in a supply chain, "*such as uncertain customer demand, uncertain supply, and uncertain cost*", whilst disruption risks are caused by major natural or man-made disasters "*such as earthquakes, floods, hurricanes, terrorist attacks, etc., or economic crises such as currency evaluation or strikes*" (Tang, 2006, p. 453; also Pujawan and Geraldin, 2009).

Oke and Gopalakrishnan (2009) accept the distinction between high-likelihood, low-impact risks (the authors refer to them as inherent and frequent risks) and low-likelihood, high-impact risks (or disruption and infrequent risks as the authors call them). Acknowledging that there is significant work in the literature focusing on high-likelihood, low-impact risks, these authors argue, as other authors before them (e.g., Chopra and Sodhi, 2004), that low-likelihood, high-impact risks demand attention but are just as forsaken by researchers as they are by companies in their risk protection plans. Furthermore, the authors claim that their empirical findings indicate the existence of a third category: medium probability, moderate impact risks. Most importantly, however, is their contention that,

"(…) generally, studies that address mitigation of risks in supply chains have tended to propose strategies but have not separated mitigation strategies for different types of risk (i.e. the Why versus the How)" (Oke and Gopalakrishnan, 2009, p. 169).

3.5.3 - Vulnerability, robustness, resilience, flexibility and agility.

Despite the recognition that investors take supply chain vulnerability into consideration, as it has been demonstrated by, *inter alia*, Hendricks and Singhal (2003, 2005a, 2005b), the context of modern supply chains has revealed the increasing exposure of global supply chains to threats of all sorts and this added exposure has been recognized by both practitioners and academics (e.g., Wagner and Bode, 2006). In this scenario, some concepts have gained increasing attention and their meaning for the purpose of this research must be clarified. Vulnerability is a concept that was unexplored in the literature on supply chain management until Svensson's (2000, 2002, 2004) efforts to develop a conceptual framework for the analysis of supply chain vulnerability. Since then, supply chain vulnerability as a subject of study has benefited from a general increase of the interest in risk management in several other areas, both in commercial and public management (Peck, 2006). Svensson (2000, 2002) suggests two components of vulnerability - disturbance and the negative consequences of disturbance – and his conceptual framework for the analysis of vulnerability consists of three principal components: source of disturbance, category of disturbance and type of logistics flow. This author sees vulnerability as

"the existence of random disturbances that lead to deviations in the supply chain of components and materials from normal, expected or planned schedules or activities, all of which cause negative effects or consequences for the involved manufacturer and its sub-contractors" (Svensson, 2000, p. 732),

or, in less words, the author defines vulnerability as

"(…) a condition that affects a firm's goal accomplishment dependent upon the occurrence of negative consequences of disturbance" (Svensson, 2002, p. 112).

The concept of vulnerability, however, has been used in several different contexts and it has been understood with many different meanings. In the context of a supply chain, the concept of vulnerability in Christopher and Peck (2004a, p. 3) is often referred:

> *"an exposure to serious disturbance arising from risks within the supply chain as well as risks external to the supply chain".*

It is often used where the supply chain is seen as suffering from a lack of robustness or resilience (two concepts to be clarified below) to face different threats that are both within and outside the supply chain's boundaries (Asbjørnslett, 2009). This lack of robustness or resilience may be associated to

> *"(…) the properties of a supply chain system; its premises, facilities, and equipment, including its human resources, human organization and all its software, hardware, and net-ware, that may weaken or limit its ability to endure threats and survive accidental events that originate both within and outside the system boundaries"* (Asbjørnslett, 2009, p. 18).

For the purpose of this research, the above cited concept of vulnerability in Christopher and Peck will be adopted but stressing the relevance of the characteristics of the supply chain that increase its exposure to risks. This relevance of the characteristics of the supply chain is also stressed by Wagner and Bode (2006, p. 304) - *"We posit that supply chain vulnerability is a function of certain supply chain characteristics (…)"* – who identify two sets of supply chain vulnerability drivers: customer dependence and supplier dependence; and supplier concentration and single sourcing. By then, there were still doubts regarding the origin of the increased supply chain vulnerability of modern supply chains as Peck (2006, p. 139) suggests:

> *"Within SCM there is no clear consensus as to whether supply chain vulnerability is simply a symptom of poor SCM—to be remedied with more effective SCM and the wider adoption of a SCO—or whether it is the unintended downside consequence of its successful application. Perhaps it should rightly be regarded as a combination of all of these."*

More recently, however, Stecke and Kumar (2009) summarized the relevant supply chain management practices in modern supply chains linked to the vulnerability causing factors

identified in their research: increase in the number of exposure points; increase in distance/time; decrease in flexibility; decrease in redundancy.

A long list of disruptive events, some of which have been mentioned herein, has exposed the vulnerability of modern supply chain and lead researchers to address the construct of supply chain resilience. The increasing complexity of supply chains and of their context renders efforts to anticipate disturbing events based on the history of the system hopeless (Pettit *et al.*, 2013). To tackle disruptive events, supply chains must incorporate event readiness, the ability to face disruptions with effective responses that allow them to return to their pre-disruption state (Ponomarov and Holcomb, 2009). This is the essence of the construct of supply chain resilience, a construct that draws from many disciplines and represents a multidimensional phenomenon (Ponomarov and Holcomb, 2009; Pettit *et al.*, 2013). As several researchers focused their attention on this construct (Rice and Caniato, 2003; Christopher and Peck, 2004; Kleindorfer and Saad, 2005; Sheffi and Rice, 2005; Sheffi, 2007; Blackhurst *et al.*, 2011), the quest for resilience, together with robustness, became a strategic imperative concern of supply chain risk management (Pettit *et al.*, 2013). Robustness and resilience are, thus, two fundamental constructs, related but different. Robustness is *"(…) a system's ability to resist an accidental event and return to do its intended mission and retain the same stable situation as it had before the accidental event (…)"*, while, resilience, on the other hand, can be defined as *"(…) a system's ability to return to a new stable situation after an accidental event"* (Asbjørnslett, 2009, p. 19*).*

Ponomarov and Holcomb (2009, p. 131) define supply chain resilience as:

> *"The adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function."*

Put in simple terms, as Fiksel (2006, p. 16) does, resilience is

> *"(…) the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change"*

All these definitions of resilience are, in their core, equivalent and neither adds much to the often-cited definition in Christopher and Peck (2004a, p. 2) and, consequently, their definition will

be henceforth considered so that resilience is

> *"(…) the ability of a system to return to its original state or move to a new one, more desirable state after being disturbed."*

Pettit *et al.* (2010) suggest that resilience consists of two constructs: vulnerabilities and capabilities. These authors define vulnerabilities as "*fundamental factors that make an enterprise susceptible to disruptions*" and supply chain capabilities as "*attributes that enable an enterprise to anticipate and overcome disruptions*" (2010, p. 6). This distinction results in the identification of a set of *"vulnerability factor"* and a set of *"capability factors"* (Pettit *et al.*, 2010, pp. 11 and 12). Furthermore, these authors distinguish resilience and risk management, based on the fact that their suitability to tackle low-probability, high-impact events is different. According to these researchers, a critical step of risk management is risk assessment from the point of view of the event's likelihood and its impact. Hence, risk management fails to adequately deal with low-probability, high-impact events. Moreover, the authors consider that traditional risk assessment cannot deal with unforeseeable events. Consequently, they consider that

> *"…the concept of supply chain resilience can fill these gaps and supplement existing risk management programs, thus enabling a supply chain to survive unforeseen disruptions and create competitive advantage"* (Pettit *et al.*, 2013, p. 5).

One of the propositions in their research suggests that there is a link between each of the vulnerabilities in a supply chain and a specific set of capabilities. Developing these capabilities would ultimately create a state of balance between investment and risk that the authors call *"balanced resilience"* (Figure 4), through the reduction of what the authors call the *"resilience gap"* (Pettit *et al.*, 2013, p. 56):

> *"(the) imbalance from the theoretically optimal state of balanced resilience for each vulnerability/capability linkage."*

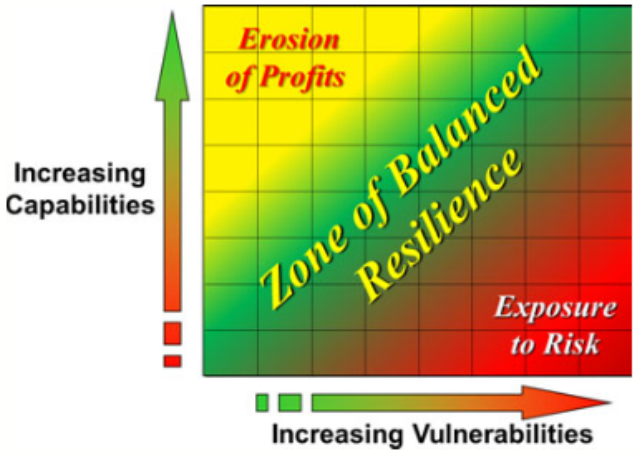


Figure 4 - Resilience fitness space (source: Pettit *et al.*, 2013, p. 47)

Blackhurst *et al.* (2011) also look at resilience as a means to reduce the likelihood and severity of supply chain disruptions, providing an in-depth systematic investigation of supply resilience. Based on empirical generalizations extracted from their multiple case-study research, these authors derive a set of what they call *"supply resilience enhancers"*, divided into three main categories: (1) human capital resources; (2) organizational and inter-organizational capital resources; and (3) physical capital resources. Conversely, the authors identify factors that can act as *"resilience reducers"*, factors that detract from supply resilience. The author's acknowledge that moderating the impact of these resilience reducers can sometimes be outside a firm's control, hence it could be more effective for firms to focus on developing resiliency enhancers (Blackhurst *et al.*, 2011).

The concern with building a resilient supply chain gained increased focus with the work of Christopher and Peck (2004a, 2004b) and their effort to build a framework for a resilient supply chain, but other constructs have been introduced by researchers throughout the years. Some of those constructs, although treated as secondary factors in the framework developed by Christopher and Peck, according to Pettit *et al.* (2010), are also inevitable in any discussion on supply chain risk management and, consequently, need some clarification for the purpose of this research.

Christopher and Lee (2004) suggest the importance of increasing confidence to better cope with supply chain risk. This added confidence depends on the ability to quickly adjust to

changes and to react to disturbances. Earlier, Christopher had already highlighted the importance of this ability as it focused on agility as an important way to ensure the necessary supply chain resilience: *"(…) the ability of an organization to respond rapidly to changes in demand, both in terms of volume and variety"* (2000, p. 38). Hence, agility is primarily focused on responsiveness to market fluctuations, it refers to the effort of *"being demand-driven rather than forecast-driven"* (Christopher *et al.*, 2006, p. 281). Faisal *et al.* (2006a) include agility in their list of enablers for supply chain risk mitigation. This list has already been referred herein:

- Information sharing
- Agility in the supply chain
- Trust among supply chain partners
- Collaborative relationships or partnerships
- Information security in the supply chain
- Corporate social responsibility
- Aligning incentives and revenue sharing policies
- Strategic risk planning
- Risk sharing in the supply chain
- Knowledge about various types of risks in a supply chain
- Continual risk analysis and assessment

In the context of supply chain risk management, and on a firm level, agility can be defined as

> *"(…) the capability of the firm, both internally and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions, contributing to the agility of the extended supply chain"* (Braunscheidel and Suresh, 2009, p. 119).

For the purpose of the present research this definition of agility will be adopted and the distinction between agility and flexibility is also recognized. This distinction has been made in the literature, considering that, although flexibility is a characteristic of agility (Christopher, 2000), the two concepts are distinct. Flexibility can be viewed as an internally focused competency that is antecedent to agility, which is externally focused (Braunscheidel and Suresh, 2009). Agility, rather than efficiency, has been established by research as one of the key characteristics of well-known successful supply chains such as Wall-Mart's, Dell's or Amazon's (Lee, 2004).

The ability to adjust to change calls for increased end-to-end visibility over the supply chain in order to be able to anticipate disturbances and to react accordingly (Christopher and Lee, 2004). The staggering increase in the use of the Internet to carry out day-to-day operations and the widespread deployment of enterprise resource planning solutions (ERP) has allowed speedier information transactions and added visibility and, consequently, a reduction of inaccuracy and redundancy (Narayanan and Raman, 2004; Tang and Musa, 2011). The importance of supply chain visibility is such that it is consistently ranked by practitioners as one of the most important issues in supply chain management (Francis, 2008). The literature offers different definitions of supply chain visibility but for the purpose of this research the definition suggested by Francis (2008, p. 182) will be adopted:

> *"Supply chain visibility is the identity, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events".*

Christopher and Holweg (2011), whose criticism of the traditional approach to supply chain management has been referred before, consider that structural flexibility is paramount to cope with the turbulence of the new reality that supply chains face. Before the evidence that current models for supply chain management were designed to cope with a reality that no longer exists, the authors call for a new approach to tackle turbulence: *"(e)mbrace volatility, do not fight it"* (Christopher and Holweg, 2011, p. 77). According to these authors, the traditional approach to supply chain management was based on control exerted over factors that produced variability. In this context, all efforts were focused on reducing cost through increased control This was the goal of operational practices, identified by the authors, such as lean, SIX Sigma, outsourcing and contract manufacturing and concepts such as vendor-managed inventory (VMI), collaborative planning, forecasting and replenishment (CPFR). Despite their potential to increase profits in a stable environment, as Christopher and Holweg (2011) argue, in a volatile environment, these forms of control introduce added rigidity, rather than the desirable flexibility, affecting performance. This new reality begs a new paradigm:

> *"We need a new mental model for how to deal with turbulence in the supply chain, by shifting away from a single-minded quest for efficiency to a balanced view on how to create adaptable supply chain structures"* (Christopher and Holweg, 2011, p. 70).

Christopher and Holweg (2011) stress the need to build structural flexibility into the supply chain strategy and present some guidelines for that effort. First, acknowledging that uncertainty cannot be changed, the authors remember that it is still possible to manage the exposure to the risks that uncertainty creates. Furthermore, they stress the importance of understanding the exact nature and impact of turbulence on the specific supply chain. For instance, do oil price swings affect the supply chain and, if so, what is their real cost impact? Which legs of the whole supply chain are affected? One final guideline derives from the authors' belief, based on previous studies, that the economies of scale argument should no longer be the overriding argument in determining supply chain decisions, due to their understanding that it is based on stability to realize the returns predicted. According to these authors, in a turbulent context, the economies of scale argument is overridden by the need to ensure

> *"the ability of the supply chain to adapt to fundamental changes in the business environment"* (Christopher and Holweg, 2011, p. 70),

in other words, structural flexibility.

The importance of the concepts discussed above and the awareness of the attention they ought to attract in supply chain management is noticeable in the literature. More than a simple frivolous quest for supply chain management, inspired by some sort of theoretical dilettantism, their impact on supply chain performance has been established by research. For instance, Wieland and Wallenburg (2012) try to go beyond what they consider a generalized belief in the literature that agility and robustness are equally important in improving the supply chain's customer value and business performance. Based on survey data collected from 270 manufacturing companies, these researchers show that there is strong support for that assumption. According to their conclusions, whereas agility has an indirect impact on business performance, which is mediated by the supply chain's customer, robustness has a strong positive direct effect on both the supply chain's customer value and business performance. Consequently, these authors suggest that a shift in the focus of attention of researchers and managers, who in the past

> *"(…) paid a lot of attention to agility, whereas robustness turns out to be the real driver of business performance*" (Wieland and Wallenburg, 2012, p. 898).

3.5.4 - Supply chain risk sources, drivers, disturbances and disruptions.

There is a number of terms that are frequently associated to the concept of supply chain risk and that are prone to confusion with that concept (Jüttner *et al*., 2003; Manuj and Mentzer, 2008b). One of those concepts is "supply chain disruption", the importance of which is related to the fact that planning and managing disruptions is currently deemed as a natural part of managing supply chains (Zsidisin et al., 2005). Svensson (2000) defined supply chain disruption as an unplanned event that may occur in the supply chain which might affect the normal or expected flow of materials and components.

Wagner and Bode (2008, p. 309) define supply chain disruption as a combination of

> *"(1) an unintended, anomalous triggering event that materializes somewhere in the supply chain or its environment, and (2) a consequential situation which significantly threatens normal business operations of the firms in the supply chain."*

In short, "*the situation that leads to the occurrence of risk*" (Wagner and Bode, 2006, p. 304). Supply chain disruptions can have their origin in areas that are internal to a supply chain or in areas that are external to it, but in either case they will lead to the occurrence of a risk (Wagner and Bode, 2006, 2008). However, the term disruption is also frequently replaced by terms such as glitch, disturbance, or crisis, according to the severity of its consequences (Wagner and Bode, 2006). Furthermore, the term disruption is also commonly used in the literature as a specific type of supply chain risk. In fact, disruption risk management is one of the topics that has become hot in supply chain management research and practice in the past decade and several authors have focused their research on supply chain disruption risk (among others, Norrman and Jansson, 2004; Kleindorfer and Saad, 2005; Craighead *et al*., 2007).

In order to avoid possible misunderstandings, the term disruption will be used solely to refer the disruption risk, and the term disturbance will be used whenever the situation to describe fits the concept of disturbance in Svensson (2002, p. 112):

"A disturbance is defined as a random quantitative or qualitative deviation from what is normal or expected. A negative consequence of disturbance refers to a deteriorated goal accomplishment in terms of economic costs, quantitative deviations - such as increased cycle times and down times - and qualitative deviations."

The term supply chain risk source is also commonly used albeit sometimes with different meanings. Jüttner *et al.* (2003) suggest that supply chain risk sources can be (1) external to the supply chain, (2) internal to the supply chain or (3) network-related. For these authors, the term "risk" is often mistaken by what are, in fact, risk sources and these are

"(…) the environmental, organisational or supply chain-related variables that cannot be predicted with certainty and that impact on the supply chain outcome variables" (Jüttner et al., 2003, p. 200).

Peck (2005) considers that risk sources can operate at different levels: value stream/product or process; assets and infrastructure dependencies; organizations and inter-organizational networks; environment. This author, however, uses the term driver and source interchangeably. Similarly, Jüttner *et al.* (2003) categorize risk sources as either environmental, network-related or organizational. Wagner and Bode (2006), consider that "supply chain risk source" is a label often given to the derived classes of supply chain disruptions. Wagner and Bode (2006), on the other hand, incorporate three types of supply chain risk sources in their research: demand-side, supply-side, and catastrophic. These authors consider (citing Kleindorfer and Van Wassenhove, 2004, and Sheffi, 2005) that

"(…) demand- and supply-side risks belong unquestionable to the most important issues in supply chain risk management and are therefore of high relevance for practitioners (…) and catastrophic risks are currently very topical and receive ample attention" (Wagner and Bode, 2006, p. 302).

Some factors may have a significant impact on the risk exposure of a supply chain, affecting either of the two dimensions (or both) exposure to the consequences of risks: likelihood and consequences. The term "driver" has been introduced to distinguish those factors (Ritchie and Brindley, 2007b). These vulnerability factors often result from supply chain management decisions taken with a view to increasing supply chain efficiency, competitiveness and profitability. Such

decisions are materialized through the implementation of modern supply chain management practices, often considered best practices, but these competitive pressures often become risk drivers or calculated risks (Svensson, 2002). The literature on supply chain risk has identified trends in supply chain management that can be considered as drivers of the risk levels. These trends have already been alluded to herein and have been summarized by Pfohl *et al.* (2010): globalization, outsourcing, centralization, lean processes, complexity, IT-dependence, deficits of information. Thun and Hoenig (2011), in their research based on a survey with 67 manufacturing plants in the German automotive industry, asked managers to give their estimations about the key developments driving supply chain risks and depicted the results in Figure 5.

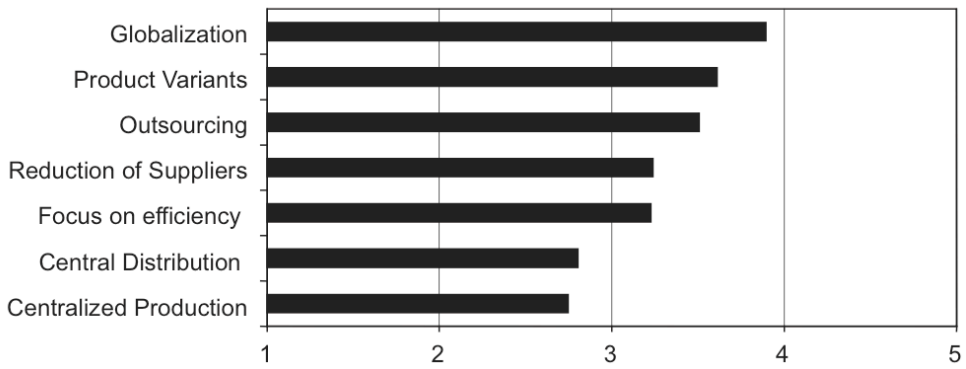


Figure 5 - Drivers of supply chain risks (source: Thun and Hoenig, 2011, p. 246)

Ritchie and Brindley call "drivers" the sources and causal pathways of risk, explaining that they relate to

> *"(…) the nature of the event and the sources and causes that generate it, influencing the likelihood of it occurring and the scale of the consequences or outcomes"* (2007b, p. 306).

These authors identify risk drivers as factors with a significant impact on risk exposure, but also as factors providing an opportunity to improve performance. This will be the meaning of risk driver in this research.

3.5.5 - Supply chain risk management

No manager can expect to totally eliminate risks from his supply chain, however every manager is expected to tackle those risks by setting up strategies that take into account the variables related to those risks (Faisal *et al.*, 2006). Therefore, managers tend to recognize the importance of managing risks as demonstrated by Green (2004) who reported, ten years ago, before most of the great scale natural disasters of this XXIst century, that about 28% of some 600 CFOs, treasurers and risk managers at the 1,000 largest companies in North America and Europe viewed a disruption to their supply chains as being the biggest threat to the company's revenue. Hence, risk, risk perception and risk management are acknowledged as critical in management and strategy research (Das and Teng, 2001). However, there is not a generally accepted definition of supply chain risk management. For instance, supply chain risk management is defined by Jüttner *et al.* (2003) as the process of identification of risk sources and the implementation of adequate risk mitigation strategies, through the coordination of supply chain actors, with a view to reducing supply chain vulnerability.

A report by the School of Management of Cranfield University on Supply Chain Vulnerability (Cranfield University - School of Management, 2002) had already suggested that supply chain risk management calls for a coordinated approach with a view to reducing supply chain vulnerability, defining supply chain risk management as

> *"(…) the identification and management of risks within the supply chain and risks external to it through a co-ordinated approach amongst supply chain members to reduce supply chain vulnerability as a whole."*

E-business is a key enabler to achieve supply chain coordination and integration, allowing supply chain actors to benefit of added visibility across the extended network and the possibility of quicker responses to change and to uncertainty (Cucchiella and Gastaldi, 2006). Norrman and Lindroth (2004) also highlight this collaborative approach in the application of risk management strategies to deal with uncertainty in the supply chain. In his definition of supply chain risk management, Tang (2006a, p. 453) adds the objective of ensuring profitability and continuity to this need for a coordination and collaboration approach:

"(…) the management of supply chain risk through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity"

According to Norrman and Jansson (2004), the focus of SCRM is to anticipate and avoid, as much as possible, the negative effects on the supply chain of both major disasters and minor disruptions. The primary goal of supply chain risk management is to reduce the probability of risk events occurring but also to increase supply chain resilience - "*the ability of a system to return to its original state or move to a new, more desirable state after being disturbed*" (Christopher and Peck, 2004, p. 2). This lack of consensus, the fact *"that there is much diversity in the scope including in definition of SCRM*", is also referred in Sodhi *et al.* (2012, p. 6). These authors attempted to define the scope of SCRM by focusing the concept of supply chain risk and SCRM in their focus groups. In short, when asked "what is SCRM?" over 33% of the respondents considered that it was *"Dealing with supply-demand stochastic (probability)"* and 31% said that it *meant "Dealing with risk within supply chain operations ".* To the question *"How is SCRM Different from Supply Chain Management?"*, more than 52% considered SCRM as a subset of SCM.

In spite of the diversity in the literature, there seems to be general agreement between different views in the literature as to what the risk management process should be, in the context of business management (Khan and Burnes, 2007). Risk management seeks to address the three dimensions of the risk construct that have been identified above: (1) likelihood of occurrence; (2) consequences; (3) causal path. It seeks to do so by analysing the sources and trying to understand the forces that determine a sequence of events that result in negative consequences. This analysis aims at discovering the adequate strategies to break or alter that chain of events, in order to keep that negative impact from happening or to reduce it, or, if such events are inevitable, to adopt measures to cope with them (Ritchie and Brindley, 2007b).

In the words of Borge (2002, p. 12)

"*The Holy Grail of risk management is to find the best possible decision to make when faced with uncertainty.*"

To achieve this goal, risk management must adopt a proactive approach rather than a reactive one, focusing primarily on avoiding risks, rather than on risk reduction that should come second (Kleindorfer and Saad, 2005) as a condition to reach the goal of risk management activities: reducing the frequency and impact of supply risks (Kern *et al*., 2012). As Ivanov and

Sokolov stress (2010, p. 82, citing Sheffi, 2005), the company's ability to cope with the consequences of disruptions depends more on what it does before those disruptions occur than on the actions it takes after their occurrence. It has also been repeatedly highlighted that supply risk management must go deep into the supplier base, beyond the company's operations and beyond the first few tiers of suppliers, therefore requiring collaboration between supply chain partners by sharing information and best practices (e.g., Colicchia and Strozzi, 2012):

> "*The focus is not on the focal company anymore, rather, a system-wide perspective involving networks of supply chains is adopted in order to increase value to all supply chain members and effectively handle the complexity of supply networks ...*"

This cross-company orientation distinguishes supply chain risk management from traditional risk management in general, as Thun and Hoenig (2011, p. 243) explain:

> "*A main particularity of Supply Chain Risk Management (SCRM) contrary to traditional risk management is that it is characterized by a cross-company orientation aiming at the identification and reduction of risks not only on the company level, but rather focusing on entire supply chains.*"

Bearing in mind the extreme diversity of interpretations that the many concepts have in the literature, it is important to settle the meaning of the key concepts, as they will be construed for the purposes of the present thesis. That list of concepts and their meaning as adopted herein is in Table 4. This list is not exhaustive because some other concepts will be introduced further ahead (e.g., the meaning of specific risks in risk classifications) as it proves adequate.

Table 4 - Definitions adopted.

Concept	Definition	Reference
Agility	"(…) the capability of the firm, both internally and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to marketplace changes as well as to potential and actual disruptions, contributing to the agility of the extended supply chain."	Braunscheidel and Suresh, 2009, p. 119
Demand risk	"...the distribution of outcomes related to adverse events in the outbound flows that affect the likelihood of customers placing orders with the focal firm, and/or variance in the volume and assortment desired by the 198 customer."	Manuj and Mentzer, 2008b, p. 199
Event readiness	The ability to face disruptions with effective responses that allow them to return to their pre-disruption state.	Ponomarov and Holcomb, 2009
Operations risk	"...the distribution of outcomes related to adverse events within the firm that affect a firm's internal ability to produce goods and services, quality and timeliness of production, and/or profitability."	Manuj and Mentzer, 2008b, p. 199
Risk drivers	"(…) factors with a significant impact on risk exposure, but also as factors providing an opportunity to improve performance."	Ritchie and Brindley, 2007b, p. 306
Risk management system	"(…) basically an action plan that specifies which risks can be addressed, and how to address them:"	Shi, 2004, p. 223
Security risk	"...the distribution of outcomes related to adverse events that threaten human resources, operations integrity, and information systems; and may lead to outcomes such as freight breaches, stolen data or proprietary knowledge, vandalism, crime, and sabotage."	Manuj and Mentzer, 2008b, p. 199
Supply chain disturbance	"A disturbance is defined as a random quantitative or qualitative deviation from what is normal or expected. A negative consequence of disturbance refers to a deteriorated goal accomplishment in terms of economic costs, quantitative deviations - such as increased cycle times and down times - and qualitative deviations."	Svensson, 2002, p. 112
Supply chain resilience	"(…) the ability of a system to return to its original state or move to a new one, more desirable state after being disturbed."	Christopher and Peck, 2004a, p. 2
Supply chain risk management	"On the identification and management of risks for the supply chain in order to reduce its vulnerability."	Jüttner and Maklan, 2011, p. 246
Supply chain robustness	"A system's ability to resist an accidental event and return to do its intended mission and retain the same stable situation as it had before the accidental event."	Asbjørnslett, 2009, p. 19
Supply Risk	"The probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety."	Zsidisin, 2003a, p. 222
Visibility	"Supply chain visibility is the identity, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events."	Francis, 2008, p. 182
Vulnerability	"An exposure to serious disturbance arising from risks within the supply chain as well as risks external to the supply chain."	Christopher and Peck, 2004a, p. 3

3.6 - Supply chain risk management process: suggestions in the existing literature

The risk management process is the sequence of stages that a company, or a supply chain, could follow to reduce supply chain risks (Vanany *et al.*, 2009). In order to successfully manage risk, different authors suggest different supply chain risk management processes with different stages. Highlighting the need for a network-wide perspective, Kiser and Cantrell (2006) suggest that a good risk management strategy must include several key elements:

- The identification of risks for the entire life cycle of every product or service the company provides;
- The ability to anticipate the possible impact of a supply disruption;
- Strategies to mitigate the effects of a supply disruption;
- An analysis that goes beyond the first tier of suppliers.

These authors suggest a six-step management process for supply risk management:

- Profile supply base;
- Assess vulnerability;
- Evaluate implications;
- Identify mitigation and contingency actions;
- Complete cost/benefit analysis;
- Gain management support and implementation.

Different researchers have identified these stages, but there is a great lack of consistency in the use of terminology. For example, while a considerable number of authors use the term risk analysis to identify a certain step of the risk management process, Sinha *et al.* (2004, p. 155) consider that

> "*(...) the purpose of risk analysis is to develop a structured way of defining, identifying, assessing, and mitigating the risks*".

Ergo, these authors consider risk analysis to be the whole risk management process and not just a part of it. Most scholars refer the same aspects in their proposed risk management processes, albeit with different wordings. For instance, White (1995, p. 35), referring to risk management in general, states that a review of the literature suggests a risk assessment process broken down into three stages (Figure 6):

"*(1) risk identification;*

(2) risk estimation; and

(3) risk evaluation ... ".

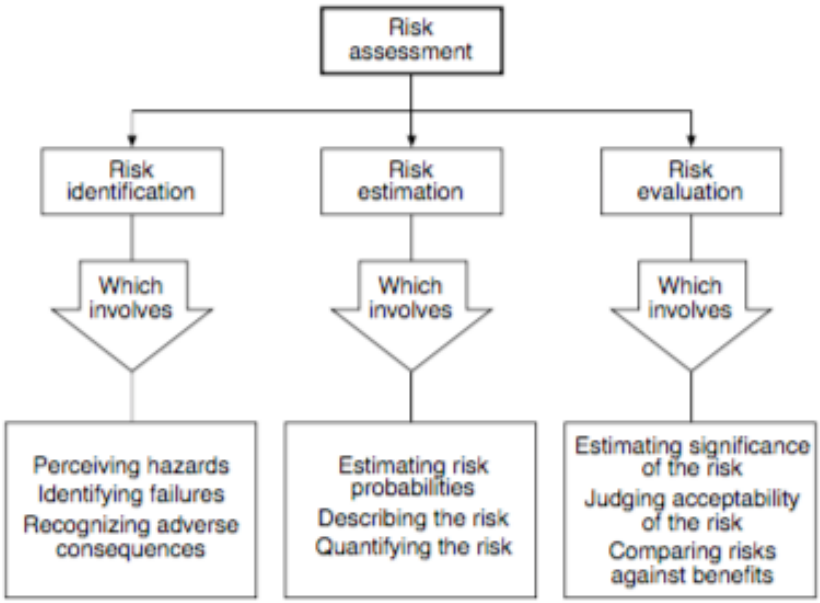


Figure 6 - The process of risk assessment (source: White, 1995, p. 36)

According to White, as it can be seen in Figure 6, risk identification involved perceiving hazards, identifying failures and recognizing adverse consequences; risk estimation implied estimating risk probabilities, describing the risk and quantifying it; and, finally, risk evaluation involved estimating the significance of the risk, judging its acceptability and comparing risks against the benefits (1995, p. 36). Although White refers only to the risk assessment process, the stages in which the author breaks down this process are frequently identified (despite differences in terminology) in the literature regarding supply chain risk management. For instance, Gaudenzi and Borghesi (2006, p. 116) identify four phases of the risk management process:

"*(1) risk assessment (which can be broken down into risk analysis and risk evaluation);*

(2) risk reporting and decision;

(3) risk treatment; and

(4) risk monitoring."

The first phase referred - Risk assessment - can be divided, as Gaudenzi and Borghesi refer, into risk analysis and risk evaluation.

Other authors identify these two moments as risk identification and risk assessment (e.g. Zsidisin *et al.*, 2005 although referreing to Business Continuity Planning in particular; Kern *et al.*, 2012). In their model for inbound supply risk analysis, Wu *et al.* (2006) split risk analysis into a greater number of components, using the term "risk calculation" instead of risk assessment, and identify four steps for the inbound risk analysis procedure:

- risk classification;
- risk identification;
- risk calculation;
- implementation / validation.

"Risk classification" is identified as the first step due to the importance that these authors place on its purpose: "*to get a collective viewpoint on a group of factors, which will help the managers to identify the group that contributes the maximum risk*" (Wu *et al.*, 2006, p. 351).

Based on the existing literature, Manuj and Mentzer (2008a, p. 143) propose a five step model for risk:

"*Step 1: Risk Identification*
Step 2: Risk Assessment and Evaluation
Step 3: Selection of Appropriate Risk Management Strategies
Step 4: Implementation of Supply Chain Risk Management Strategy(s)
Step 5: Mitigation of Supply Chain Risks."

The fact that there are different proposals in the literature for risk classifications has been discussed above and the most relevant proposals have been identified. In spite of the fact that some authors suggest risk classification as the first step for the risk management process, it is suggested that this does not seem adequate because risk classification can be a one-off step (without prejudice of the necessary revisions) and not really a step in the loops of the never-stopping risk management process. If, indeed, a classification must be adopted - either a specifically construed classification or an adopted one (and revised if deemed necessary) - it is not a recurrent step of the risk management process as the other steps are. Risk identification

would, therefore, be the first stage of the risk management process and this task can be performed with different tools, for instance using risk checklists and risk taxonomies (Adhitya *et al.*, 2009, p. 1449):

> "*Risk checklist is a list of risks that were identified on previous projects, and of- ten developed from managers' past in-house experience. The risk taxonomy provides a structure to organize the checklist of known enterprise risks into general classes.*"

Most techniques used in this stage are, in their nature, qualitative techniques (Vanany *et al.*, 2009). Lynch (2012) talks about the distinction between qualitative likelihood judgments and probability judgments based on calculations, stressing that neither is a perfect science but highlighting the extremely suspect nature of the former for its need for "organized guessing" and the fact that it is largely dependent on the manager's ability to imagine or willingness to manage.

Brainstorming is a technique commonly used by researchers to identify risks, frequently with the help of industry experts who offer their insights to the researchers (e.g., Hallikas *et al.*, 2002; Zsidisin, 2003b; Wu *et al.*, 2006;). Adhitya *et al.* (2009, p. 1449) identify other techniques used by companies for risk identification but they also stress their shortcomings:

> "*Risk identification could be done through 'stress testing', i.e., identifying key suppliers, customers, plant capacity, distribution centers and shipping lanes, and asking 'what if' questions to probe potential sources of risk and assess possible supply chain impacts. Role-playing or 'red-blue teaming' is a similar approach commonly used in the military. In this approach, a Red Team generates a set of scenarios that they believe can lead to serious disruptions. The Blue Team attempts to provide mitigation or countermeasures against the scenarios. These methods suffer the same shortcomings of checklists and taxonomies, they are ad-hoc and not systematic*".

Failure Mode and Effects Analysis (FMEA) is also frequently referred as a tool for risk identification (e.g. Sinha *et al.*, 2004; Khan and Burnes, 2007; Tummala and Schoenherr, 2011). This is the case, for instance, of White (1995, p. 36):

> "*Failure mode and effects analysis (FMEA) is essentially a systematic brainstorming session aimed at finding out what could go wrong with a system or process*"

However, as Christopher and Lee (2004) remind us, FMEA is a tool primarily of benefit within the business for the control of repetitive activities and several other tools or systems are suggested in the literature (for an overview of several of those systems, White, 1995). Together with FMEA, it is also commonly suggested (e.g., Tummala and Schoenherr, 2011), the use of Cause and Effect Analysis (CEA) – the well-known fishbone diagrams – to discover the root of the supply chain risk incident once the failure has been identified.

Risk identification, is critical to the risk management process because the identification of risks is a condition precedent to any subsequent risk management activity (Kern *et al.*, 2012). In this stage, all efforts are put into identifying all the possible "single points of failure (SPOF)" - as they are called in Lynch (2012) - that can potentially cause the collapse of the supply chain:

> "*A SPOF is invariably singular in physical ... or virtual location but when realized, can trigger systemic effects across today's globally interdependent, integrated, and highly-synchronized supply ecosystem. The repercussions extend far beyond the individual organization, in many instances to unsuspecting stakeholders along the chain such as an organization within that industry or the economic and social well-being of an entire country*" (Lynch, 2012, p. 320).

To identify these single points of failure a mapping of the possible events must be made, identifying sources of risk and risks, to determine which links in the supply chain could be a SPOF. In fact, Lynch (2012, p. 320) identifies this as the primary goal of supply chain risk management:

> "*The primary goal of supply chain risk management is to uncover, prioritize, measure, treat (mitigate and finance), and monitor the risk of these SPOFs; and to diminish the impact of an event through comprehensive and efficient resiliency practices*".

This step is equally critical in the sense that should the relevant risks fail to be identified their actual potential to harm the organization's supply chain would never be established until it was too late (Kern *et al.*, 2012). Its importance is also visible in the fact that Ghadge (2012, p. 324) identified the majority of papers (35%) written on risk management process to be focused on risk identification activity, although in the author's view this is "*a sign of the embryonic stage of research on supply chain risk management*".

Risk identification, according to Wu et al. (2006, p. 351), "*entails the enumeration of risk factors, is performed to be later categorized into appropriate branches in the classification system*".

Some authors consider risk identification as part of risk assessment (e.g., Ritchie and Brindley, 2007b; Paulsson and Nilsson, 2008) but risk assessment (also called risk calculation or risk evaluation, as referred above) aims at evaluating "*the factor's impact on overall risk*" (Wu *et al.*, 2006, p. 351) because to establish priorities "*risk has to be quantified through a disciplined risk assessment process*" (Kleindorfer and Saad, 2005, p. 54). As Kern *et al.* (2012, p. 64) clearly distinguish:

> "*The target of risk identification as we define it in our study is to identify as broadly as possible all potential threats and all relevant vulnerabilities within the upstream part of the supply chain. Risk assessment then aims at evaluating and understanding each risk in detail for its relevancy.*"

Risk identification and risk assessment are, therefore, two different steps. Together, they aim at preparing the company's "risk portfolio", the basis for the company's methodology to prioritize cost and risk elements to achieve a best-cost outcome (Manuj and Mentzer, 2008a). The identified risks are also the basis for the search of new risks, with the purpose of avoiding the inefficient use of the organization's resources. A totally undirected search for new risks would not guarantee that efficiency, hence the risk portfolio is used to define observation fields, to keep an adequate look-out for new risks with the least use of the scarce resources of the organization (Kern *et al.*, 2012). Risk identification is too important to be considered a part of risk assessment, as it is the very core of supply chain risk management:

> "*Supply chain risk management aims to identify the potential sources of risk and implement appropriate actions to avoid or contain supply chain vulnerability*" (Jüttner et al., 2003, p. 201).

The need for risk assessment or calculation, on the other hand, results, as explained, of the practical impossibility of managing all risks.

Ultimately, the goal of risk assessment is to reduce exposure to risk through a proactive attitude towards risk and to improve the way companies cope with risk (Van Mieghem, 2011). Therefore, risk assessment and evaluation (Manuj and Mentzer, 2008a), or risk calculation (Wu *et al.*, 2006), aims at providing the necessary in-depth information about a risk identified, in order to "*effectively avoid it, reduce its likelihood and impact, accept its occurrence or prepare contingency plans*" (Kern *et al.*, 2012, p. 65). Risk assessment can be defined as:

"*... the evaluation of the likelihoods and consequences of prospective risks, either by the use of frequency data or on the basis of expert judgments, scenarios and subjective probabilities*" (Knemeyer et al., 2009, p. 143).

This evaluation of likelihoods and consequences is based on either historical data or on subjective judgments, scenarios and probabilities (Knemeyer *et al.*, 2009). Therefore, risk perception is often a key driver of the risk management options that companies make and its importance is reflected on the fact that this is one of the most common issues under the spotlight in the literature (e.g. Das and Teng, 2001; Blackhurst *et al.*, 2005; Zsidisin, 2003b; Zsidisin et al., 2008; Ellis *et al.*, 2010). Manuj and Mentzer (2008a) also highlight the importance of risk perception when they identify three broad categories of risk assessment tools and frameworks: decision analysis and case study and perception based. According to these authors, historical data can be useful to understand the behaviour of risk distribution probabilities, although often times there is no historical support data, or the data available is unreliable or simply unusable. As an example of such a case, the authors suggest a case of a first time off-shoring manufacturing decision in which other methods will have to be used, as, for instance, the Delphi method referred by Manuj and Mentzer (2008a), which is considered a perception based technique (White, 1995).

An example of the use of a case study approach to developing a supply chain network risk tool can be found in Harland *et al.* (2003). Perception based risk assessment tools and frameworks can be useful when management has no historical hard data to build probabilistic models (Manuj and Mentzer, 2008a) and must decide on the basis of an intuitive understanding of the context which often the case of rare and extreme events. However, in general, expected value decision-making is misleading in these cases, due to the fact that it does not adequately capture this sort of events. This is argued, for example, by Aven (2010) who concludes that the probability component of the risk concept should be replaced by uncertainty. Hallikas *et al.* (2002) suggest a tool that considers risks in supplier networks analysing them divided in two of their commonly recognized dimensions: risk severity and risk probability. Thus classified, risks can be, from the point of view of their probability, very unlikely, improbable, probable, or very probable. According to the authors' classification, considering the severity of their impact, risks can be insignificant, minor, serious, or catastrophic.

March and Shapira (1987) have shown that managers are more susceptible to the magnitude of loss than to probability of loss and in extreme cases, executives completely discounted the notion of loss probability (Ellis et al., 2010). As Hauser (2003, p. 64) reminds us,

> *"Risk management in the supply chain does not equate to disaster response. Rather, it means keeping an increasingly process moving efficiently at the lowest total cost and without compromising the quality of the product or customer satisfaction".*

However, as referred before, Chopra and Sodhi (2004) sustain that most companies have plans to face recurrent low-impact supply chain risks whilst they ignore low likelihood risks with potentially high impact. This is a reminder that when using a subjective risk map it must be borne in mind, as Van Mieghem (2011, p. 22) highlights, that

> "*(t)he word 'subjective' reminds us that this risk map is based on expert opinion only and not on statistical analysis.*"

Hence, the aforementioned use of perception based risk assessment tools and frameworks, when management has no historical hard data to build probabilistic models (Manuj and Mentzer, 2008a), must pay due heed to the limitations of these tools. Be that as it may, one thing seems clear: despite the fact that risk assessment is generally accepted as fundamental, there is much debate regarding the different approaches, tools and techniques suggested to operationalize this step (Khan and Burnes, 2007). After discussing different points of view in the literature regarding the use of qualitative or quantitative techniques or measures, Khan and Burnes suggest that

> "*(…) top business leaders tend to prefer approaches to risk management which combine subjective and objective measures because this allows them some freedom of manoeuvre rather than being pushed into taking decisions based solely on numerical analysis*" (2007, p. 204).

Likelihood of an event occurring is typically expressed as a probability and it can be expressed in subjective or objective terms (Ritchie and Brindley, 2007a). Different authors use different scales to assess supply chain risks. The severity of the consequences can also be expressed in different scales and from different perspectives, for the impact of a certain event may be translated in different negative results, such as loss of sales and to the company's reputation due to a missed product launch (e.g., Apple's losses due to the delaying of the launch

of its iMac G5 and Sony's failure to launch the PS3 in Europe in time for Christmas, Sodhi and Lee, 2007) or the unnecessary cost as a consequence of the supply chain chaos originated by the well-known "*bullwhip effect*" (Childerhouse *et al.*, 2003). However, Hallikas *et al.* (2002) stress that it is essential that the assessment model of risks is simple, because the goal is not to provide an absolute value of risk, but rather to provide some guidance for the decision-making process with an estimation of the probability and the effect of risk based on subjective estimation. Hence, while some authors may use a scale of 1 to 5, to represent the magnitude of the impact and the likelihood of the risk (e.g., Hallikas *et al.*, 2002), others may use a fewer number of levels, such as simply "high" and "low" (e.g., Sheffi and Rice, 2005).

Once risk identification and risk assessment have been completed, they must lead to the choice and implementation of adequate risk management strategies towards the goal of reducing the probabilities of losses associated to the risks identified as critical (Manuj and Mentzer, 2008a). This stage depends on the adequate execution of the previous tasks, but those tasks are a pointless exercise if they are not followed by the selection of appropriate risk strategies to reduce the probability of, or losses associated with, adverse events. As Manuj and Mentzer (2008a, p. 136) assert, "*to manage global supply chain risk, companies need to follow a path from risk identification to strategies to deal with risks*". Whichever name this stage is given - *inter* alia, risk treatment (Gaudenzi and Borghesi, 2006), implementation / validation (Wu *et al.*, 2006), risk management (Zsidisin *et al.*, 2005), mitigation (Knemeyer *et al.*, 2009), risk treatment / management (Norrman and Jansson, 2004) - it focuses both on developing risk mitigation strategies and on deciding on those, in order to reduce the consequences if an adverse event is realize (Norrman and Jansson, 2004; Manuj and Mentzer, 2008a).

Although mitigation strategies could be critical for the survival of a company, in light of the consequences of potential disruptions, investment in mitigation planning needs adequate justification for the use of resources implicated (Stecke and Kumar, 2009). Arguably, investing in risk mitigation increases efficiency and to sustain this idea Stecke and Kumar (2009) identify several benefits of mitigation strategies, such as efficient production planning and forecasting, reduction in lead time and lead time variability and better inventory management. However, as these authors recognize, both the potential losses and the benefits can be hard to calculate (Stecke and Kumar, 2009). One simple way to ensure some protection is to keep high levels of stock. This however, is poorly though out strategy, as an interviewee in Manuj and Mentzer (2008b, p. 205) bluntly put it:

"Well I think the number one thing people would do is just put inventory in the system. So that's one, one almost no-brain approach to dealing with risk, just have a layer of inventory on the system."

Thoughtless use of added inventory is a costly way to afford some protection against supply disruptions but.

"*... while stockpiling inventory may shield a company against delivery delays by suppliers, building reserves in an undisciplined fashion also drives up costs and hurts the bottom line*" *and* "*(m)anagers must keep a vigilant eye on the trade-off between the risk and the cost of building a reserve to mitigate it*" *(Chopra and Sodhi, 2004, pp. 54 and 60).*

If the necessary cost/benefit analysis has been thoroughly carried out, risk management strategies should lead to reduction in loss, probability, speed, frequency, and/or exposure of risk events and thereby improve the supply chain outcomes (Manuj and Mentzer, 2008b). This thorough analysis is hampered by the fact that most managers are too conditioned by conventional crisis planning and find it difficult to anticipate unfamiliar risks but this added difficulty does not excuse companies for not making an effort to anticipate abnormal events, for instance through joint-thinking about random scenarios and event simulation (Mitroff and Alpaslan, 2003).

Several authors (e.g., Harland *et al*., 2003; Wu *et al*., 2006; Manuj and Mentzer, 2008a), as referred before, identify Implementation of Supply Chain Risk Management Strategy as a stage of the supply chain risk management process. Kiser and Cantrell (2006) include implementation in a two-fold stage - gain management support and implementation - an option that reflects the critical need for discipline, leadership and stakeholder commitment, within the company and across the supply network. Freedman (2003), among others, in his model of strategy process, has clearly made a point on the crucial role that implementation plays on the success of company strategies. At the same time, the author highlighted the importance of a set of activities deemed necessary for a successful implementation (2003, p. 29):

- Communicate the strategy
- Drive planning
- Align the organization
- Reduce complexity
- Install an issue resolution system

Some of these activities, in fact, are directly linked to supply chain risk strategies suggested by some authors. For instance, different researchers suggest flexibility as a supply chain risk mitigation strategy to cope with the consequences of complexity. Rice and Caniato (2003) and Sheffi and Rice (2005), for example, suggest two basic approaches when it comes to selecting countermeasures for supply chain risk: building either redundancy or flexibility. Increasing flexibility (*"being able to bend easily without breaking"*, Peck, 2005) is one way to manage complexity of supply chains and it is one of the five generic responses identified by Miller (1992) to environmental uncertainties, along with avoidance, control, cooperation and imitation. Recognizing the importance of strategy implementation, Manuj and Mentzer (2008b, p. 205) included it in their definition of global supply chain risk management:

> "*Global supply chain risk management is the identification and evaluation of risks and consequent losses in the global supply chain, and implementation of appropriate strategies through a coordinated approach among supply chain members with the objective of reducing one or more of the following – losses, probability, speed of event, speed of losses, the time for detection of the events, frequency, or exposure – for supply chain outcomes that in turn lead to close matching of actual cost savings and profitability with those desired.*"

The same authors identify a number of key enablers that affect strategy implementation, namely, organizational learning, information systems and performance metrics (Manuj and Mentzer, 2008a). Organizational learning is achieved, for instance, through the promotion of continuous analysis of improvements and of mistakes made, through seeking feedback and ensuring communication and through transfer of knowledge across the supply chain. Information technology has a fundamental role in risk management. First and foremost, due to the fact that it is a process that is supported by intensive use of data, relying on information technology to provide and filter that data, but also because the way that managers implement supply chain risk management strategies can be considerably affected by metrics used to assess their performance. Metrics that focus on the achievement of objectives irrespective of the risk will drive managers towards neglecting supply chain risk concerns but information technology may ensure greater transparency to managerial performance.

Some authors (e.g., Kiser and Cantrell, 2006; Manuj and Mentzer, 2008a; and Gaudenzi and Borghesi, 2006, who call it risk treatment) identify a stage of the risk management process that

refers to the mitigation of risks. In this stage, companies will make plans to cope with risks that may not have been avoided, despite the risk management strategies implemented. Thus, a distinction can be made between preventive strategies and mitigation strategies, to cater for the cases in which events can materialize into unforeseen losses despite all efforts to anticipate them with the focus on preventive actions (Pujawan and Geraldin, 2009).

Finally, some authors (e.g., Bandyopadhyay *et al.*, 1999; Norrman and Jansson, 2004; Cucchiella and Gastaldi, 2006; Gaudenzi and Borghesi, 2006) add a risk monitoring stage to the risk management process. According to Bandyopadhyay *et al.* (1999), referring to risk management of information technology, risk monitoring evaluates the performance of risk-reducing measures and performes a continuing audit function, ensuring that effective risk control counter-measures are adequately implemented. In this stage,

> "*(...) managers should focus on the uncertainties that are weather (sic) in consistent with predictions or not. So that the decision makers will know when to implement or abandon the options that were built into (the) system*" (Cucchiella and Gastaldi, 2006, p. 717).

This need for constant risk monitoring - that Manuj and Mentzer (2008a) also acknowledge, when they refer to the need for constant feedback on the strategies implemented - is essential to ensure continuous improvement as even well drafted and implemented risk management processes may lose their efficiency to face the ever changing circumstances in which global supply chains operate. Even after an episode in which a risk has been successfully mitigated, continuous monitoring is vital to ensure the control of that risk, to analyse the effectiveness of the applied mitigation strategy, to adopt new measures or adapt the previous ones and to do it all across the supply chain in a joint-learning process based on previous experience (Giunipero and Eltantawy, 2004; Norrman and Jansson, 2004; Craighead *et al.*, 2007). Therefore, the need for constant monitoring has been stressed in the literature by often cited researchers such as Hendricks and Singhal (2005b) and Kleindorfer and Saad (2005).

Despite the different definitions of supply chain risk management, the differences between several frameworks in the literature and the different stages that those frameworks identify, it is submitted that most of the differences concerning the different stages of the risk management process refer to form rather than substance and that the substance is captured in the definition given by Shi (2004, p. 223) who says that a risk management system is "*basically an action plan*

that specifies which risks can be addressed, and how to address them". In essence, the different risk management process stages suggested contemplate a number of concerns that are reflected in the classification that Sodhi *et al*. (2012) suggest for the existing literature on supply chain risk management when they classify it according to four key elements for managing supply chain risks, namely: risk identification; risk assessment; risk mitigation; and responsiveness to risk incidents. As referred by Wu and Blackhurst (2009, p. 9), supply chain risk management

> "*(...) represents the risk management response primarily to supply chain risks, although... it has a much wider influence at the strategic enterprise risk level.*"

3.7 - Supply chain risk mitigation strategies

The literature often distinguishes two different perspectives that derive from the fact that the occurrence of supply chain disruption introduces a change in the supply chain that demands specific action. Therefore, there are actions that are suitable in the context before a disruption happens and there are actions to be taken in the post-disruption period. This difference is on the basis of a distinction often drawn in the literature between two different systematic approaches: on the one side there is the need to identify potential disruptions, to assess their likelihood and impact in order to prioritize the use of resources to implement adequate management strategies; on the other, there is the effort to anticipate the actions suitable to manage disruptions once they have actually materialized. The first systematic approach matches the common focus of the different definitions of supply chain risk management such as the definitions mentioned above and, for example, the definition in Jüttner *et al* (2003, p. 201):

> "*Supply chain risk management aims to identify the potential sources of risk and implement appropriate actions to avoid or contain supply chain vulnerability.*"

The second systematic approach, which entails responding to a risk incident that has already occurred, is generally regarded as being within the domain of disruption management (also called event management) or business continuity (Sodhi and Tang, 2012). Business continuity, in the words of Norrman and Jansson (2004, p. 437) "*aims at getting interrupted businesses restarted*" and these authors add that

"*In many ways, risk management and BCM are overlapping, and some argue that business continuity plans development is the risk management action to take for risks of low probability (such as fires and floods), but whose potential impact is a business failure.*"

In this latter context, Business Continuity Management, the concept of supply chain resilience, discussed elsewhere herein, gains added relevance as it aims at developing the adaptive capability to prepare for unexpected events and to respond to disruptions and recover from them (Ponomarov and Holcomb, 2009, p. 131). The supply chain resilience perspective, in the words of Jüttner and Maklan (2011, p. 246), "*is based on the underlying assumption that not all risk events can be prevented*". In spite of their differences, these two systematic approaches must be adopted to ensure effective disruption management, which is materialized in the adoption of strategies that anticipate disruptions. This effective risk anticipation prevents most disruptions from happening, but, as explained before, due to the scarcity of resources, managers must prioritize risks and determine which disruptions will they try to avoid and which will they rather take their chances with. This is the reason why, as Tomlin (2006) suggests, for rare disruptions one might expect managers to adopt contingency tactics to face contingency costs that only exist if the disruption does happen. This acceptance of risks explains why what companies do after a disruption is just as important as what they do before the disruption, as they cannot avoid, or try to avoid, all risks, they must ensure that they have the right tools to deal with the consequences of a disruption that has happened.

Although some researchers have focused on the post-disruption reaction (e.g., Blackhurst *et al.*, 2005), considerable more attention is given in the literature to supply chain risk management strategies, and several often cited analysis have their focus on the pre-disruption approach (e.g., Hallikas *et al.*, 2004; Norrman and Jansson, 2004; Wu *et al.*, 2006; Manuj and Mentzer, 2008a; Knemeyer *et al.*, 2009; Harland, 2013).

The purpose of any supply chain risk management process is to effectively avoid or, at least, reduce the negative consequences of the occurrence of supply chain risk. Consequently, setting up a number of risk management strategies designed to achieve that goal is a crucial task for management, one upon which all hopes for the company's survival may rest. For this reason, the choice of adequate strategies is critical and it is of utmost importance to have a clear notion of the available strategies, their applicability and their reach. With this concern in mind,

researchers have put great effort into describing and categorizing supply chain risks and supply chain risk mitigation strategies (Hopp *et al.* , 2012).

Some authors highlight generic strategies to face supply chain risks. Examples of such "*holistic risk mitigation*" strategies (Ghadge *et al.*, 2012, p. 324) are: increasing agility (Christopher, 2000); increasing visibility (Chopra and Sodhi, 2004); using redundancy to accommodate supply chain variability (Tomlin, 2006); both increasing flexibility and using redundancy (Sheffi and Rice, 2005); reducing uncertainty and complexity (Christopher, 2000; van der Vorst and Beulens, 2002); implementing collaboration relationships between supply chain actors (Sinha *et al.*, 2004); and promoting supply chain alignment (together with agility and adaptability - the "*Triple-A supply chain*", Lee, 2004). Some of the generic strategies referred are closely associated to the fact that the complexity of the supply chain network often determines its vulnerability (Neiger *et al.*, 2009).

Several authors, on the other hand, suggest different classifications of specific risk management strategies. However, even the expression "risk management strategies" is not universally used. For instance, Elkins *et al.* (2005) list 18 "*best practices*" (rather than strategies) to deal with risk, suggesting, however, that companies could use their list as a "*thought-starter*" to establishing priorities in the adoption of the most rewarding best practices. Extreme diversity is, therefore, a characteristic of the extensive list of strategy classifications in the literature, including classifications as long as the 22 strategies ("*or... generic risk handling methods*") for risk mitigation list of alternatives suggested by Paulsson and Nilsson (2008). Basically, however, risk management strategies can be included in one of three approaches: *accept, avoid* or *mitigate* risks (Sodhi and Tang, 2012).

Accepting a risk, as Sodhi and Tang (2012) explain, means that the company simply decides to bear the consequences of the risk. Frequently, though, this acceptance is, in fact, a deflection of that risk, or part of it, to a second party, namely an insurer or another actor (purposefully avoiding the term "*partner*" used by those authors) of the supply chain. As the authors also recall, shifting risk to another supply chain party or to an insurer does nothing to reduce the likelihood of the risk in the supply chain. In fact, it may induce a risk-prone behaviour of the company, thereby increasing the risk exposure of the supply chain. Furthermore, it must not be forsaken that the consequences of dumping risk to another supply chain member may bounce back to the company *via*, for instance, the supplier's failure to meet contractual obligations, the increase of

costs being carried along the supply chain, quality or even safety issues affecting consumers with a detrimental effect on the company's reputation.

Organizations choose *avoiding risks* when they try to prevent risk events from happening (Sodhi and Tang, 2012). To achieve that goal, they adopt strategies of preventive nature, fail-proof systems to prevent incidents. As an example, Sodhi and Tang (2012) refer the Container Security Initiative (CSI), already mentioned herein, implemented by the U. S. Homeland Security, in the wake to the 9/11 attack on the twin towers, which forced maritime ports across the world to install x-ray scanners for shipping containers bound to the United States of America. Some authors refer "*Avoidance*" as a specific risk management strategy. For example, Jüttner *et al.* (2003, p. 206) refer avoidance as "*dropping specific products / geographical markets / supplier and / or customer organisations*". Manuj and Mentzer (2008b, p. 211) on the other hand, also refer this strategy but distinguish what they call avoidance strategies "*Type 1*" and "*Type 2*":

> "*Avoidance strategy Type 1 is geared toward driving overall probabilities associated with risk events of a decision to zero by ensuring that the risk does not exist. In avoiding risks, managers are aware of the supply-demand and/or operating trade-offs associated with the options and choose to avoid or drop some of these risks.*
> *Avoidance strategy Type 2 takes the form of preempting adverse events... In avoidance strategy Type 2, reducing the frequency and probability of a risk event is of concern. This usually arises when managers have no option but to venture into high uncertainty demand or supply markets*".

Finally, if we understand the concept of risk mitigation as Sodhi and Tang (2012) use it, mitigating risks is all that the organization can hope to achieve when, despite whatever risk management strategies it has adopted, it fails to avoid a given risk event from taking place. While it is important to set up a preventive system of risk management strategies, it is also important to bear in mind the possibility of facing unexpected events (Manuj and Mentzer, 2008a). Thus understood, mitigating risks consists of an attempt to minimize the impact of a supply chain disruption should that disruption actually occur (Sodhi and Tang, 2012). Using the words of Sarathy (2006, p. 31)

> "*Mitigation can consist of attempting to reduce the damage caused by supply chain disruptions, or taking actions to prevent or reduce the chance of supply chain disruptions...(it)*

can range from designing and maintaining back-up systems in reserve and developing response plans for worst-case scenarios, to rethinking product design, redesigning supply chains, and focusing on loss avoidance rather than mitigating losses..."

Sodhi and Tang (2012) suggest three broad risk mitigating strategies: alignment of supply chain incentives across the supply chain, flexibility and building "buffers" or redundancies. Bearing in mind the purpose of risk management it should be no surprise that researchers tend to favour a proactive approach to risk mitigation, rather than a reactive one (Ghadge et al., 2012). However, if a given risk never does materialize - in a manager's perception - the investment that a proactive approach implies, with those broad risk mitigating strategies, is hard to justify (Zsidisin *et al*., 2000). Yet, the often-cited Philips/Ericsson case (Norrman and Jansson, 2004) has shown that there is much to be gained from adopting a proactive stance. The same conclusion is in Stecke and Kumar (2009) who, based on the analysis of catastrophe and economic data from different sources, overview a comprehensive set of mitigating strategies to reduce risk disruptions, stressing the importance of proactively managing, developing advance warnings and coping with catastrophes by identifying three categories of strategies: proactive strategies, advance warning strategies, coping strategies. These authors also favour a proactive approach to a reactive one, recognizing that, if feasible and cost permitting, companies should adopt strategies that can ensure that their supply chains are not affected by catastrophes. The proactive strategies suggested by Stecke and Kumar (2009) are:

- "*select safe locations*" - based on statistical information that can help to determine the likelihood of catastrophes for a given area;
- "*choose robust suppliers and transportation media*" - considering that a robust supplier is expected to be prepared to cope with disruptions and that a solid carrier is more likely to be able to face catastrophes successfully;
- "*establish secure communication links*" - which benefits communication across the global supply chains, thus ensuring speedy and accurate communication when facing threats;
- "*enforce security*" - which is particularly aimed at man-made threats to the supply chain;
- "*use efficient human resources management*" - which considers both the need to prevent workers from being threats themselves and the role of worker resilience, competence and experience in avoiding threats.

These authors consider "*advance warning strategies*" as a third category of strategies

beyond the usual dual classification proactive/reactive. The purpose of the strategies of this type is to provide the company some time to prepare to face the coming disruptions, in order to minimize their consequences. In short, they aim at providing useful foresight to adequately prepare for the impact of the disruption. Within this category, the authors include:

- "*enhance visibility and coordination*" - acknowledging the relevance of vertical coordination to help prevent disruptions and the role of supply chain visibility in forecasting disruptions;
- "*increased transportation visibility*" - to ensure updated information regarding transportation and to secure the inbound and outbound flow of goods;
- "*monitor weather forecasts*" - with an obvious purpose and oriented to one very specific type of risk;
- "*act according to terrorist threat levels*" - a strategy suggested mostly with the U.S. reality in mind and which, on the one hand, affords added security where this sort of risk is concerned and, on the other, helps the company to meet the legal requirements specific to the relevant threat level; and
- "*monitor trends*" - such as customer preference, technology, laws and regulation, with a view to helping the company to adjust to those trends with the desirable smoothness.

Finally, Stecke and Kumar (2009) also suggest a category of strategies that can be seen as reactive strategies and that these researchers call "*coping strategies*". These strategies are based on flexibility and redundancy, to balance disturbances on a given link or branch of the supply chain with other unaffected links or branches. The "*coping strategies*" that the authors identify are:

- "*maintain multiple facilities with flexible/redundant resources*" - benefiting of the low likelihood of the different alternatives being simultaneously affected;
- "*carry extra inventory*" - the already referred "*almost no-brain approach to dealing with risk*" (Manuj and Mentzer, 2008b, p. 205), can indeed be a strategic options in some instances, critically ensuring the continuity of operations in extraordinary circumstances as well as adequate response to ordinary demand variability;
- "*alternative sourcing arrangements*" - which, again, can be fundamental to secure supplies, accommodating product shortages from a given source with the use of alternative sources, as well as to respond to demand variability;
- "*flexible transportation*" - this can be fundamental for global companies for they are more exposed to transportation disruptions or the simple increased variability of transit times, often depending on alternative emergency solutions to secure their supplies;
- "*maintain redundant critical components*" - this is especially recommended when the

cost of maintaining those components is minimal when compared to the potential impact of not having them (the authors refer maintaining power generators as an example);

- "*standardize various processes*"- allowing for processes to be relocated at different facilities should one facility be affected by some sort of disruption;
- "*redesign products to pool risks*" - implementing postponement, benefiting from centralized inventories (although centralization of inventories may increase risk exposure);
- "*influence customer choice*" - through marketing efforts can be critical to make sure that a shortage is not felt by the customer;
- "*purchase insurance to cover risks*" - insurance protection against the consequences of disruptive events may afford the company some relief should the event occur.

This rather comprehensive classification suggested by these authors uses descriptive naming for the strategies, which can benefit an immediate understanding of their applicability from a managerial point of view, and it will be taken into account later herein.

Based on the analysis of risk mitigation strategies they found in the literature, Ghadge e*t al.* (2012) suggest two groups of generic strategies: reactive risk mitigation strategies and proactive risk mitigation strategies. The proactive strategies identified by these authors (Ghadge e*t al.*, 2012, p. 324) are:

- "*Supplier development/management: risk sharing through contract manufacturing, contractual governance, dual/multi-sourcing.*"
- "*Supply chain contracts: developing incentive contracts, mix and volume flexibility contracts for risk mutual benefits, VMI/buffer stock.*"
- "*Product/process management: product variety, postponement, product design and delivery management.*"
- "*Supplier relationship: supplier collaboration through improved confidence, cultural adaptation, continuous coordination.*"

However, most of the risks responses that these authors observed in their research had a reactive nature and were taken in response to either government regulations or other mandates. This observation led Ghadge e*t al.* (2012) to the conclusion that, for those companies whose reactions were driven solely by regulations or other mandates, the reason why that they had not yet faced a major disruption was sheer luck. As reactive strategies the authors identify:

- "*Contingency planning: strategic event management plan, enhanced flexibility in options.*"
- "*Disaster management: robust recovery, rebuilding of supply chain, resource utilization/ management, scenario analysis for future disruptions.*"
- "*Demand management: operational rerouting, shifting customer demand, dynamic pricing.*"

According to the findings in Thun *et al.* (2011) there is a greater use of preventive strategies among large-scale enterprises than among SMEs. Their research indicates that SMEs focus on reactive instruments such as safety stocks or overcapacities rather than on preventive instruments such as supplier with high quality or on-time deliveries. Larger companies, on the other hand, act on supply chain risks by trying to reduce the likelihood of the occurrence of incidents. There findings are consistent with the suggestion in Stecke and Kumar (2009), as referred above, that cost-related concerns determine the choice between proactive strategies, advance warning strategies and coping strategies:

> *"These companies might have more resources available to invest in capital-intensive instruments such as strategic supplier development or tracking and tracing. Furthermore, the level of understanding and implementation of lean production and management principles might be higher than in SMEs"* (Thun et al., 2011, p. 5520).

Tang, whose distinction between operational and disruption risks has been referred above, associated supply chain risks with four management areas that the author considered "*approaches... that a firm could deploy through a coordinated/collaborative mechanism*" (2006a, p. 453): supply management, demand management, product management and information management. Tang further suggests that these basic approaches could improve supply chain operations via different forms of coordination or collaboration:

- with upstream supply chain actors to ensure efficient supply of materials along the supply chain;
- with downstream supply chain actors to influence demand, with the same purpose suggested by Stecke and Kumar (2009) with their aforementioned "*influence customer choice*" strategy;
- modifying the product or process design to make it easier for supply to meet demand;
- reciprocally granting access to various types of private information that is available to

individual supply chain partners.

In Tang (2006b), the same author suggests the need for a set of "*robust strategies*" to motivate firms to secure their supply chains. Those *"robust strategies*" would have two purposes: they should help a firm reduce cost and/or improve customer satisfaction under normal circumstances; and they should enable a firm to sustain its operations during and after a major disruption. Nine robust strategies are identified:

- "postponement" - this strategy allows a supply chain to reconfigure the product quickly, in a cost-effective way, should the supply suffer a disruption;
- "strategic stock" - keeping stock in strategic locations (warehouse, logistics hubs, distribution centers) to be shared by multiple supply chain partners (retailers, repair centers) but without disregard for the financial impact of keeping extra inventories;
- "*flexible supply base*" - waving the benefits of a single supplier policy in favor of keeping alternative sources to secure supplies;
- "*make-and-buy*" - balancing the options for in-house and outsourced production, this strategy allows firms to shift production quickly should a supply disruption occur;
- "*economic supply incentives*" - by offering economic incentives to suppliers, the company can entice a greater number of suppliers into its qualified suppliers list, in order to have alternative sources, should the need arise;
- "*flexible transportation*" - adding flexibility can add robustness to the supply chain, this can be done either using, as suitable, multi-modal transportation, using alternative carriers and alternative routes;
- "*revenue management via dynamic pricing and promotion*" - through the use of this mechanism, often adopted for selling perishable products/services companies, companies can guide clients' purchase decisions towards products that are not affected by the disruption;
- "*assortment planning*" - a traditional strategy of brick and mortar retailers but also available to other channels retailers, that also guides clients towards products unaffected by a disruption that has occurred;
- "*silent product rollover*" - by slowly leaking new products to the market in a low-profile approach, companies manage to keep consumers unaware of the unique features of each specific product thus allowing them to choose the products that are available instead of those products that are out of stock or being phased out.

Miller (1992) identified five generic responses to what the author called "environmental uncertainties": avoidance, control, cooperation, imitation, and flexibility. For this author, avoidance

occurs when managers consider a given risk associated with a certain product or market unacceptable. This could mean deciding not to invest or postponing investment in, for instance, a certain geographic market, or even pulling out of a market where the company already operates. Some other uncertainties managers may opt to try to control. This is can be the case, according to Miller, when managers believe that those variables are susceptible of being influenced by their action and thus opt to try to influence those variables rather than just passively accept them as constraints that they have to cope with. As examples the author refers, among others, lobbying for or against laws or regulations, gaining market power, vertical integration to control supply or demand uncertainties or horizontal integration to control competition uncertainty. Cooperation, unlike control, involves some sort of agreement, such as long-term agreements with suppliers or buyers, setting up joint ventures or consortia, maintaining overlapping board membership, among other examples referred by Miller (1992). Companies sometimes resort to a strategy of imitation, in order to cope with uncertainty, when they follow the competition, especially the market leaders, in their strategic moves. Finally, increasing organizational flexibility is the fifth general strategy referred by the author who explains that "*flexibility responses increase internal responsiveness while leaving the predictability of external factors unchanged*" (Miller, 1992), for instance through product and geographic market diversification, through diversification of suppliers, by introducing changes that benefit the speed of design and manufacturing, making use of flexible and work force, among others.

For a supply chain to be able to absorb the changes caused by a risk event it needs to be flexible enough to quickly react through effective responses (Jüttner and Maklan, 2011). Even though traditionally, supply chain designs primarily focus on cost efficiency (Nahmias, 2009 *apud* Stecke and Kumar, 2009), increasing flexibility is a strategy that has frequently referred in the literature in the context of supply chain risk management since the days when the focus was still on efficiency. Back in the year 2000, Christopher (2000, p. 37) had already admitted that "*a key characteristic of an agile organization is flexibility*" and suggested postponement was one of the strategies to achieve the desirable flexibility, although this author's focus was on agility as a capability that companies needed to succeed in increasingly volatile markets and to cope with the risk of "*lengthy and slow-moving logistics pipelines*". In Christopher *et al.* (2006) it is further explained how flexibility plays a fundamental role in contexts where demand is volatile and the customer requirement for variety is high. In such contexts, lean supply chains face added risk exposure and a different approach is needed, based on agility, and that is to say based on

"*...the ability to match supply and demand in turbulent and unpredictable markets... (in) essence, it is about being demand-driven rather than forecast-driven*" (Christopher et al., 2006, p. 281).

It is a mix of lean concepts and of agility - with flexibility as its key characteristic - that equip the supply chain with the tools to face risk, or, as the authors say:

"*...the issue is not "Lean versus Agile" rather it is the judicious selection and integration of appropriate aspects of these paradigms appropriate to the particular supply chain strategy*" (Christopher et al., 2006, p. 281).

The issue of flexibility in the selection of counter-measures is further explored by Tomlin (2006, p. 640) who distinguishes between mitigation tactics

"*...those in which the firm takes some action in advance of a disruption (and so incurs the cost of the action regardless of whether a disruption occurs)...*"

and contingency tactics

"*...those in which a firm takes an action only in the event a disruption occurs.*"

This author focuses on the supply-side tactics available to a firm (i.e., sourcing mitigation, inventory mitigation, and contingent rerouting) and investigates six countermeasures that can be used isolated or combined: business interruption insurance protection, adding inventory, multiple-supplier sourcing, increased production or alternate route to market, and demand management. Throughout his analysis, Tomlin highlights the impact of flexibility in the reach of each of the counter-measures.

Also with a focus on flexibility, Tang and Tomlin (2008), suggest the development of mechanisms that take into account the "Triple-A" principles suggested by Lee (2004) - Alignment, Adaptability and Agility - to reduce the negative implications of certain undesirable events associated with supply, process, and demand risks. Consequently, these researchers focus their analysis on strategies that are based on the Agility principle and identify five basic flexibility strategies:

- Flexible supply strategy via multiple suppliers;
- Flexible supply strategy via flexible supply contracts;
- Flexible process strategy via flexible manufacturing process;
- Flexible product strategy via postponement; and
- Flexible pricing strategy via responsive pricing.

According to these authors, these are strategies that grant the necessary flexibility to supply chains, allowing the reduction of the negative implications of the occurrence of events associated with supply, process, and demand risks.

Picking up the concepts in Miller (1992), Jüttner *et al.* (2003) also identify flexibility as a generic supply chain risk mitigation strategy used by organizations, together with avoidance, control and co-operation. Based on the information collected in their research, these authors consider a strategy of avoidance in situations where there is risk associated to either specific products, suppliers, geographical markets or customer organizations. Their research also confirmed control strategies as most widespread amongst the organizations that the authors interviewed namely through the use of vertical integration, contractual requirements imposed on suppliers and maintaining excess capacity in production, storage, handling and/or transport. The authors also identify holding additional levels of stock as an example of a strategy of control while other researchers consider this as an autonomous strategy (e.g. Tang, 2006b) which indicates that different researchers identify strategies that are in their essence similar, despite the differences in their grids for formal classification of strategies. In their research these authors refer to co-operation in the supply chain as joint agreements with a view to enhancing supply chain visibility and understanding, to sharing information regarding specific risk sources and to prepare joint business continuity plans. Although they have identified these practices among the companies that they interviewed, they found them to be restricted to forms of co-operation with key suppliers. As examples of a strategy of flexibility, Jüttner *et al.* (2003) highlight postponement (as explained above), multiple sourcing (as a form of risk spreading) and local sourcing (favoured for its short lead times and potential for quick response solutions).

Based on the classifications of supply chain risk mitigation strategies in Miller (1992) and Jüttner *et al.* (2003), Manuj and Mentzer (2008a) classify risk management strategies into seven categories: avoidance, postponement, speculation, hedging, control, sharing/transferring, and

security. Avoidance is adopted as suggested by Miller (1992), it is used

> "*... when the risks associated with operating in a given product or geographical market, or working with particular suppliers or customers, is considered unacceptable... Avoidance may take the form of exiting through divestment of specialized assets, delay of entry, or participating only in low uncertainty markets...*" (Manuj and Mentzer, 2008a, p. 142).

However, as explained above, the same authors distinguish two types of avoidance strategy:

> "*(t)ype 1 avoidance strategy is adopted when a supply chain has an option not to enter a high demand or supply risk environment. Type 2 avoidance strategy is adopted when a supply chain has no option but to enter a high demand and/or supply risk environment*" (Manuj and Mentzer, 2008b, p. 211).

All supply chains, these authors explain, adopt avoidance strategies, although in different degrees depending on their available options, which explains the existence of those two different types of avoidance strategy. Through postponement, a strategy also identified by Manuj and Mentzer (2008a, 2008b), companies ensure the desirable flexibility through delaying the commitment of resources, thereby also delaying incurring costs.

Speculation, according to the authors (citing Bucklin, 1965), takes the form of decisions made on anticipated customer demand, by finishing goods at an earlier stage in order to gain economies of scale in either production, procurement or transportation, as well as to enhance the company's responsiveness to demand. As the authors stress, speculation - which is, to some extent, the opposite of postponement - depends on accurate demand forecasts to avoid becoming a waste of the company's resources. Hence, the authors' posit

> "*(s)upply chains facing low demand uncertainty are better suited to achieve the benefits of speculation*" (Manuj and Mentzer, 2008b, p. 208).

Speculation takes the form of actions such as maintaining forward inventory in specific markets, forward buying and early commitment to the form of a product, all in anticipation of future demand in order to limit the loss of consumer good will due to stock-outs (Bucklin, 1965, p. 27). In Manuj and Mentzer (2008a, 2008b), *hedging* means, in the context of global supply

chain risk management, creating different options for decision variables in order to split the odds of being affected by a single event. However, because a firm's exposure to risk is often extremely difficult to calculate, there instances in which there can be doubts as to whether a firm uses derivatives as a form of hedging risks or simply to speculate (Michel-Kerjan *et al.*, 2011, p. 11). To illustrate the concept of hedging, Manuj and Mentzer (at p. 209, citing Berger *et al.*, 2004) refer the case of dual sourcing used "*as a hedge against risks of quality, quantity, disruption, price, variability in performance, and opportunism*", and they also explain that

> "*(…) hedging is undertaken by having a globally dispersed portfolio of suppliers and facilities such that a single event (like currency fluctuations or a natural disaster) will not affect all the entities at the same time and/or in the same magnitude*" (Manuj and Mentzer, 2008b, p. 208).

Thus understood, hedging could probably be identified as "diversifying", one of the ten risk strategies identified by Borge (2002, p. 70): "*You diversify risk when you don't put all your eggs in one basket*".

Schlosser and Zsidisin (2004, p. 4), on the other hand, define *hedging*, in the context of risk of fuel surcharge price fluctuation, "*as using offsetting gains (or losses) in the futures market with rising (or falling) prices in the physical market*", considering the possibility of hedging using future contracts. However, using future contracts as hedging tools has some limitations, first and foremost the fact that not all products are traded in futures markets (Zsidisin and Hartley, 2012b). In such cases, cross hedging is an alternative strategy that is based on the use of futures of a commodity that is strongly related, in its price swings, to the commodity concerned (Zsidisin and Hartley, 2012b).

Moreover, using hedging as a risk management strategy involves some sacrifice because there is a trade-off associated to its use. Manuj and Mentzer (2008b) recognize this by stressing that hedging involves creating alternatives for decision variables, as referred above. Hence, it is an expensive management strategy and the authors use dual sourcing as an example, reminding that it involves more investment than single sourcing. This is one of the aspects that must be considered when trying to establish whether one should undertake hedging, as Okochi (2008, p. 44) warns, referring to commodity hedging:

"*(f)or starters, the cost of the hedging programme needs to be weighed against the benefit of the protection and impact to profitability. Commodity hedging can be expensive as the markets are very volatile these days and can be one-sided.*"

Even though hedging is a costly strategy, it is still less expensive than forward buying (a form of speculation) as the latter impacts the company's cash flow due to the fact that the company must pay the purchase upfront, while buying future contracts involves the payment of a percentage of the purchase price only (Zsidisin and Hartley, 2012). Nonetheless, Manuj and Mentzer (2008b) still propose that, in the context of supply chain risk management in general, due to its costs, hedging is a strategy more suitable for supply chains facing high risks, implying that there is a relationship between the degree of risk and the use of hedging. This relationship has also been suggested by establishing risk aversion as "*one of the main drivers for firms' financial hedging activities*" (Kouvelis *et al.*, 2011, p. 10).

Beyond the use of hedging to manage commodities price exposure, the following excerpt in Van Mieghem (2011, p. 16) provides a couple of good examples of hedging strategies and their benefits:

"*Strategic risk mitigation involves the structuring of global networks with sufficient flexibility to mitigate the impact of hazards. For example, BMW enjoys demand risk mitigation through its global operations network by building cars in Germany, Britain, the U.S., and South Africa. Out of the annual 160,000 Z4 roadsters and X5 sport "activity" vehicles built in 2003 in its Spartanburg, South Carolina plant, about 100,000 were exported, mostly to Europe. At the same time, BMW imported about 217,000 cars from Europe to reach annual U.S. sales of about 277,000 cars.*

Partial balancing of flows through global manufacturing networks such as those of BMW or DaimlerChrysler's service networks (e.g., large consulting and accounting companies) can also mitigate currency exchange risk. For example, Michelin, the world's biggest tire maker, drew 35% of its 2003 annual sales from North America. While this would normally expose the French company to dollar-euro currency exchange risk, Michelin was not worried about exchange rates. They compensated for the loss caused by translating American revenues into euros by purchasing raw materials that are priced in dollars.

In contrast, companies like Porsche, which builds cars mostly in Germany, must raise local prices to make up for currency changes (a dangerous approach that almost wiped Porsche out in the U.S. in the early 1990s). Otherwise, it must absorb the changes in the form of lower

profits, or may resort to financial hedging..."

Manuj and Mentzer (2008a, 2008b) also identify *Control/share/transfer* of risks as risk management strategies. *Control* is frequently reinforced through integration, as the investigation carried out by these authors has shown. This integration can be either horizontal or vertical and the company can make use of vertical integration either by adding assets (i.e. stakes in other companies) upstream or downstream, thereby addressing supply risks or demand risks, respectively (Manuj and Mentzer, 2008b). The authors also identify some examples of links between certain types of risk and the different forms of integration referred (e.g. the risk of supplier opportunism and vertical upstream integration) and refer some of the disadvantages of vertical integration, such as the impact on the available capital. *Sharing* and *transferring* risks through the use of outsourcing or the use of adequate contractual clauses are common alternatives to control that Manuj and Mentzer refer.

To the generally recognized advantages of the use of well-specified contracts (e.g., Norrman, 2008, where examples of supply chain risk-sharing mechanisms are provided) the authors add the contractual sharing or transferring of risks as an alternative to the costly vertical integration, particularly relevant in fragmented supply chains. Finally, Manuj and Mentzer (2008b, p. 210) refer *Security* as a supply chain risk management strategy, including within its spectrum

"*information systems security, freight breaches, terrorism, vandalism, crime, and sabotage (...) to sort out what is moving, and identify unusual or suspicious elements*".

The existing literature is fertile in proposals for supply risk management strategies but, whichever list is adopted, care must be taken when it comes to choosing strategies due to the fact that some strategies may adversely affect others (Chopra and Sodhi, 2004).

3.8 – The contextual nature of supply chain risk

Along the literature review section, it has already been referred the importance of context when supply risk is considered and several examples of acknowledgment of that relevance have been cited. For instance, reference has been made to the framework proposed by Ritchie and Brindley (2007b) to explore the application of the concepts underpinning risk management in which these authors considered risk context and drivers as one of the five main components to a framework in managing supply chain risk. Furthermore, the authors concluded that there was a need for research to develop a broader spectrum of risk management tools that effectively addresses the diversity of issues and contexts (Ritchie and Brindley, 2007a). As it has been discussed herein and has been stressed, *inter alia* by Zsidisin (2003a), the very concept of risk varies, it often includes sources of risk and its impact and the need to understanding it has different scopes according to industry. The same relevance of context in the understanding given to risk concepts has been acknowledged by Jüttner et al. (2003). An example is the distinction between systematic and unsystematic risks: the same risk can be considered systematic in a given supply chain and unsystematic in another (Ritchie and Brindley, 2007b).

Given this contextual nature of risk in general and supply chain risk in particular, it is not surprising that there are countless examples of analyses that are focused on a problem within a specific context. Some examples of this are publications focusing on: external risks of global supply chains in the chemicals industry (Lu, 2015; Van Wyk and Baerwaldt, 2005); Financial Risk and Return across Grocery Supply Chains (Corstjens *et al.*, 2008); the impact of volatility in the European automotive sector (Childerhouse *et al.*, 2008) or the use of supply chain risk management strategies in the Indian automobile industry (Sharma *et al.*, 2014); managing disruptions in a retail supply chain (Oke and Gopalakrishnan, 2009); managing production outsourcing risk in the apparel industry (Kam *et al.*, 2011; Routroy and Shankar, 2014); a specific type of hazard (security) and its consequences (product recall) in a given industry such as the US toy industry (Hora *et al.*, 2011); in the aerospace industry (Sinha *et al.*, 2004); and on risk and resilience in the agri-food supply chain (Leat and Revoredo-Giha, 2013).

Others studies, although they do not purport to analyse a problem within a specific context limit their field research to a given context. There are several examples of this, such as: analyses limited to an industrial sector such as: in the auto/automotive industry (Blos *et al.*, 2009;

Schwartz, 2011; Svensson, 2004; Thun and Hoenig, 2011); in the electronics industry (Blos *et al.*, 2009; Sodhi and Lee, 2007); or in the food industry (Diabat *et al.*, 2012; Vlajic *et al.*, 2012).

This clearly shows the need to study the phenomena associated to supply chain risk in a contextual perspective. Factors relevant to risk that have an external nature are likely to affect firms regardless of their nature or sector. However, the intensity of its impact can be quite different, between the hiccup and total havoc, depending on the supply chain. Its configuration, the options made by the organizations in the supply chain, different exposure to different legal systems and so many other circumstances can make a difference:

> *"Industry specific supply chains may have different degrees of exposure to risks. A regional grocery will be less impacted by recalls of Chinese products involving lead paint than will those supply chains carrying such items" (Olson and Wu, 2010, p. 697).*

A context specific approach does not necessarily mean that a specific industry sector is used. It often means that a problem in analysed bearing in mind a specific reality, such as: a type of company as regards its size (Thun *et al.*, 2011); a geographical area (Lavastre *et al.*, 2012; Leat and Revoredo-Giha, 2013; Ruamsook *et al.*, 2009); a certain historical period or economical context (Blome and Schoenherr, 2011); a given organization (Nagali *et al.*, 2008); a specific model of a product such as the Boeing 787 (Tang and Zimmerman, 2009a, 2009b); a specific type of product such as pork meat (Leat and Revoredo-Giha, 2013) or oil (Cigolini and Rossi, 2010); or a generic type of product such as commodities (Cole and Kirwan, 2009; Zsidisin, 2005).

The relevance of context is clear from what has been said above and from all the examples in the literature. In the case of the present research, supply chain risk management is analysed within the context of commodities supply chains, more specifically in the context of steel supply chains. The reasons for the choice of this context have been explained before, in the motivation and in the research gap sections, but will become more perceptible in the following sub-section. Bearing the relevance of context in mind, any approach to supply chain risk management should be well aware of the risk of increased limitations to its findings if it chooses to generalize. The focus of this research on a certain context is, consequently, aligned with the option for context-based research that populates the literature on supply chain risk, but heed must be paid to the limitations inherent to this option.

3.9 - Risk in Commodities SCM in the literature

3.9.1 – The international trade of commodities and the international trade of steel

The reality of international commodities trade can be quite daunting, both to the layman and to the seasoned professional who is, despite his experience, a newbie to a particular commodity's trade. When it comes to futures markets specialists, the market participants can fall into one of the following categories: hedgers[7], speculators (trader)[8] or arbitrageurs[9]. For a distinction between these categories see, for instance, Fabozzi *et al.* (2008, pp. 5–6). Whichever category is concerned, from the point-of-view of an investor with an interest in futures markets, the simple diversity of commodities markets can be overwhelming, with a plethora of commodities in trading markets to choose from. This diversity, however, can be reduced for a number of reasons, particularly when it comes to "long hedgers", such as industry manufacturers, seeking to hedge increasing commodity prices (Fabozzi *et al.*, 2008).

In any case, where an investor is concerned, the core of an investor's relationship with commodities is dealing with – if not gambling on – their price swings. However, commodity price swings affect much more than investors in futures markets, as those swings take their toll on companies and households across the globe and this is true both for soft commodities, such as soybean, cocoa or sugar (generally, agricultural products and livestock) and for hard commodities, such as oil, gold, coal and iron ore. To make things worse, the fact that some commodities with important uses and no substitutes usually have low price elasticity of demand makes the international commodity markets the playground for speculators (Radetzki, 2008). Thus, it is not surprising that a commodity with low price elasticity demand is more likely to be

[7] "A market participant who has or will have a position in the cash commodity and who attempts to eliminate or reduce risk exposure by taking an offsetting position in the futures or forward market" (Lee and Lee, 2013, p. 97).

[8] *"Speculators represent the largest group in the futures markets (…) Contrary to the commodity producers or the manufacturing industry, which try to avoid susceptibility to unfavorable price developments, the intention of speculators is to take a distinct market position and speculate for a price change. To make a profit, speculators deliberately take on risk by betting on rising or falling prices. As opposed to hedging, speculation is subject to both huge gains and huge losses, since speculators do not hold compensating cash positions" (Fabozzi et al., 2008, pp. 5–6).*

[9] *"An arbitrageur is a speculator who attempts to lock in near riskless profit from price differences by simultaneously entering into the purchase and sale of substantially identical financial instruments" (Kaliski, 2006, p. 196).*

under monopolistic control by producers (Radetzki, 2008).

Steel[10] is a commodity that is produced by combining iron and another element. Ore is generally traded in one of four forms – fines, concentrates, lumps or pellets[11] – and its quality depends of different factors, including its source: for instance, despite the fact that they are in the top list of ore sources, ore from China and from Russia is generally considered of lower quality (Fish, 1995). Carbon steel, obtained by combining iron with carbon, represents approximately 90% of steel production (Warrian, 2012). When iron is combined with another product, and carbon is not the only possibility, the variations of the amounts of this other product added to iron determine different qualities of steel, such as its hardness. Steel is produced in two fundamental ways: either by using raw materials directly or by using steel scrap that is re-melted.

The past decades have witnessed a tremendous rise of global demand for commodities and a consequential skyrocketing increase of their prices. For example: between 2003 and early 2008, Uranium prices went from USD $7 per pound to USD $100 (Geman, 2009b); hot-rolled coil/sheet sold FOB by Japanese producers, mainly to Asian buyers, was sold at USD $550 per metric ton by the end of 2004 and 2 years later it was priced at USD $1000 ("Index Mundi," 2012). According to Radetski (2008, p. 40),

> *"(b)etween 1990 and 2005, demand for aluminum, nickel, and copper increased six- to eight-fold".*

This increase has been explained with the existence of a "super cycle" – "*a prolonged (decades) trend rise in real commodity prices, driven by the urbanization and industrialization of a major economy*" (Heap, 2005).

This "supper cycle" is demand-driven due to the intensive economic growth of Brazil, Russia, India and, especially, China, the four countries referred to as "BRIC" countries. China's extreme influence in commodity pricing can be guessed in the numbers referred by Fabozzi et al. (2008, p. 4) when these authors state that "between 2001 and 2005, China's demand for

[10] Notwithstanding the need to sufficiently describe the context of the steel industry, it is beyond the purpose of this research to provide a full account of the history of the steel industry, of its organisation and trading practices. For further information on these aspects, refer to the literature cited, particularly to the work of Warrian (2012) and Fish (1995).

[11] For a concise distinction of these basic forms of traded ore see Fish (1995, p. 67).

copper, aluminium, and iron increased by 78%, 85%, and 92%, respectively". Additionally, Figure 7 can give a clear view of the impact that China can have in the global market of any given commodity, in this case iron ore.

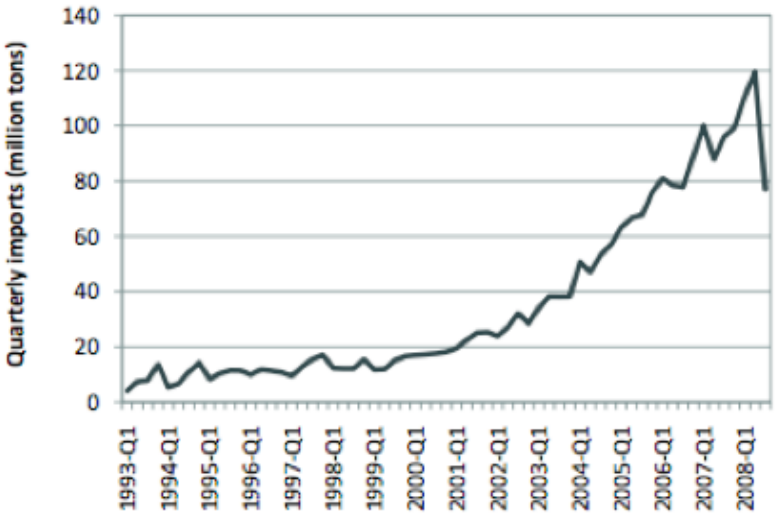


Figure 7 - Quarterly import of iron ore in China (source: Clarksons, 2008, *in* Wijnolst *et al.*, 2009, p. 31)

Even more striking is the fact that China alone accounts about 20% of the global demand for copper and other commodities (Heap, 2005). The response from the supply side has been to increase exploration expenditures with a view to increasing production. Yet, the increasing demand outpaces the results of the increasing exploration with an impact on costs and on production lead times (Heap, 2005).

Furthermore, increased global demand for energy has had a ripple effect on other soft commodities in different ways. On the one hand, using ethanol as an alternative fuel has diverted crops into ethanol production, rather than being used for foods and livestock feed, as well as it has reduced the availability of land for soy, barley, wheat and other crops. On the other, the energy price increase has had an impact on the shipping costs for these commodities, further increasing their price (Okochi, 2008).

The pressure on the shipping costs is also a consequence of the higher demand for freight,

as it has been demonstrated, for instance, by Poulakides and Joutz (2009) in relation to the impact of the increase of crude oil demand on the spot tanker rates. However, commodities demand is not the sole factor influencing available freight capacity, the pressure on freight rates and, consequently, shipping costs for commodities. As Stopford (2009, p. 162) explains,

> *"(t)he fleet supply function works by moving ships in and out of service in response to freight rates. If freight rates fall below the operating costs of ship 10, it goes into lay-up and supply is reduced by one ship. Ship 9 breaks even and the other eight ships make a margin over their fixed expenses, depending on how efficient they are (…) Over a longer period the supply can be increased by building new more efficient ships and reduced by scrapping old ones."*

Furthermore, as Stopford (2009) also explains in detail, it is the balance between new additions and the number of ships scrapped or lost that makes the growth rate of the merchant fleet. Amongst the factors that influence scrapping are current earnings and market expectations with direct impact on the ship-owner's expectations for future operating profitability of the vessel when opposed to scrap prices. Therefore, in times of increasing scrap prices - with scrapping industry pushing up its capacity (Strandenes, 2013) - and lower freight rates, when the owner believes that there is no prospect for profitable use of the older vessels in the near future, or when the owner in dire straits needs emergency liquidity, second-hand ship values will converge to scrap value and there may be an incentive to anticipate scrapping (Cullinane, 2005). Hence, in a context of freight capacity surplus and low freight rates, with part of the fleet in lay-up (typically the older vessels and the smaller ones first) and with increased scrapping rates, the freight rates may tend to recover.

Under the influence of several conditions, as exemplified, the cost of freight has an impact on commodities markets, even though the impact of shipping cost has dropped on the overall costs of commodities along the years as the following excerpt in Stopford (2009, p. 60) exemplifies in the case of oil transport:

> *"For example, in the 1950s the average cost of transporting a barrel of oil from the Middle East to Europe was 35% of its c.i.f. cost. As a result, oil companies devoted great effort to finding ways to reduce the cost of transport. By the 1990s the price of oil had increased and the cost of transport had fallen to just 2.5% of the c.i.f. price, so transport cost became less important."*

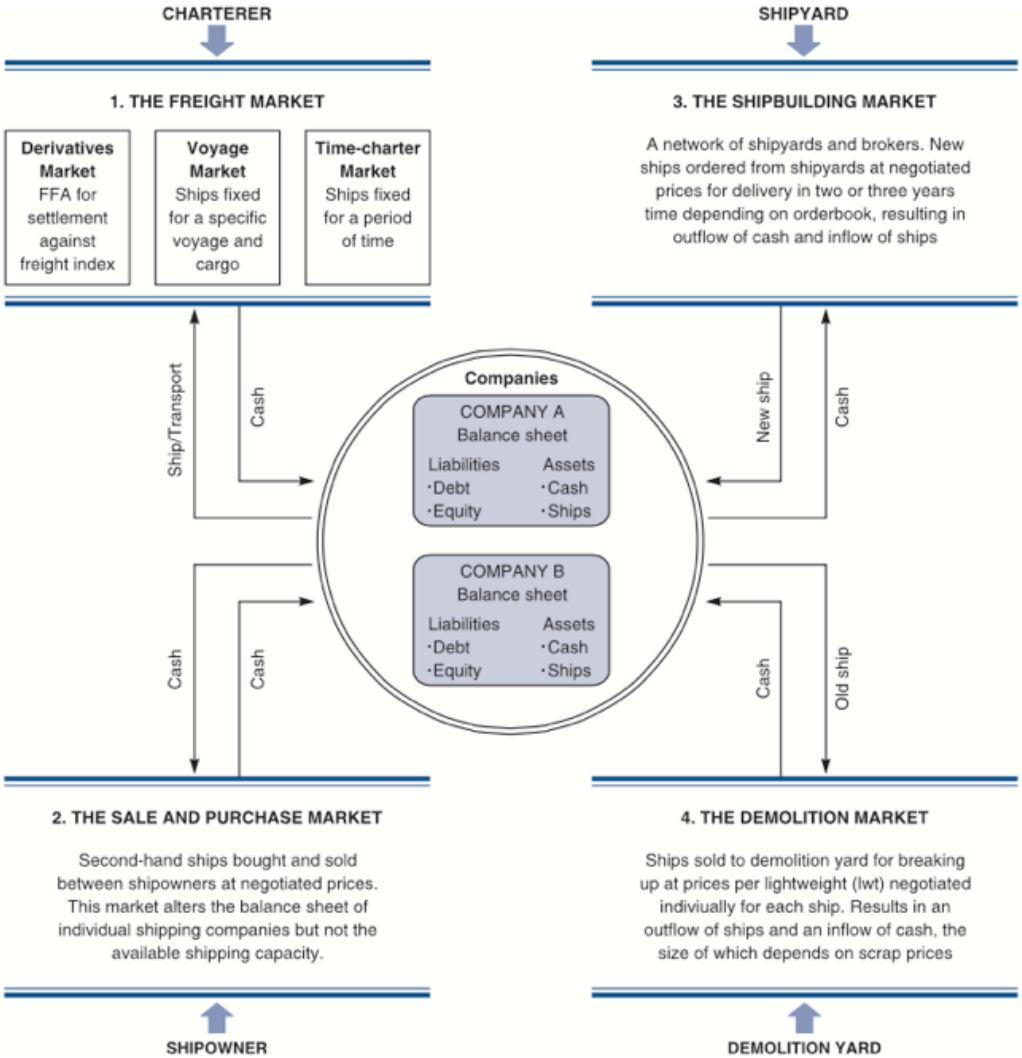


Figure 8 - The four markets that control shipping (source: Stopford, 2009, p. 179)

One aspect of the world steel trade is the fact that the main sources of good quality raw materials are often remote from the areas of steel production and this means that there will be great displacement of materials.

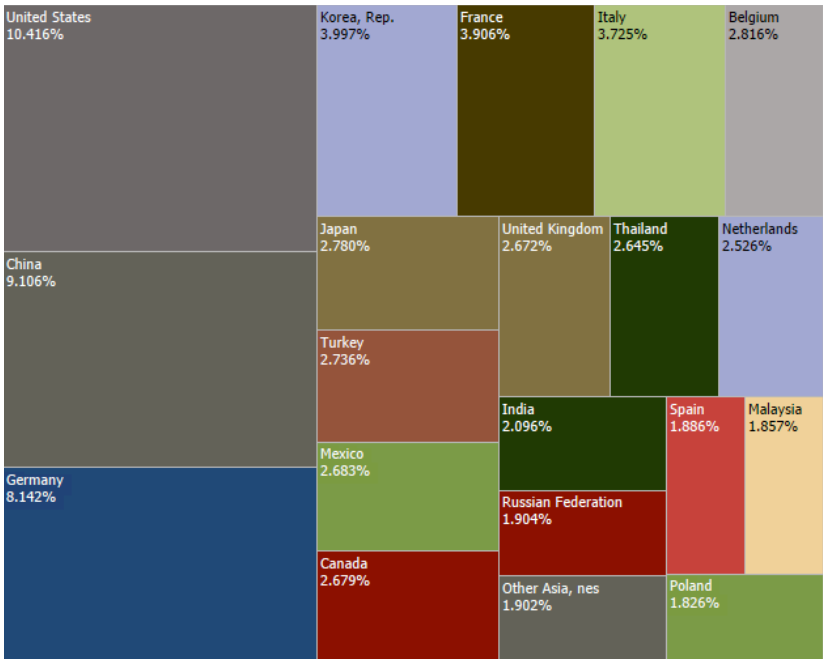


Figure 9 - Top 20 Metals Importing Countries in 2013, % of total volume (source: World Integrated Trade Solution - World Bank)

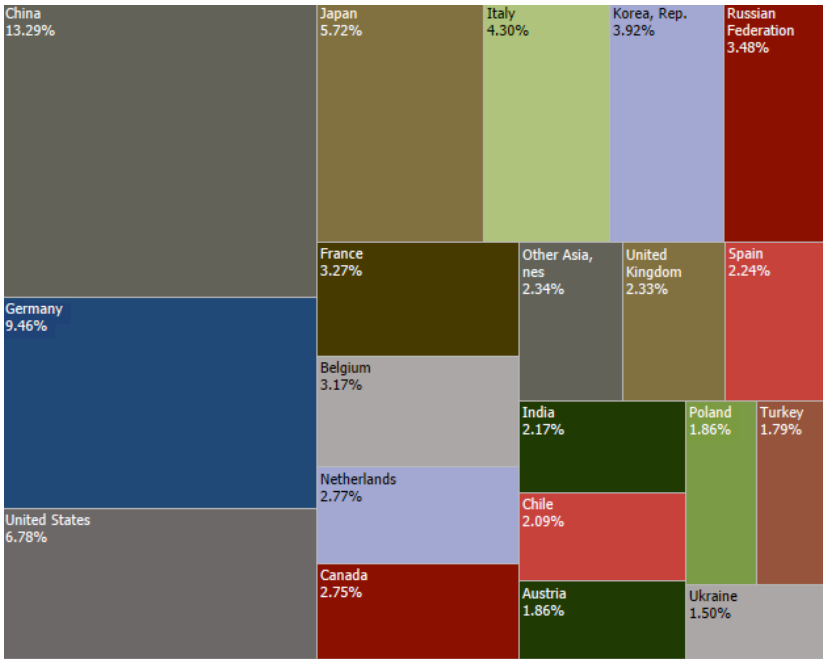


Figure 10 - Top 20 Metals Exporting Countries in 2013, % of total volume (source: World Integrated Trade Solution - World Bank)

With the newly developed countries becoming increasingly more used by companies who have off-shored their production, steel is needed where these manufacturing industries are located. This great volume of freight, however, is not bound to the developing countries alone as Figure 9 and Figure 10 clearly show as they highlight the level of concentration of exports and

imports of metals at a country level. It involves countries that used to be both coal and ore producers but, now that their natural resources have been exhausted, are left to a role of steel producers (Fish, 1995) and one of the best examples is the United Kingdom.

Unlike other sectors, the globalization process in the steel industry did not lead to a massive re-location to low-coast countries, mostly due to the fact that, through its technological evolution, the sector headed towards a relatively low share (approximately 15%) of labour in its total costs (Warrian, 2012). These changes have come about with globalization, which led to major changes in the steel industry, including changes of ownership of steel producing companies, which, in most cases, involved the internationalization of their ownership, and all sorts of possible consequences such as: the closing, the expansion and/or the specialization of some plants; technological changes; relative reduction of headcount and changes in the typical worker's skills profile; rationalization of capacity; export orientation of the industry; and, of course, the globalization of the industry's supply chains (Warrian, 2012).

From the point of view of the steel importer, trading in the world market is hardly a straightforward business. Buying locally usually makes it possible to place smaller orders to stockists or traders, whereas to buy in the international markets it is normally necessary to do so in larger scale (Fish, 1995). This is a double-edged sword, however, because it may represent a problem for smaller companies that may find it difficult to have direct access to the source and may be subject to the speculation of intermediaries. In a case that involves a storable commodity this exposure can be added because storability offers greater opportunities for speculation (Geman, 2009a; Radetzki, 2008).

On the other hand, buying in the international market carries along other sorts of difficulties. For starters, if larger orders must be placed, there will be added costs associated to the added stock volume, both in the warehouse and in transit, depending on the payment terms. Then, there are all the contractual, administrative and legal procedures associated to an international transaction, be that the customs procedures, the payment mechanisms, or the more complex transport arrangements. All this added bureaucracy engages human resources and requires specific skills that companies may be short of. To these disadvantages Fish (1995) adds the fact that steel mills tend to give priority to domestic customers for delivery and this adds up to all the possible causes for longer delivery times already associated to longer transits.

The XXth century, particularly during its second half, brought drastic drops to transport costs[12]. To cope with the Suez crisis in the 1950s, giant ships used to carry bulk cargoes of commodities around Africa brought about a revolution in commodities supply chains. As ships increased their size, infrastructures of the ports of call of these giants had to be adapted to receive their new visitors. Economies of scale in sea carriage brought transport costs down reducing their impact in the cost of commodities (Figure 11).

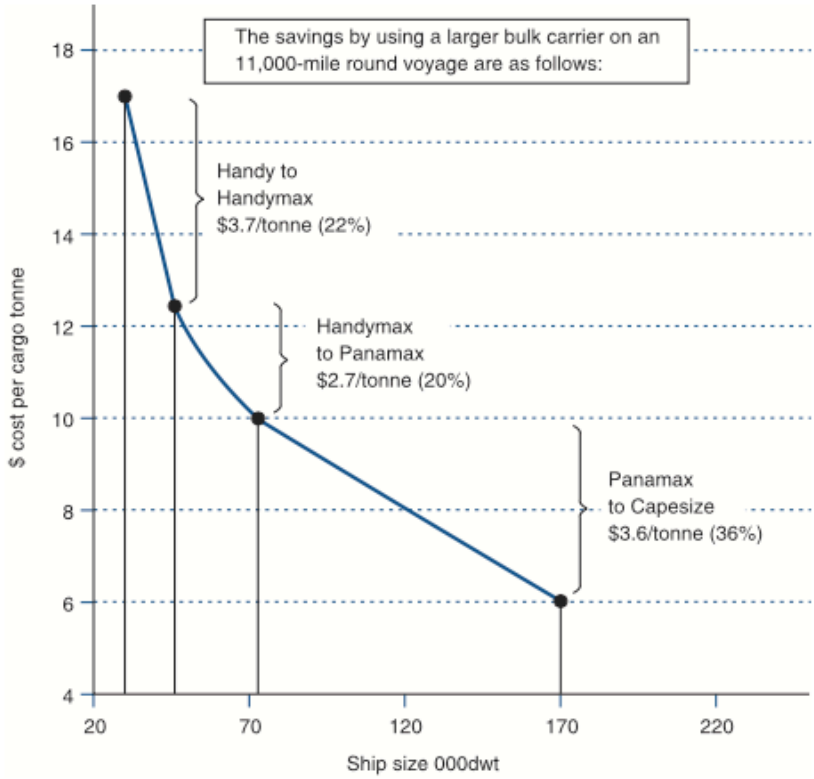


Figure 11 - Economies of scale related to ship size for bulk carriers, based on 11,000-mile round voyage (source: Stopford, 2009, p. 78, adapted)

The cheaper transport gave the world's industrial centres access to commodities in remote sources, contributing to the reduction of costs of raw material for processing industries. Furthermore, it shuffled the roles in the steel supply chain: as the introduction of these low-cost raw materials increased the pace of the growth of European industry, particularly the infrastructure and heavy industries, it also put a nail in the coffin of many European ore mining

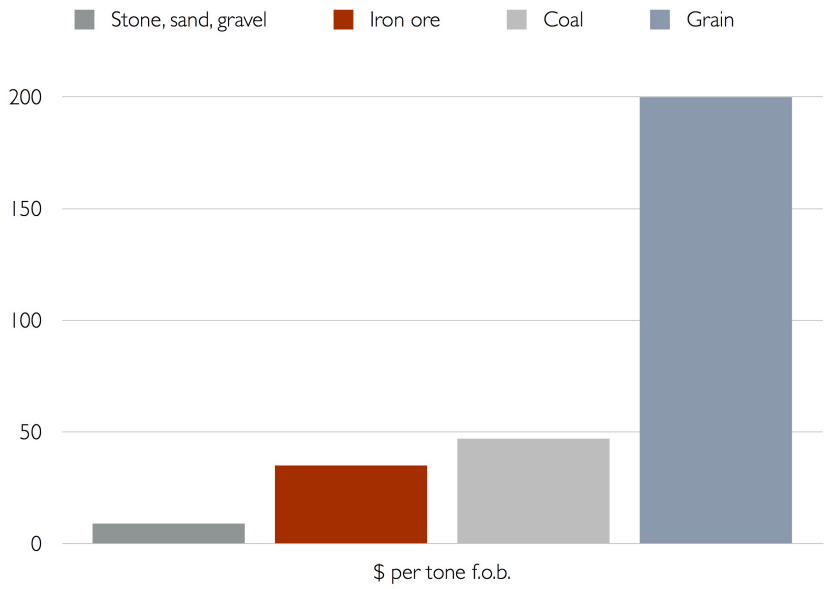
[12] For a concise overview and some figures of this evolution see, for instance, Radetzki (2008, pp. 12–15).

companies (Radetzki, 2008). Additionally, time would expose the added vulnerability of these reconfigured supply chains. Besides all the vulnerabilities discussed in Part 1 (1.1) and Part 2 (2.1) of this thesis, the added scale of commodities carriage in general, and of steel as well, deprived many steel buyers of the ability to directly contract carriage for their consignments, due to the lack of the necessary scale. On the other hand, the increased draughts of the giant bulkers estopped them from berthing at many ports thus limiting the number of points of discharge within Europe. Table 5 clearly shows the impact of ship draught in the percentage of world ports accessible. This reduction of the number of ports of discharge, also due to a considerable degree of concentration operated in the market, meant that local buyers are forced to buy from traders and large stockists and, consequently, depend on the degree of efficiency of the multimodal transport arrangements contracted by those intermediaries.

Table 5 - Relationship between ship draught and port access: Sample of bulk carriers from the "Clarkson Bulk Carrier Register" and "Ports of the World" (source: adapted from Stopford, 2009, p. 578).

Ship draught metres	Average size dwt	% of world ports accessible
7.6-9.1	16 150	73
9.2-10.7	23 600	55
10.8-11.6	38 700	43
11.7-13.4	61 000	27
13.5-15.2	89 200	22
15.3-18.5	123 000	19

The result of this is added complexity of the supply chain, less control over the operations and added uncertainty. Moreover, although the price of transport has dropped dramatically throughout the past century, the impact of the cost of transport, in the case of primary commodities in general, is still relatively high as the examples in the chart below (Figure 12) show.



	$ per tonne f.o.b.
TV sets	43 076

Figure 12 - Value for tonne of sea imports (source: UNCTAD, adapted from Stopford, 2009, p. 579)

Therefore, an item that has considerable impact on the TCO of a commodity, in this case steel, is out of control of the buyer, and the supplier, with the benefit of having greater bargaining power, will probably reflect the cost of this inefficiency on the buyer's invoice. In 2012, according to Warrian (2012), China had about 45% of the world's production capacity of steel, yet it has considerable supply chain inefficiency. Someone has to pay for this inefficiency and China's steel industry has the power to determine the marginal price of flat-rolled steel across the world (Warrian, 2012).

Moreover, according to Warrian (2012), the same lack of proper control of the supply chain affects steel producers in general as they nowadays have to cope with dispersed supply chains, whereas in the past they had control over the supply chain from the ore extraction onwards. They also have to face the effects of horizontal consolidation upstream, both between coal producers and, particularly, between ore producers, once owned by steel producers and now organized in integrated companies, shifting the scale on bargaining power. This change was due to their option, throughout the 1980s and 1990s, of disinvesting from most of their "non-core" assets, as many steel producers closed or sold mines, transportation and distribution facilities, relying, thereafter, on contractual relationships to ensure those functions. This option, according to the same author, exposed those producers to the rocketing input costs, as China's

explosive growth took off, creating unprecedented price volatility that steel producers could in no way control.

As a consequence, now the challenge for the steel industry is, as Warrian (2012, loc. 1148) refers, to *"reverticalize"*. The author refers to Brazil as an example of the power of that vertical control that companies across the globe are trying to revert to, acquiring raw material producers and locating plants to produce basic steel near the origin of those raw materials.

The movements of metal prices in international markets depend mostly on the balance of bargaining power along the supply chain of steel between its different tiers, from extraction to recycling, and of the degree of integration between these tiers (Geman, 2009a). Besides storability, already referred, other factors contribute to those price movements. Geman (2009a, p. 171) isolates the key ones:

- *"Access to downstream customers, thereby securing a route to a non-commoditized higher margin market.*
- *Ability to store product. Withheld stock, if durable, can eventually be sold or used, whereas unused capacity and non-durable stock is wasted forever.*
- *Inherent retention of terminal market price risk. A sector with low risks has low entry barriers and will eventually become a sector with low margins, as new entrants arrive.*
- *Negotiating strength. This can maintain higher profits in one part of the life cycle for long periods – it depends on financial strength and the ability to replace inputs and outputs and counterparties with alternatives."*

It is not difficult to anticipate, bearing in mind the aforementioned factors, that price will be easily influenced by the degree of competition in the supply market. Together with the fact that short-term metal demand is highly inelastic (Geman, 2009a), this should turn market price into a serious concern, for companies heavily dependent on steel, if the formation of market price is influenced by some sort of set of conditions that puts limits on competition. Unless there is a possibility to substitute steel for some other product, the demand for steel will remain fairly inelastic and, conversely, the fact that a commodity becomes dispensable will allow demand to be more responsive to a change in price (Geman, 2009a; Radetzki, 2008).

The market conditions for a given commodity can also be affected by the market

conditions for another commodity, so long as there is some relationship between the two commodities. This is particularly so with commodities belonging to the same group (Radetzki, 2008). The major substitutes for individual products are most likely within that very group and one implication of this is the fact that their price is likely going to move in tandem. An example of that is the fact that the price of coal and natural gas are likely to follow the price of oil in its swings (Radetzki, 2008). However, the relationship between prices of different commodities may well be an indirect one. The implications of steel demand on the price of other commodities, through its impact on the cost of freight (and freight is also a commodity with its own derivatives markets), as described above, are a good example of those indirect relationships.

These are complex economic mechanisms that could hardly be explained adequately herein. Nonetheless, this brief introduction should suffice to illustrate that behind the extreme swings of commodity markets are explanations that go far beyond the most easy to anticipate reasons such as lost crops, demand peaks, embargoes or pure speculation. In light of the complexity of those market phenomena, it should come as no surprise that according to a study carried out by A.T. Kearney and the *Institut für Unternehmensführung* (Austria), 30% of the European companies are not prepared to deal with market price swings of the materials they depend on (Goffre *et al.*, 2007). One of the possible causes for this unpreparedness is given by Fabozzi *et al.* (2008, p. xii of the foreword)

> *"It is the curse of markets that while there is much hard data to analyze about the past, there is no such data about the future. This means that analysts are typically biased toward previous commodity prices when predicting future commodity price behavior. As a consequence, market commentators have been consistently underestimating the price of many commodities."*

3.9.2 – Previous research on Commodities Supply Risk Management

Commodities have been fundamental for mankind since the beginning of times, be that energy, metals or agricultural products, the three commodity classes. From oil and chemicals to timber and arable crops, the role of commodities in human history has always been a central one. Even commodities that may appear to be less glamorous - when compared to precious

metals or rare earths – such as steel or aluminium, have a fundamental role in modern economy and whatever happens in their respective markets has a direct impact in industry and in society in general. Hence, it is no surprise that the interest in commodities has been gigantic, particularly as a consequence of unprecedented price rises in the last few years (Geman, 2009b). The volatility of commodity markets is by no means a novelty and it is a challenge that supply managers are well used to. However, this volatility, reflected in commodities prices has increased in the past few years (Hartley and Zsidisin, 2012). This added volatility has several factors behind it, for instance: recession and economic uncertainty regarding recovery, speculation, globalization (Hartley and Zsidisin, 2012).

Although it can also create opportunities for success, the volatility of commodity markets affects companies' bottom lines, taking a toll on profitability (Zsidisin and Hartley, 2012c). This may happen either when a given embedded commodity that is used in rather small quantities (e.g. rare earths or gold for circuit boards) suffers an extreme price variation, or when a small change in price affects a commodity that is heavily used by the organization (Zsidisin and Hartley, 2012a). Either way, the impact is considerable. For instance, in 2002, Ford Motor Co. was forced to make a USD 1$ billion write-off of the value of its stockpile of precious metals due to a steep price fall (White, 2002 *apud* Bartram, 2005). This impact may be minimal in those cases where managing the commodity price risk (hereafter CPR) exposure is a must-have expertise of the organization, due to its considerable exposure to that risk. In those cases, adequate strategies to manage that exposure may well be implemented (Bartram, 2005). Therefore, in cases where that exposure is expectably high, it is possible that an exposure to, say, oil price swings is managed by hedging through the use of oil forwards and futures (Bartram, 2005). However, as Okochi (2008, p. 43) warns,

> *"Theoretically, one can hedge if one can find the instrument to hedge, but this is not always straightforward with commodities".*

For starters, seasonality may complicate year-round hedging, as the author explains. On the other hand, the fact that certain commodities have different types, grades, origins makes it hard to make sure that one is in fact hedging the same underlying commodity incorporated into the product with the hedging tools used (Okochi, 2008). Despite these possible difficulties, hedging is frequently used when companies have great exposure to a certain commodity. For example, airline companies often act as hedgers to protect themselves against fuel price variation

(Fabozzi *et al*., 2008). In 2013, Delta Air Lines took this strategy to a whole new level through the use of vertical integration as it moved into the oil business through the acquisition of an oil refinery, with a view to managing its fuel expenses and taming the fuel price curve (Postrel, 2012). This, however, is not quite an example of commodity risk management and, in fact, it exposes the airline to the risk of crude oil price variation, just as it would expose any refinery. Apparently, though, this strategy aimed at maximizing the production of jet fuel to ensure the availability of jet fuel in the Northeast of the US, rather than managing risk associated to oil price or even to avoid the post-refinery cost increase ("An airline buys an oil refinery," 2012).

Bearing in mind the relevance of risk associated to commodities, it is somewhat surprising that, over the past few years, risk management in commodities has received little attention in academic literature, in spite of being a serious concern for managers (Bartram, 2005). Schlosser and Zsidisin (2004), in the early years of this century, describe how a large chocolate manufacturer successfully hedges, via fiscal hedging instruments, fuel surcharges passed on from its carriers. This was one of the first in a string of articles authored or co-authored by Zsidisin concerning the management of commodity spend and risk management in commodities. The same author (Zsidisin, 2005), in an article published by CAPS Research, addressed the problem of commodity price volatility. In this work the author provides three overarching techniques for supply chain managers to consider implementing to manage commodity price volatility. These techniques are: the use of financial instruments to hedge significant price increases; the use of adequate contractual provisions with suppliers and adopting business practices to offset and share risk of commodities price increase; and, finally, gathering business and market intelligence benefiting the timely and informed sourcing decisions. Zsidisin and Hartley (2012a, 2012b) suggest a flexible process that companies can use to manage commodity price volatility. Starting with a risk exposure assessment and with understanding the organization's risk tolerance level, the authors suggest a Price Risk Management Strategy that includes several options: substituting, passing/sharing price risk, forward buying, hedging with futures contracts, cross-hedging and, as a last option, absorbing risk and reducing demand. Elsewhere, the same authors suggest a few strategies that managers can turn to in order to manage price risk exposure, namely:

- *"using market intelligence and market analysis tools*
- *establishing formal processes for selecting commodity strategies*
- *increasing supply chain visibility*
- *fostering internal and external collaboration"* (Hartley and Zsidisin, 2012, p. 24).

Apart from the research carried out by Zsidisin and Hartley, it is hard to find other contributions in literature to the research on commodity supply risk management in general. Okochi (2008) also focuses on commodity hedging to face price risk and most of the literature referred is concerned with price risk. Yet, Bartram (2005, p. 164) has concluded that

> *"while commodity prices are substantially more volatile than exchange rates and interest rates, commodity price exposures do not appear more significant overall than foreign exchange rate and interest rate exposures".*

The author further explains that commodity prices may affect only few corporate cash flows, reducing the relative importance of their impact *vis-à-vis* the impact of other economic variables and, it is here submitted, other types or risks. In companies that - due to the fact that commodities expenditure is a most relevant part of their total costs - have considerable exposure to CPR are, most likely, monitoring those price swings as routine (Bartram, 2005). There are several examples in the literature of companies doing just that and examples of companies that, when that impact so justifies, are even trying to actively counteract those swings through the use of hedging or other tools (several examples can be found in, e.g., Fabozzi et al., 2008; Zsidisin and Hartley, 2012a, 2012c). However, even in cases where there is such an exposure to price variability, the real impact can be very different depending on other circumstances. Bartram (2005), highlights just that by referring that, in some cases, the impact of those price swings may be passed on to other actors (suppliers or clients) on the value chain. This will be the case when it is somewhat immune to those price swings due to factors such as the market share of the company, the level of competition within the industry in which it operates, and the level of competition on the markets in which it buys or sells. That author further explains that in so far as passing the cost on to customers is concern, the elasticity of the demand curve may be determinant: if the demand is relatively inelastic, raising the price will dampen the impact of the increased price, passing it on to the customer without significant lost sales.

As it has been referred above, the considerable exposure of some industries to the price fluctuations of certain commodities has increased the interest in the problem in the context of supply chain risk management, albeit with little research published on the subject. However, the impact of CPR in the case of the large companies with greater exposure is arguably less than one

could probably expect, due to the fact that it is an anticipated impact, hence one that is managed with the existing expertise and the implemented tools (Bartram, 2005). In such cases, it may not even be accurate to use the expression "risk" as the price fluctuation is indeed bound to happen, it is expected and, consequently, lacks the uncertainty. Of course, "when" and "how much" price will change will still be uncertain, therefore there still remains some uncertainty in the variation of price, otherwise it would be impossible, as a matter of principle, to insure CPR as *"the very essence of insurance is to insure against risks and not certainties"* (Hodges, 2013, p. 231)[13]. Yet, one could argue that, in such a case, managing the exposure to commodity price fluctuations is in the core of the organization's scope and hardly a risk *sensu stricto*. Be that as it may, it seems that, at least in some cases of companies heavily dependent on their commodities supply chains, CPR is most likely not the only relevant risk. For smaller companies, however, even though their exposure might be just as high, is may well be impossible to implement the same sort of solutions that the large corporations adopt. This is admitted by Zsidisin and Hartley (2012) who refer that smaller companies may lack the skills, the information or the human resources (i.e., the time) to make use of different procedures frequently used by companies exposed to CPR, such as monitoring price trends of that commodity and of its substitutes, monitoring expected changes in capacity and demand, monitoring technological evolution and gathering market data from all sorts of sources. The same applies to the three techniques for supply managers to use, in order to manage commodity price volatility, suggested elsewhere by Zsidisin (2005): the use of financial instruments, either exchange-based derivatives (such as option, calls, puts, and collars[14]) or over-the-counter derivatives (such as swaps, caps, floors and collars[15]) to hedge price fluctuation; the

---

[13] *"It covers a risk, not certainty (…)"* was the expression of Lord Summer in the leading case of Marine Insurance Law regarding "wear and tear" losses *Gaunt* v *British & Foreign Marine Insurance Co Ltd. (1921) 26 Com Cas 247*. It is beyond the scope of this research to discuss the availability of insurance for CPR but a discussion of this subject can be seen in Dana and Gilbert (2009, p. 226) where neither of the two arguments that the authors mention against an insurance solution for CPR is the fact that it involves a certainty.

[14] For the benefit of economy, these concepts are clarified using the Zsidisin's (2005, p. 4) words:

*"**Futures** are standardized, transferable, exchange-traded contracts that require delivery of a commodity at a specified price on a specified future date (…) Calls, puts, and collars, on the other hand, are options contracts. **Calls** give the holder the right to buy a certain quantity of a commodity from the writer of the option, at a specified price up to a specified date (…) **Puts** are the opposite of calls because they give the holder the right to sell certain quantities of a specified commodity. **Collars** are a combination of put and call options that can limit, but not eliminate, the risk that the commodity will decrease."*

The author further explains the use of these instruments, for more information refer thereto.

[15] Also as Zsidisin (2005, p. 5) clarifies:

"Instruments used in over-the-counter derivatives include swaps (which are the same as futures), caps (the equivalente to calls), floors (the same as outs), and collars."

use of strategies to share and off-set risks through contractual solutions and business practices; finally, gathering and sharing market intelligent to anticipate price swings.

The relevance of CPR is made irrefutable by the existing literature and, before that, by the experience of companies. That said, the main doubt, if not contention, raised by the present research is that companies involved in the international trade of commodities face other risks that are not addressed by the literature. One clear example that commodity markets involve other threats beyond price volatility is the fact that the commodity risk assessments made by the World Bank for different commodities, frequently refer several other risks. For example, on its report on Ugandan Coffee Supply Chain Risk assessment of June 2011 (World Bank, 2011), the World Bank identifies production risks, market risks and enabling environmental risks. Furthermore, the United Nations Conference on Trade and Development (UNCTAD) has addressed, on more than one occasion[16], the problem of fraud in commodity trade, highlighting the severity of this risk for companies involved in international commodity trade. In spite of the devastating impact that a major fraud may have, the focus of the literature on commodity supply risk management seems constantly drawn exclusively to the risk associated to price. Depending on its final conclusions, this research might even demonstrate that beyond being adequately educated in financial management of commodity risk, supply chain managers also need to have a solid expertise regarding other sorts of risks that seem to be muffled in the existing literature by all the attention given to CPR.

The fact that the literature refers almost exclusively to CPR must have a valid explanation, particularly bearing in mind the fact that we are talking about some of the most reputed scholars in the field of supply chain management. One might wonder whether it is possible that the explanation for this exclusive focus is in the fact that the list of commodities that those researchers address is a limited one and that, in the case of that limited number, price fluctuation is, indeed, the most significant risk. However, looking into that literature, different examples of commodities can be found, such as: arabica coffee beans, silver, natural gas, steel, aluminium, plastic (Hartley and Zsidisin, 2012); oil, grains, sugar, dairy, cocoa, soybean oil, butter, cheese (Zsidisin, 2005); fuel (Schlosser and Zsidisin, 2004); precious metals, agricultural products, services (such as transportation) and several more (Bartram, 2005). Consequently, the reason for this exclusive attention to CPR must be different. It might be linked to the difficulty in CPR management, noticeable in the fact that, as Zsidisin (2005, p.1) reports, in February 2005, the

[16] E.g., the 1998 report "Documentary Risk in Commodity Trade" (UNCTAD, 1998).

Bank of America stated that, in attempting to assess the future behaviour of oil price,

> *'none of the historical correlations analysis that we have used – inventories primarily for oil, storage for natural gas, and oil prices for rig counts – work'*

Or it might be linked to the fact that the impact of CPR ripples downstream along the supply chain, hitting the cost structures of companies incorporating that commodity into their products. Or is it possible that there is some glamorous nature, so to speak, in the *"primary commodities"*[17], or in commodities that are hedge through the use of derivatives that attracts more attention to commodity price risk management?

Probably, there is no way to know what explains this exclusive focus on price volatility in the case of commodities, but it is possible to investigate whether there are other risks relevant and just how relevant are they. This is one of central purposes of this research.

[17] The expression is used with the meaning given by Radetzki (2008, p. 7):
"I derive a definition of primary commodities from the national accounts, t to equal the value of output from the primary sector, comprising agriculture (including hunting, forestry and fishing), mining and utilities."

Part 4 - Methodology

4.1 - The case study approach

Theory-oriented research aims at giving a contribute to the development of theory and has the academic community as the primary recipient of its findings, while practice-oriented research aims at contributing to the knowledge of practitioners in a specific field (Dul and Hak, 2008). This research aims at contributing to theory development regarding supply risk management in the case of commodities through the analysis of supply chain risk management practices of a number of organizations that have their supply chain focused on a certain commodity, in order to draw conclusions regarding a set of research questions.

As referred above, the analysis of the existing literature has revealed that, when it comes to analysing commodities' supply chain risk, authors tend to focus their research on the risk associated to the fluctuation of prices in the international markets. One of the objectives in this research, however, is to ascertain whether this is the most relevant risk in the case of commodities or whether there are other risks also extremely relevant. Moreover, this research will try to establish whether, in the context of commodities, supply chain risk management should pay heed to other risks. It is anticipated that this calls for the adoption of a systematic risk management policy in the case of commodities, especially bearing in mind the increasing volatility of international markets. To sustain this suggestion, the relevance of risks in the case of commodities - other than risks related to price fluctuations - must be investigated. On the other hand, despite the fact that the present research is theory-oriented, it is expected to afford some assistance in setting up a comprehensive supply chain risk management policy for companies whose reality resembles that of the organizations considered in this research. With this purpose, it will endeavour to suggest a framework for supply chain risk management but keeping in mind that such suggestion cannot be applicable without due regard to context as it is limited by the limitations of the scope of this research. In order to address the goals established, this will be a two-stage research: the first stage will investigate the relevance of other risks besides the risk of price fluctuation; the second stage will aim at proposing a framework for supply chain risk management building on the information and managerial experience gathered in the first stage, with regard to risk identification.

Bearing in mind that the present research has been considered theory-oriented, several

characteristics need to be defined. To start with, one must define the object of study, the concepts, and the domain (Dul and Hak, 2008). The object of the theory – its stable characteristic – has been clearly established: supply chain risk management of commodities. The relevant concepts, such as "risk", "risk source" and "risk driver", have been defined above. For some concepts, this was done by accepting the meaning suggested by other authors for the purpose of this research, for a smaller number by making assumptions about their meaning. It is also necessary to establishing the relevant research questions and these have been formulated above. The research has been carried out through the analysis of the practices of a numbers of companies in the Portuguese industrial sector aggregated in two groups. For the second group (the steel group) a number of companies have been selected, all of which have in common the fact that they depend heavily on the supply of steel. Hence, the domain of the theory has also been defined. In the first group a number of industrial organizations operating in different sectors in Portugal have been selected and the purpose of this group in this research is to provide contrast to the realities in the second group of companies.

Through the years, a recurring debate has populated research literature about the differences between qualitative versus quantitative research approaches. Influenced by this debate, the literature in the field of logistics and supply chain management has also adopted different approaches depending on whether the researchers have been influenced by the positivist paradigm or analytical school, or by the interpretive paradigm or behavioural school (Sachan and Datta, 2005). When researchers are closer to the analytical school, they tend to favour quantitative research, focusing their efforts on controlling bias in order to understand the facts objectively. Researchers on the behaviour school camp, on the other hand, tend to be influenced by interpretative methods, as Sachan and Datta (2005) explain, searching for an holistic view of the phenomena they study. Quantitative approaches are examples of the objectivist approach to social science and inherit its positivist epistemology and deterministic view of human nature, while a qualitative approach is a subjectivist one, anti-positivist and with a voluntaristic of the human nature (Ritchie *et al.*, 2013). The qualitative, naturalistic approach is used when the researcher observes and interprets reality with a view to developing a theory that will explain what was experienced, unlike the quantitative approach that is used when the researcher has a theory (or hypothesis) as a starting point and tests to confirm or not that hypothesis (Newman and Benz, 1998). A full discussion of these contrasting approaches can be found in Zuber-Skerritt (2013, p. 127) where the author lists the labels commonly attached to both currents of research in Table 6.

Table 6 - Educational research methodology: two paradigms of research in higher education (source: Zuber-Skerritt, 2013, p. 127)

Paradigm 1	Paradigm 2
Natural Science	Human Science
Traditional	Alternative
Experimental	Naturalistic
Prescriptive	Descriptive
Reductionist	Holistic
External	Internal
Nomothetic	Ideographic
Normative	Interpretive
Positivist	Non-positivist

Sachan and Datta (2005), having scrutinized the articles published in three top rated journals throughout five years (1999-2003), have concluded that the majority of the research published on supply chain management and logistics was based on empirical research but less than one-fifth of the publications was empirical qualitative research (Sachan and Datta, 2005). These authors acknowledge that the percentages of qualitative research, including research using the case study strategy, have increased, but still most of the articles published have a quantitative nature. The fact that qualitative research has been the target of much criticism is likely to have some bearing on this reality. Miles (1979) takes this attack on qualitative research to the point of comparing it to the legal doctrine in American Tort Law of "attractive nuisance", which, in short, holds a landowner liable for damages caused by potentially dangerous conditions (e.g., railroads, swimming pools, parked cars) that are likely to attract strangers (most cases concern children) that may have trespassed his land. In other words, recalling Miles' words (1979, p. 590),

> *"just as most children think that driving is easy, so many researchers somehow think that qualitative data present few problematic methodological issues".*

Although it is not known whether the dominance of quantitative research in supply chain management literature still exists as it did in 2005, it is clear that, along the past couple of

decades, several prominent studies have adopted a qualitative approach (inter alia, Mentzer et al., 2001; Dubois and Gadde, 2002; Hallikas et al., 2002; Oke and Gopalakrishnan, 2009; Tang and Zimmerman, 2009a). This fact, as well as the increasing concerns with ensuring rigor in research conclusions and other factors referred by Sachan and Datta (2005) are some of the several reasons to explain the rehabilitation of qualitative methods. Yin (2011, p. 6) recognizes this by saying that the use of qualitative methods "has become acceptable, if not mainstream" in research in several academic and professional fields. Amongst these qualitative methods, is the case study method that generally focuses on in depth study of one or multiple case studies (Sachan and Datta, 2005). The fact that the there is little literature on the subject of this research (and, as a consequence, the lack of a theoretical framework) together with the complex nature of the phenomena concerned, justify the qualitative nature of the research (Yin, 2003).

According to Yin, as a research strategy

> *"the distinguishing characteristic of the case study is that it attempts to examine: (a) a contemporary phenomenon in its real-life context, especially when (b) the boundaries between phenomenon and context are not clearly evident" (1981, p. 59).*

In the context of supply chain management research, with this strategy, the researcher approaches reality to study a given contemporary phenomenon in its natural scenario, in real life context (Yin, 2003), having thereby the opportunity to explore complex links within the whole supply chain (Oke and Gopalakrishnan, 2009).

The case study strategy is often regarded with some contempt, as Gerring (2007, p. 6) states, referring especially to the single-case option:

> *"(i)ndeed, the case study research design is viewed by most methodologists with extreme circumspection. A work that focuses its attention on a single example of a broader phenomenon is apt to be described as a 'mere' case study, and is often identified with loosely framed and nongeneralizable theories, biased case selection, informal and undisciplined research designs, weak empirical leverage (too many variables and too few cases), subjective conclusions, nonreplicability, and causal determinism."*

The fact that it is not unusual for the use of this method to become the excuse to do whatever a researcher decides to do, exposes even well-structured applications of the case study methodology to some scepticism (Gerring, 2007), especially coming from researchers using other

empirical approaches such as surveys (Seuring, 2008). Whereas the use of other research strategies usually involves considerable efforts of the authors to document the technical options throughout their research, in the use of case study methodology it is sometimes argued that there is a smaller degree of concern with methodological considerations (Gerring, 2007). It is, thus, no surprise that case study research has often been considered a method lacking rigor and this is also applicable to the field of supply chain management as highlighted by Seuring's (2008) assessment of rigor of case study research in supply chain management. This author, besides questioning the abundance of unjustified single case options in research, emphasized the fact that in a great deal of case study research in supply chain management it is unclear how the data was analysed and how the rigor of the research was ensured (Seuring, 2008). As another author refers,

> *"(c)ase studies have become in many cases a synonym for free-form research where everything goes and the author does not feel compelled to spell out how he or she intends to do the research, why a specific case or set of cases has been selected, which data are used and which are omitted, how data are processed and analyzed, and how inferences were derived from the story presented. Yet, at the end of the story, we often find sweeping generalizations and "lessons" derived from this case"* (Maoz, 2002 *apud* Gerring, 2007, p. 6).

However, the value of this type of research approach has been firmly established and, if carried out in a structured and well documented way, it may allow the in-depth analysis of contemporary phenomena (Seuring, 2008), so much so that it has been said that

> *"(c)ase study has collapsed the generalization viewpoint of the quantitative research tradition, and has contributed to the creation of new methods in the social sciences" (Mills et al., 2009, p. 67).*

In the context of logistics and supply chain management research, case study research has been deemed valuable by a considerable number of researchers (*e.g.,* Ellram, 1996; Barratt *et al.*, 2011; Pedrosa *et al.*, 2012). However, where qualitative research based on cases is concerned, the researcher cannot neglect six factors to ensure the quality of the qualitative research (Mayring, 2002 *apud* Seuring, 2008, p. 131): (1) process documentation; (2) safeguarding interpretations by arguments; (3) research process structured by rules of conduct; (4) closeness

to the study item; (5) communicative validation; and (6) triangulation.

Although there are examples of case study research being used for theory testing purposes, the relevant literature commonly associates the use of case studies to theory building rather than to theory testing (Eisenhardt, 1989; Dyer and Wilkins, 1991). Yin (2003, p. 1) distinguishes the case study approach as

> *"the preferred strategy when 'how' or 'why' questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context".*

This recommendation is a consequence of the shortcomings of the positivist approach

> *"which assumes that (the) whole is equal the sum of its parts while SCM is based on "systems thinking". In this paradigm, it is assumed that the whole differs from the sum of its parts due to synergy effects, i.e. knowledge depends on the system and how it is defined"* (Sachan & Datta, 2005).

According to a hierarchical view of the different research strategies case studies are only suitable for the exploratory stage of a research, but Yin (2003) questions this hierarchical perspective. This author (2003, p. 3) argues that "*each strategy can be used for all three purposes of research: exploratory, descriptive or explanatory*". The goal of an exploratory case study is to define questions and hypotheses for a future study, or to determine whether a given research procedure is feasible, whereas a descriptive case study purports to make a complete description of a given phenomenon in its singular context and an explanatory case study comprises data that relate to and explain cause-effect relationships (Yin, 2003).

According to Yin (2003), the case study method is particularly useful when the researcher approaches a topic that has not received much attention from previous research, with a view to gaining theoretical and empirical insight into that topic. Aiming at uncovering the interaction between the factors that characterize de phenomenon addressed by the researcher, the case study is particularly convenient for situations in which separating the phenomenon's variables from its context is impossible (Yin, 1994).

The case study strategy is a research strategy that focuses on understanding the dynamics within specific settings (Eisenhardt, 1989b). It is this linkage to specific settings, a major concern that Grounded Theory also shares, that implies the possibility of, and the need for, drawing boundaries around the specific case to be studied in order to maintain a clear conceptualization of the case's limits (Yin, 2009), a task that often proves to be problematical (Mills *et al*., 2009). The fact that the conclusions drawn from such single settings will always be limited as to the possibility of extending to other situations (Eisenhardt, 1989b) should not deprive this strategy of its usefulness, or as Dubois and Gadde (2002, p. 554) stress:

> *"(l)earning from a particular case (conditioned by the environmental context) should be considered a strength rather than a weakness".*

Hence, although the analysis carried out refers to a limited reality only, that does not, by itself, render the research conclusions scientifically worthless, provided that the researcher is not tempted to loosely extend those conclusions to different settings or phenomena (Eisenhardt, 1989b). The objective of qualitative research is to refer back to a theory or application rather than to draw inferences about some larger population (Yin, 2003). It is not to generalize but rather to provide the flexibility and freedom to explore a phenomenon in depth (Strauss and Corbin, 1998). This, however, does not mean that the conclusions drawn from a single setting cannot be subject to generalization if it is useful for theory-building and testing as argued by, *inter* alia, Dyer and Wilkins (1991).

Case study research does not necessarily have to rely on previous literature or on prior empirical evidence and this allows researchers to use this strategy for theory-building, even in the case of phenomena about which there is little knowledge (Vissak, 2010). Vissak (2010, p. 371) refers some important advantages of the case study method over *"those research methods that aim at statistical correlations and focus less on their underlying explanation"*. According to this author, case study research can help to discover causal relationships, it can help to explain the "why" and "how" of a certain phenomenon or reality, and *"to create thick, interesting, and easily readable descriptions and rich understandings (…) of phenomena in their natural settings"* (Vissak, 2010, pp. 371–372, citing several other authors). On the other hand, the case study research method has been frequently and successfully used in documented management research, particularly to explore new research areas (Eisenhardt, 1989b; Yin, 2003). Furthermore, having established the focus for this research – supply chain risk management in commodities' supply

chains – the adoption of a multiple case study strategy follows the recent trend that Dubois and Araújo (2007, p. 173) have identified in supply chain management research, as the authors reach the conclusion that

> *"comparative multiple case studies have become the dominant approach (and) papers have progressively focused on more specific aspects of purchasing and supply management".*

The use of a multiple case study strategy also aims at adding robustness to the research carried out, even though it is recognised that it represents an increased risk of premature conclusions (Li and Barnes, 2008). Nevertheless, an approach based on several different sources, adopting a corroborative mode, will likely be more accurate, hence more convincing (Yin, 2003). This, however, is far from being a consensual option and some authors question the idea that the more cases a researcher studies, the better for generating theory. This is the case, for instance, of Dyer and Wilkins who accuse Eisenhardt of losing the essence of case study research, which, according to these authors, is

> *"the careful study of a single case that leads researchers to see new theoretical relationships and question old ones" (1991, p. 614).*

Having said that, according to Dubois and Araújo (2002), the multiple case study approach has been the dominant approach for research in this field in the recent past and, although the idea that a multiple case study strategy affords added robustness to the research is far from being undisputed, the option made in this research finds some confort in the words of Eisenhardt (1989b, p. 627) who claims that

> *"the similarities between single- and multiple-setting research are vastly more important than the differences".*

4.2 - Case study selection

As in every research, the main objective here is to confront theory with the empirical world (Dubois and Gadde, 2002). However, theory on the subject area of this research has been identified as being at an early stage of development, lacking specific attention in the existing literature. As it has been previously reported herein, in the specific case of commodities the literature on supply chain risk management is quite scarce. Consequently, given the exploratory nature for the objectives of this research, a qualitative case study strategy was considered adequate (Eisenhardt, 1989b; Yin, 2003) as the nature of the subject calls for deeper understanding of the topic (Hallikas e*t al.*, 2004). This is a typical scenario for the application of methodological approaches, influenced by Grounded Theory, that, in their essence, build theory from case studies, frequently overlapping data analysis with data collection (Eisenhardt, 1989b) and allowing the relevant theoretical constructs to emerge from that data analysis. Through a systematic analysis of evidence collected, the researcher seeks to end up with a well constructed theory: a grounded theory, grounded in the data collected (Glaser and Strauss, 1967). Unless the researcher's purpose is to elaborate and extend existing theory, rather than beginning a project with a preconceived theory in mind, the researcher begins with an area of study. From that point onwards, theory will emerge from the data and theory thus created is more likely to resemble the "reality" (Strauss and Corbin, 1998). For Glaser and Strauss (1967), the role of evidence is clear: evidence from which conceptual categories emerge is used to illustrate the concept, but the concepts will not change even if the facts have changed, they will only have their meaning re-specified. These authors further clarify that

> *"evidence and testing never destroy a theory (of any generality), they only modify it. A theory's only replacement is a better theory"* (Glaser and Strauss, 1967, p. 28).

The idea of building theory in continuous dialectical interplay between theory and data is not an exclusive of Grounded Theory. Yin makes a colourful analogy to this building theory from cases with his reference to the work of a detective:

> *"An analogous situation may be found in doing detective work, where a detective must construct an explanation for a crime. Presented with the scene of a crime, its description, and possible reports from eye-witnesses, the detective must constantly make decisions regarding*

the relevance of various data. Some facts of the case will turn out to be unrelated to the crime; other clues must be recognized as such and pursued vigorously. The adequate explanation for the crime then becomes a plausible rendition of a motive, opportunity, and method that more fully accounts for the facts than do alternative explanations" (1981, p. 61).

Just like the detective's work, theory evolves during the research process itself and is a product of continuous back-and-forth between analysis and data collection (Strauss and Corbin, 1998; Goulding, 2002). This back-and-forth constitutes one of the foundations of what Dubois and Gadde call systematic combining (2002) and is closely linked with the sampling type. With Grounded Theory, sampling is directed by theory, as an on-going part of the process of data collection and analysis that leads the researcher in the sampling process. When it comes to qualitative research, according to Morse (1990 *apud* Coyne, 1997), sampling procedures tend to be more loosely prescribed that in quantitative research and this, as the author adds, has resulted in much confusion in qualitative research.

The starting point for case selection in this research was the adoption of a rationale for case selection that resembles the rationale behind what Grounded Theory literature has called *"theoretical sampling"* (Glaser and Strauss, 1967), a method that, as Eisenhardt (1989b, p. 537) explains, seeks to *"choose cases which are likely to replicate or extend the emergent theory"*. Accordingly, the multiple case study research strategy was implemented through the study of a set of organizations that have been selected on the understanding that they were representative of the reality addressed by the research. As Eisenhardt (1989b, p. 537) further explains,

"(w)hile the cases may be chosen randomly, random selections is neither necessary, nor even preferable (...) given the limited number of cases which can be studied, it makes sense to choose cases such as extreme situations and polar types in which the process of interest is "transparently observable".

The terms "theoretical", "selective" and "purposeful" sampling are frequently used interchangeably, as if they were synonymous, but those terms have different meanings as discussed, for instance, in Coyne (1997). For Patton the goal of purposeful sampling is to

"select information-rich cases strategically and purposefully" and the "specific type and number of cases selected depends on study purpose and resources" (Patton, 2002, p. 243).

Yin (2011), on the other hand, says that in qualitative research a *"purposive sampling"* is likely to be adopted as the samples are chosen in a deliberate way. In Yin's (2011, p. 88) words:

> *"(t)he goal or purpose for selecting the specific study units is to have those that will yield the most relevant and plentiful data, given your topic of study".*

Here, once again, the terminology in the literature is far from being unanimous let alone carved in stone. For instance, beyond the slightly different terms – *"purposeful"* versus "*purposive"* sampling - these two authors use, Yin (2011) distinguishes *"purposive sampling"* from sample options such as convenience sampling, snowball sampling, and random sampling, whereas Patton includes convenience sampling and snowball sampling within *"purposeful sampling"* as opposed to *"random probability sampling"*. However, with the risk of over simplifying the existing differences, suffice it to say, for the purpose of this research, that Patton considers that there is a purpose behind both convenience and snowball sampling, as well as behind several other forms of sampling. Therefore, they are all considered under the umbrella term *"purposeful sampling"*.

The option for a multiple case study strategy, rather than using a single case study, was a consequence of the goals of this research. One aspect that clearly emerged from the literature review, as explained on a specific sub-section of this thesis, was the contextual nature of SCRM. Although this was not a focal aspect of this research, hence it was not one that contemplated on a specific research question, the strategy adopted was expected to afford relevant information to understand whether and how context had an impact on the supply risks experienced by companies and the strategies they used to manage such risks. Carrying out the interviews in two stages separated in time and using two sets of companies (one multi-sector and one focused on a single commodity), was anticipated to cast some light upon the relevance of context on the risks to which organizations are exposed. On the other hand, the use of the two sets of companies aimed directly at the core of this research's goal, i.e. ascertaining whether there were risks that the companies were particularly exposed to as a consequence of their dependence on a certain commodity and on the strategies used to cope with those risks. Consequently, the selection of organizations was based on theoretical criteria rather than statistical reasons (Eisenhardt, 1989b), or, using Yin's words, they were selected with the purpose of having

> *"those that (would) yield the most relevant and plentiful data, given your topic of study"* (Yin, 2011, p. 88).

With this goal in mind, the organizations were selected on the assumption that they could *"illustrate or highlight what is typical, normal or average"* (*"typical case sampling"* - Patton, 2002, p. 243) among the type of organizations that the research was intended to consider.

Bearing in mind that the purpose of this research is theory construction, the number of experiences captured should not be too limited (Yin, 2003). This concern takes into account the fact that the representativeness of case study investigation will always be subject to disbelieve because it includes, by definition, only a small number of cases of some more general phenomenon (Gerring, 2007). However, it was not considered adequate to establish *ab initio* a target number of organizations but rather to gather information until the point of theoretical saturation was reached, that is to say,

> *"(at) the point at which incremental learning is minimal because the researchers are observing phenomena seen before"* (Glaser and Strauss, 1967 *apud* Eisenhardt, 1989, p. 545).

In other words, it was considered that no more cases should be added when adding another case would not bring any relevant new information that could justify that effort. Although it is not possible to know beforehand the information that a new case might offer, it is possible to systematically assess the marginal increment of information that each case has added. The result of this assessment should determine whether the researcher should seek further information. Given the fact that this assessment is never error free - considering that there is always the possibility of the last case being a misleadingly "poor" one - the decision as to whether the theoretical saturation has been reached should consider the information gathered globally and not just the new data collected from the last unit of research. Thus supported, the decision to stop collecting information would still be a discretionary one, albeit not an arbitrary one.

This research has a qualitative nature and aimed at offering useful descriptive insights from the observations in the practice of companies regarding their supply risk management. Its purpose was to conduct an exploratory study to collect information of a qualitative nature within the particular environmental context of the organizations, with a view to understanding the dynamics of that context (Dubois and Gadde, 2002). As a consequence of the objectives of this research, the empirical data collection was carried out in two different stages. On the first stage, a group of companies operating in the Portuguese industrial sector was selected with the main

purpose of gathering information focusing on industrial companies of different sectors. This aimed at analysing their supply risk management experience in general, as opposed to an analysis focused on a single product.

Having excluded large scale single commodity buyers for this first group, a *"theoretical sampling"* (Eisenhardt, 1989b) selection method was used, which means that the main concern was to have some diversity and to ensure - based on the existing knowledge their operations - that the cases selected could provide useful input and were suitable to represent the targeted reality. Another important concern was to make sure that the analysis carried out on companies selected would not overlap the second stage, i.e. that the analysis of the organizations was not focused on a single type of "traditional" commodity supply chain, in order to avoid contradiction in the information collected. The information would be collected through personal interviews with the purchase managers, or equivalent, of the organizations selected.

There was no previous definition as to the number of cases that would be used in this stage. As a result of the exploratory nature of this analysis and of the qualitative nature of the research, it was anticipated that the number of cases analysed would be smaller than it would have been expected if, for instance, the study purported to extract statistical data of the reality studied (Eisenhardt, 1989b). Accordingly, the selection of cases, using a *"purposeful sampling"*[18], and the collection of information would continue until the saturation point was reached (Eisenhardt, 1989b; Glaser and Strauss, 1967).

In the first stage of the research, the interviews took place at the premises of the organizations and were audio recorded with the permission of the interviewees. There was a common script (Annex 5) and, in order to fine-tune it, a preliminary test interview took place. The resulting script was the basis for semi-structured interviews, that lasted between 50 and 110 minutes, and was used as a mere guide to keep the interview from going off-track and to ensure that some information that was deemed important was not left out. Along the data collection period it proved necessary to slightly change the way some questions were formulated, on the one hand to help on the effort to keep the interview from going astray and, on the other, to ensure that the questions were not too vague and that the concepts implied were clear so that the questions were well understood. This would contribute to reduce doubts in the interpretation of the answers and to ensure easier comparisons between the different

[18] According to Patton's (2002) interpretation of "purposeful sampling" referred above.

experiences reported.

Notwithstanding this concern, it was deemed of extreme importance to ensure that the interviewees were not led into using specific terms that are commonly used in the context of supply chain risk management or into referring certain risk or strategies, in order to have to avoid conditioning the accounts of their experience. However, there is clearly a difficult balance to achieve. On the one hand, an effort must be made to ensure the spontaneous nature of the information received, a concern expressed by the words of Ellegaard (2008, p. 429):

> *"Instead of forcing risk management terminology upon informants, possibly provoking misunderstandings and incomplete accounts, the idea was to let the SCOs provide rich accounts of their purchasing and SCM practices in layman's terms. In the dialogue information was sought out that allowed plausible interpretations of supply risk management practices."*

On the other hand, it is important to ensure that the fact that the interviewees are given a considerable degree of freedom in the use of terminology does not lead to contradictory information. Time and again, it proved necessary to clarify the meaning of some expressions used by the interviewees and occasionally to lead them into abandoning the use of inadequate terminology. This concern was present both on the first and on the second stage of the research and the experience from the first stage suggested the possibility that a preliminary clarification of terminology could prove beneficial in the second stage. However, all things considered, an option was made not to make that preliminary clarification to avoid the risk of leading the interviewees into referring some aspects that they would otherwise not refer.

In order to try to avoid the possibility the interviewees forgetting to mention some risk or strategy that could possibly be of great relevance, a checklist of risks was prepared to verify at the end of each interview as the information gathered, concerning risks and strategies, was checked with the interviewees. Thus, it remained possible to distinguish the facts that the interviewees referred in a truly spontaneous fashion and those that they had forsaken but considered relevant once their memory was jogged. This was done in both stages of the research: on the first stage using the list of risk events construed by adapting the list suggested by Manuj and Mentzer (2008b, pp. 199–200) as described below; on the second stage by adapting the list used on the first stage to expressly included the risk of price swings, to try to ascertain if its relevance meets the attention given by the existing literature to price risk in the case of

commodities.

Due to the fact that a common script was being used with organizations in different sectors and with different characteristics, some of the questions were not equally pertinent although this was already expected. At the end of each interview, the essential information was summarized to the interviewees for their validation, focusing on the risks and strategies identified. This option allowed for frequent corrections of some ideas and it almost always allowed for further information to be added. Whenever it proved necessary to clarify doubts or the meaning of some expression or idea, the interviewees were contacted again on a second shorter conversation, this time over the phone, or by email.

The interviews were not scheduled according to the order in which the companies will be introduced below, but rather according to the availability of the interviewees and to the order by which the companies were selected. Although there was a list of possible companies to study, this list suffered changes, throughout the interviews stage, that were considered convenient bearing in mind the information collected in the interviews already carried out. For the benefit of a better understanding of the information collected and discussed further below, it is useful to provide a short introduction of each of the companies included in this stage of the research, along with some aspects that are relevant concerning both the firm and the interviewee. This will be a short description at this time, as several other aspects that are relevant, regarding either the companies or the interviewees, will be referred when appropriate.

For the second stage of the research, the fundamental requisite for companies to be selected was the fact that they were large-scale buyers of steel. There was also an effort to choose companies that had relevant differences between them bet that of scale or o the products they manufactured, to allow some diversity. Geographical considerations were also relevant for practical reasons and so was the fact that the companies were willing to share their experience. The interview procedure replicated the one used in the first stage in its essential aspects. Consequently, the interviews were semi-structured, based on a common script that evolved from the script used in the first stage, with the necessary changes bearing in mind the fact that the reality addressed was that of a single-commodity supply chain perspective.

Just as in the first stage, the interviews took place at the premises of the chosen companies and were audio recorded with the permission of the interviewees. The interviews lasted between 1h20m and 1h50m. Following the procedure used in the first stage, at the end of each

interview, the essential information was verbally summarized to the interviewees for their validation, focusing on the risks and strategies identified. This option allowed for a few corrections of some ideas and most of all allowed for further information to be added by the interviewees. It is important to stress that this identification of risks and strategies was as descriptive as possible, avoiding the use of risk or strategy labels. The interviewees were all willing to be contacted again if it proved necessary to clarify doubts or the meaning of some expression or idea.

Part 5 - Supply chain risk as experienced by companies

5.1 – Multi-sector perspective of supply chain risk experience

5.1.1 – The cases selected

The company here identified as *Pharma* is a branch of a multinational industrial group that is an important player in the pharmaceutical sector, with about 200,000 employees in numerous countries. The group has a central procurement platform in a European country that harbours some corporate projects and represents over thirty plants worldwide. In this platform, some contractual negotiations are centralized in *"lead-buyers"* who do have the role of negotiators and not purchasers. These *lead-buyers* are, in fact, buyers from some of the group's plants who take responsibility for those corporate projects, representing all the other plants. The contractual solution negotiated by these *lead-buyers* is not a mandatory one, as there is usually the liberty to opt-out on a case-by-case basis, although, due to the benefit of added bargaining power, the terms negotiated by those *lead-buyers* are usually the most favourable ones.

About 60% of *Pharma's* costs are purchases, a percentage that is split between the *"productive"* area and the *"non-productive"*. The "*productive"* area spending was split between the "*chemical part"* of the product, which includes excipients and active ingredients, and packaging materials. The interviewee was the supply manager of the company, with 10 years of experience as buyer, first a repetitive buyer and later an initial buyer. He was also head of logistics and answered hierarchically to the organization's board with a considerable degree of autonomy. At the time of the interviews, *Pharma* had clients in over 20 countries with which the firm had *"supply chain agreements"* that involved the possibility of monitoring the stocks of *Pharma's* products at the clients' premises, in order to ensure adequate stock levels and timely deliveries. This allowed easier production planning, although there was limited flexibility due to some production constraints derived from the need to clean equipment to change product.

There are a few more characteristics of this type of industry that proved extremely relevant: highly unpredictable demand; quality and availability are two fundamental issues regarding raw materials; suppliers of raw materials tend to be large international companies; and strict legal requirements with consequences on the time to respond to demand variations and on

the possibility of using different suppliers.

The organization identified as *Plastic* is an industrial company that produces plastic sanitary flushes and plastic components for ceramic flushes. It also imports other products for resale and its main clients are in the construction sector. The company was created over 50 years ago, it has over 300 employees and it is currently a member of an international industrial group with roots in a European country that has been an important market in the company's history, both as seller and buyer. In this case the interviewee was *Plastic's* head of purchasing who had 14 years of purchasing experience, all of them in this company.

During the interview, there was a second interviewee present due to her role as responsible for purchasing in the Far East. Due to the unstable economic situation in Portugal and especially for the construction industry, it was no longer possible for *Plastic* to operate with a two months forecast of materials requirements. The company used to operate with sales forecasts that were considerably accurate as contracts were frequently closed 6 months before the anticipated delivery date.

The firm identified as *Auto 1* is a first tier supplier of components for the auto industry. It is also a plant belonging to a foreign industrial group that has production units in several countries across the world. The procurement function is centralized in the central headquarters of the group in another country in the European Union, but there is a purchasing department in every plant of the group. Coordination of purchasing is centralized but there is considerable autonomy of the local purchasing departments. Negotiations are conduct with autonomy but there are cases in which there are *"corporate suppliers"*.

Previously the interviewee had been a member of the quality department, holding responsibility over suppliers' quality, at the Portuguese plant and, at the time of the interview, he was its purchasing manager with two years on that role.

Metallic is a procurement centre of an industrial group that operates in several sectors, including the constructions and structures for the energy sector. This procurement centre is responsible for the negotiation and, in many cases, the actual purchase of all references that are common to the several business units of the group. This centre aggregates purchasing volume as leverage for negotiation and it also establishes the purchasing policies for the whole group,

applicable both when a centralized purchase is involved and when the purchasing departments of particular business units have the freedom to make specific purchases.

The interviewee started his professional career in this group as construction manager, which implied preparing and managing the project in constant contact with the client. Later he was in charge of sub-contacting for the group and when the group considered that with would benefit from centralizing purchasing this purchasing centre was created and the interviewee became its manager. The group had recently started to buy directly in the international markets. Until then, it lacked scale in its purchasing needs to have the necessary bargaining power to venture in the international market buying directly to foreign suppliers, opting to use local traders. Centralizing purchasing for common needs was an important step towards this objective.

The company referred as *Food* is the centralized procurement unit for a large national group operating in different sectors but with a long history in the food sector. This firm centralizes the negotiation with suppliers for five companies within the industrial group benefiting of volume in terms of bargaining power.

The interviewee is the CEO of the company, however, due to the company's small structure (low headcount), the CEO also acts as negotiator. The interviewee had several years of experience as logistics manager in a previous job position on a local unit of a large North American corporation. This procurement unit had considerable autonomy within the industrial group and its CEO has a seat in the board of the group, which reinforces this autonomy.

Spot purchases by the different companies of the group was to be avoided and whenever they were aware of better conditions than those negotiated by the central procurement unit, the purchasing departments of the different companies were expected to inform *Food*. Most suppliers were Portuguese branches of international companies but the number of foreign suppliers was increasing.

The company identified as *Shipyard* is a small shipyard that builds and, most of all, repairs ships with several decades of history, which had been bought by the industrial group to which *Metallic* also belongs.

All its purchases were centralized in *Metallic*. Although the company's purchasing

requirements are extremely specific, centralizing its purchasing was necessary to ensure that the company could have reasonable prices, because *Shipyard* had a fragile position before its suppliers, due to the company's financial straights prior to its acquisition by *Metallic*. Hence, the interviewee's account referred mostly to the period before the purchasing was centralized, although not exclusively.

Shipyard's activity has a few particular characteristics: it is a *project-based* activity; it purchases an extremely wide variety of materials that includes from the one-off ship engine or part for a special repair to the most common bolt; for some products there are very few alternative suppliers worldwide. In the case, the interviewee was *Shipyard's* general manager due to the fact that the company has a small structure and does not have a procurement or purchasing department.

Auto 2 is a second tier supplier of components for the auto industry. It is a plant belonging to a foreign industrial group that operates in several sectors including the automotive, military, aerospace industry, and medical appliances. This unit, however, is a small plant and this is reflected on its purchasing volumes.

Due to its position in the supply chain of several carmakers and its small scale, this company experiences the expectations of its customers (who are 1st tier suppliers for the automakers) for high levels of performance of *Auto 2*, experiencing the same type of pressure that it exerts on its own suppliers.

The differences between *Auto 1* and *Auto 2* were seen as an opportunity to compare two companies in the same sector but in different tiers of the supply chain, consequently they were the reason behind the decision to use two cases within the same sector. The interviewee started his career in the electronics industry as quality engineer, moving on to different roles in logistics in different organizations until his arrival at *Auto 2* to become its logistics and purchase manager.

5.1.2 – Discussion of the information collected

The information gathered throughout the first stage of the research focused on ascertaining which were, according to the experience of the companies selected, the most relevant supply chain risks, as well as other relevant information regarding the supply chain risk management practices of companies in the Portuguese industrial sector. The first set of interviews afforded an insight into the practices of the companies selected and an account is due of the aspects that were considered most relevant and, particularly, of those aspects that will be directly compared to the information gathered in the second set of interviews.

A first aspect that seems worthy of mention is the fact that all the interviewees in this first set of companies confirmed that they monitored the risk associated to each supplier on regular basis. However, only some of the interviews confirmed that the company had specific tools to ensure that supplier risk was indeed monitored. Furthermore, it is, perhaps, not surprising that the companies that did seem to have such tools were the larger companies, namely, *Pharma*, *Auto 1*, *Metallic* and *Food.*

In several cases the interviewees could clearly identify specific sources of risk that they considered the most relevant. For instance, *Auto 2* finds it difficult to secure the possibility of alternative sources for many of its purchases, due to the characteristics of the products and of the industry. Although the interviewee recognized that dual sourcing could reduce that risk, this is often not possible, exposing the company to all sorts of risk that happen to affect its sole suppliers.

Distance was a factor that different interviews mentioned as having potential impact on risk. For instance, *Auto 2* had experienced frequent disturbances in the scheduled supply due to delays caused by extreme weather conditions that suppliers in Canada, in the USA, or in China, aggravated by the distance that the products have to travel through such harsh conditions. Another aspect that this interviewee mentioned is the impact that currency changes have on the availability of freight, through the imbalances of transits between Europe and, for example, the USA and in the cost of freight *via* the surcharges applied by carriers (e.g. CAF, or BAF in the case of oil price fluctuations), aggravated by distance. Distance can also have an impact for different reasons that were highlighted by the interviewee in *Metallic*, namely by making it impossible (or

at least difficult) of visit the supplier's facilities whenever the supply manager deems it convenient and the possible delays in the many different ports of call of ships on long sea journeys.

Different companies referred some issues internal to the supply chain as being sources for added risk. For instance, whereas *Auto* 2 indicated the pressure to maintain low stock levels as a source of added concern, *Plastic*, *Pharma* and *Auto 2* referred that tight quality requirements increased the exposure to risk of failure of a supplier to meet the quality standards and the added difficulty to qualify alternative suppliers to swiftly replace the defaulting supplier. In some cases, this difficulty was also due to the lack of cooperation by the customers in the effort to qualify alternative suppliers. *Auto 1* and *Auto 2*, curiously both in the auto industry, highlighted this lack of cooperation in what they both said was a cumbersome task but which, apparently, it seemed to be of the exclusive interest of their companies and not of their clients. Having said that, this did not seem to be a major reason for concern since, as the interviewee in *Auto 2* said, past experience shows that when the need arises for a fast qualification of an alternative supplier (*i.e.* when supply chain disruption is eminent), clients usually become much more cooperative.

The answer to the question whether the perception that the interviewees had of different risks depended on probability and possible impact is not a straightforward one. In fact, the information collected reflected contrasting attitudes. The interviewee in *Shipyard* said:

> *"(…) we are only concerned with risks that have low probability of happening but also have great impact, because the others are already part of our activity."*

In a sense, this interviewee does not see recurring risks with low impact as true risks, but rather as events that are expected to happen and, consequently, manageable. However, this may have implicit a confusion as to the meaning of risk on behalf of the interviewee. The interviewee in *Food*, on the other hand, admitted to worrying more, on a day-to-day basis, about small risks than with great risks, but he also added that

> *"(…) we are often left in doubt as to whether we got it right because our tactics and our sensibility achieve it or, on the contrary, whether we incurred in great risks without even being aware of that".*

A final aspect that became apparent, concerning likelihood and impact, was the fact that

the interplay between these two is not static: it depends on the product and even for the product it varies in time. The interviewee in *Auto 2* gave an example as he recalled the piracy surcharge that sea carriers were charging for every cargo from the Far East that sailed past the Somali coast. This used to be a type of event with a slim chance of happening but it seemed to have become a high likelihood risk.

In all of the cases analysed in the first stage there was no formal contingency plan created to cope with a case in which a risk might materialise into a supply disruption that jeopardized production. Although the absence of a contingency plan seemed to be generalized, the reasons given for that were different. In *Food*, according to the interviewee, although there did not exist a formal concept of risk described in the companies' procedures the relevant risk were clearly identified. Even so, the interviewee admitted that this aspect could be linked to a manager's willingness to accept risk and with the company's "*risk culture*". In *Shipyard*, again, the interviewee doubted the feasibility of such a plan saying that

> *"failure of any supplies could only be adequately anticipated and catered for in the case of what we call warehouse products. Otherwise, as the products are extremely specific, their replacement in good time would not be possible. With regard to quality, risk is controlled in a preventive way through product certification."*

A final point of view worthy of mention is that of the interviewee in *Metallic* who justified the absence of a formal contingency plan with the diversity of relevance of the different risks for the different business areas that the procurement centre served.

The first stage of this research resulted in relevant information regarding the risks identified by the interviewees as being the most relevant. An effort was made, throughout the interviews, to avoid influencing the interviewees into highlighting specific risks or specific strategies. However, at the end of the script for the interviews some questions deliberately addressed specific issues that the interviewees would most likely not mention spontaneously. This was the case, for example, of question directed at the use of Incoterms by the company, due to the fact that this information was necessary to discuss some specific aspects.

The interviewees were not requested to name risk events from a previously established list, they were allowed to use whichever terminology they wished. A classification of risk events

was adopted, in order to analyse the information collected and to be able to establish comparisons, by linking the information with the relevant risk event category. The basis for this risk events list was the classification suggested by Manuj and Mentzer (2008b, pp. 199–200) complemented with further risk events that were added whenever they proved necessary to apply to events described by the interviewees that could not be included in Manuj and Mentzer's list in Table 7.

Table 7 - Risk events (Manuj and Mentzer, 2008b, pp.199-200).

Risk events	Description
Currency	Changes in Exchange rates
Transit time	Mean and variability of time spent in transit including transportation time and port clearance
Forecast	Errors in predicting demand leading to stock-outs or excess stock
Quality	Defective, damaged, or wrong product, components or materials; differences across multiple sites
Safety	Products causing safety hazards
Business disruption	Inability to produce goods or sell to customers
Survival	Firm going out of business/bankrupt
Inventory and tools ownership	Confusion and/or dispute over inventory ownership; dispute over use and IP of tools provided by one partner
Culture	Inadequate knowledge about people, culture, and language
Dependency and opportunism	A supplier's or a customer's ability to act opportunistically
Oil price increase	Changes in oil prices

The risks events that have been identified in this stage are those in Table 8, in which the list from Manuj and Mentzer's list in Table 7 above is used, with a few changes and additions. The findings from this stage, as reflected in the table, require a few comments and explanations. These comments will be organised according to the different risk events, in order to favour the comparison of the observations in the different organisations.

Disruption here is seen as an interruption of the operations due to facts internal or external to the firm. It was one of the classes of risk events that frequently referred in the answers of the interviewees and could, in fact, be identified in all of the interviews. This sort of risk events was frequently linked to suppliers inability to deliver and combined with the long transit times in those cases where companies have their sourcing in distant zones of the globe

(for instance, the Far East) was one of the reasons for the companies in this study to keep higher stock levels. In some cases, however, there other reasons that explain the need to maintain added stocks

Table 8 - Risk events identified in the first stage.

Risks events associated to ⬇	Pharma	Plastic	Auto 1	Metallic	Food	Shipyard	Auto 2
Culture		×					
Currency	×		×	×	×	×	×
Disruption	×	×	×	×	×	×	×
Forecast accuracy	×	×			×		
Inventory and tools ownership		×	×				×
Legal issues	×						×
Oil price increases		×			×		×
Quality	×	×	×	×	×	×	×
Security	×	×					
Supplier's financial situation	×	×	×	×	×		×
Supplier's opportunism	×	×	×	×	×	×	×
Survival							
Transit time		×	×	×	×	×	×

.

Pharma is such an example, as the interviewee referred, and for different reasons that are specific to its sector. One reason is the fact that, because the plant produces for countries all over the world, every single variation of international demand is another contribution for uncertainty. Coupled with the totally erratic consumption of many of its products and the long lead times for raw materials, those erratic demand variations increased stocks. Other typical causes for increased stocks in this industry are aspects such as expiry dates, extremely tight quality and the legal obligations to maintain stocks for certain products. According to the interviewee, the company

"… values the performance of the purchasing department in stock levels reduction but the priority is given to product availability. This sector allows and demands – both due to its characteristics and the applicable legal requirements – a little more traditionalism in stock management."

This added level of stocks is not seen as a major concern because, in the manager's words, *"the sector lives with confortable margins"*. This financial robustness also explains why it is not uncommon, according to this manager's experience in this very industrial group, for a company in this sector to opt for vertically integrating a supplier that represents a risk to the continuity or the quality of its supply, when it is not within the company's power or its will to replace that supplier.

Disruption also threatens *Plastic's* operation, particularly due to the pressure to keep low stock levels. This pressure calls upon *Plastic's* suppliers to meet the client's needs with added flexibility, if they wish to retain *Plastic's* business. However, for *Plastic*, the possibility of losing a supplier is also an incident to avoid, bearing in mind the cost associated to that change and the need to recover its valuable tools in possession of the supplier about to be replaced. This is one of the reasons why *Plastic* was focusing its efforts in near-shoring its sourcing whenever that change was quite straightforward (e.g. no tools removal was necessary), in order to achieve shorter lead times for delivery of supplies.

The interviewee in *Metallic* referred the same concern, as he mentioned the effort to secure suppliers that were not too distant and with some geographical dispersion, to spread its risks. Although the interviewee in *Shipyard* referred the same approach, he also stressed that in the case of that particular activity – shipbuilding and repairing – this was not an option, due to the reduced number of possible suppliers and their distant locations.

This set of interviews provided some evidence that the impact of a rupture of availability of products, be that raw materials or finished goods, can be quite diverse for different sectors or simply in different moments in time. An example of this is in the following words of the interviewee in *Plastic*:

"Right now, nobody risks having considerable stock levels. As no one has stock, clients already know that they will have to wait and there is added tolerance to stock ruptures and to longer lead times, because that is how our competitors are working, too."

Auto 1, on the other hand, provided an example that can result in added stock levels and which is also specific to a given scenario:

> *"Although we are best in class when it comes to stock management, always operating with extremely low stock levels, we are now producing for stock, hoping to avoid an extreme reduction of demand that could have a strong impact in hour headcount, because we refuse to send people home."*

This interviewee also confirmed that there were cases in which the company was placing orders that exceeded its needs in order to keep specific suppliers afloat. Despite its obvious impact on the performance of *Auto 1*, from a stock management point of view, this option was seen as a necessity. Maintaining 3 months of stock, instead of the usual 7-8 days, afforded the supplier with an opportunity to recover and gave *Auto 1* the possibility to monitor the supplier's condition and prepare a possible change of supplier.

Several interviewees referred that one of the main approaches to deal with this sort of risk events was to ensure alternative suppliers. This was the case of *Shipyard*, with the limitations referred above, confirmed by the interviewee in *Metallic* (the procurement centre of the group to which *Shipyard* belongs) who also referred the effort to maintain alternative suppliers. However, this interviewee added an important caveat that concerns this option when he reminded that splitting needs between different suppliers decreased the buyer's bargaining power and it may even have a result contrary to that envisaged by the dual sourcing (or multiple):

> *"If I reduce the volume purchased to a given supplier to protect myself from his financial instability, I may be contributing to that instability and end up by putting the supplier in the situation that I wanted to avoid in the first place. On the other hand, even if I do not jeopardize the supplier's financial condition, I may lose the importance that I had to that supplier and, in an ABC logic, that will have an impact on the priority level that he will give to my orders with consequences on the lead times."*

There were cases in which the interviewees referred the impact of contractual sanctions to enforce contractual obligations and try to avoid breaches of service level agreements.

However, *Shipyard* is, according to its general manager, an example where those contractual penalties are little more than an instrument of pressure on the supplier but by no means something on which the company can rely to manage this sort of risks:

> *"If these materials are on the critical path and each day of delay on their deliver means a delay in the conclusion of our work, there will be an huge disproportion between the penalty we will have to pay our client and the one that our supplier may have to pay us."*

Lack of quality was another class of risk events that can be seen in the information collected in every single interview. It is probably not surprising that issues concerning quality were particularly frequent in the interviews carried out in companies whose products, should they have quality issues, have an impact on consumer safety. This was, naturally, the case in *Pharma*, a company that must keep strict quality policies and procedures, frequent process and supplier auditing, constant benchmarking with the competition and, as stressed by the interviewee, technical training of buyers. In fact, almost all of the interviewees stressed the need for accurate knowledge of quality requirements by suppliers and by the company's buyers. In the words of the interviewee in *Food*:

> *"The buyer cannot be cause for wasted time for the quality department, he must be the very first filter."*

This utmost attention to quality indoors and outdoors, which implies using suppliers that have been duly certified, for instance by the sanitary authorities in their own countries, has a return in changing the profile of risk events linked to quality, in the sense that they become low probability ones. *Plastic*'s interviewee provided an example of the care taken in qualifying new suppliers, particularly in *low-cost countries*. At the time of the interview the company was involved in the process of qualification of a new Chinese supplier and this process involved sending representatives to the supplier's plant and contracting a Chinese representative to monitor the suppliers activities. This interviewee also provide a useful example of the different relevance of quality problems depending on the potential liability of the company:

> *"In general, products that we buy from China are meant to be resold and not to be incorporated in our own products. For this reason, quality problems are not so critical, as in the case of products made by us, because we are not liable for damages due those problems."*

The fact that the supply manager in *Auto 1* came out of the quality department is a sign of how important issues linked to quality are in this company, as expressly confirmed by the interviewee. One aspect that was worthy of mention is the fact that this company keeps a *top five* for its worst performing suppliers. Being in this *top five* means that a supplier will have closer scrutiny by *Auto 1*, with escalating measures that go from requests for explanations regarding possible quality issues, to a re-sourcing decision.

Anticipating and avoiding quality linked risk events is hardly an easy task in a context of cost reduction pressure. There is always a difficult balance to preserve but, as the interviewee in *Food* warned,

> *"(…) no procurement centre wants to create competitiveness through quality reduction, so all elements concerning quality requirements are clearly transmitted to suppliers even in the early negotiation stage. Quality is paramount, it is present in every negotiation and it is clearly transmitted to the supplier."*

Despite the clear importance and common concern with the technical expertise of buyers, the interviewee in *Metallic* confessed that there is often an uneven degree of technical knowledge between supplier and buyer that may result in added difficulty for the buyer to accurately assess the risks linked to quality that a specific supplier might involve.

The tools considered adequate to anticipate and avoid this sort of risk events were essentially the same by all interviewees, even though none confirmed that there was a formal list of strategies adopted by the company. With more or less assertiveness, in every interview there was reference to, among others, inspections, auditing and, most of all, certification. In the case of *Shipyard* a distinction was made between the *"warehouse products"* and products that are much more specific when it comes to quality requirements as it is the case of ship engines that undergo a test stage.

The financial stability of suppliers was a common concern between all the companies that were visited and this clearly shows the contextual nature of supply chain risk as it has been discussed in the literature (Kern *et al.*, 2012). The result of the assessment of the likelihood and impact of a given risk will depend on context and on personal experience. The fact that the interviews took place in this financially challenging period is reflected on all of the interviews,

except in the case of *Shipyard*, showed concern with the financial situation of some suppliers. In fact, in some cases it was considered the greatest reason for concern with suppliers. In the case of *Pharma*, the interviewee explained that the company was not overly concerned with this problem because it benefited from a few particularities of the industry: most of its suppliers are large international corporations with considerable financially robustness; the sector enjoys rather confortable margins; and demand is, although erratic, inelastic so that it is not drastically affected by the international economic crisis. Furthermore, in the case of this company, the fact that it belonged to a large international group allowed financial problems of suppliers to be, if necessary, neutralized through vertical integration.

Plastic afforded a good example of the subjective nature of this analysis. The company selects its suppliers based on, essentially, price, quality and lead times, and does not routinely assess the financial status of potential or current suppliers. Notwithstanding this lack of constant attention to this sort of issues – supplier financial risks were considered "*abnormal*" – the fact is that the interviewees in *Plastic* confirmed that attention to them was increasing. They further felt sure that there was a clear notion as to which suppliers represented greater risk from this point of view. Curiously, however, they disagreed as to who those suppliers were, hence the subjective nature of this assessment.

In the past, Auto 1 did not pay special attention to the financial condition of suppliers. Quality was traditionally one of the main concerns and the financial situation of suppliers was analysed as mere routine as there was no experience of supplier bankruptcy. In the present, on the contrary, this has become one of the main concerns due to the frequent information or, at least, rumours of that risk about some suppliers. The same interviewee explained

> *"As a principle reflected in our procedures we avoid having any supplier depending too heavily on our business and avoid that the business we give them amounts to an excessive percentage of their turnover."*

Bearing in mind the hard times that the sector has been going through, it is hardly surprising that the other company in the same sector – *Auto 2* – had the same concern with this sort of problem and the words of the interviewee in this case are quite eloquent:

> *"…everybody is looking around to see which company is the next one to close its doors."*

The interviewee in *Metallic* added a further precaution that their procedures included, referring that any new potential supplier was closely analysed and that this analysis included the financial history that was verified on location.

Currency exchange swings was something that most interviewees did mention, although neither expressed great concern with it. One aspect that seems to have an impact on the degree of that concern is the duration of the company's contracts that stipulate the use of USD as currency. For instance, *Pharma* had most of its supply contracts anticipating the payment in EUR but in those few cases in which payment was due in USD the exchange rate was contractually established and, in any event, they were typically short-term contracts, therefore without special need for revision clauses. The same can be said for *Auto 1*, as most of its contracts were with European suppliers, with prices set in EUR and with a maximum of 3 or 4 years duration. However, in the case of this company, the contracts included normal revision clauses to accommodate the impact of raw materials price swings or currency exchange variations.

The interviewee in *Food* said that despite buying mostly in markets with prices in EUR, there was some exposure to USD and oil price swings in some raw materials and he added

> *"Here, unlike in my previous company, there is no hedging with currency but there is the need to use some hedging with some commodities, to keep the price as stable as possible."*

When the information collected with this interview was analysed for the first time, it was not quite clear, however, whether the interviewee was making an appropriate use of the term hedging in the case of commodities. This was later clarified and what the interviewee was referring to was the use of speculation (forward buying, to be more precise) rather than hedging. This is a clear example of the difficulties that may arise with the interpretation of concepts and the use of taxonomies. On the other hand, it is also a good example of one of the advantages of the using interviews to gather information as these often afford the possibility of clarifying concepts and explaining points of view.

In the case of *Shipyard*, the interviewee said that is was quite common for a small shipyard to be free of this sort of exposure, as it did not really buy all over the world. However, should

the business expand, there would be increased probability of having clients with equipment produced in disparate parts of the globe and, consequently, of being more exposed to prices in USD. Should that become the case, the interviewee anticipated that taking out insurance to cover such risk would probably be the solution adopted. Furthermore, he said that given the fact that the Euro was a "*strong currency*" it was not difficult for both suppliers and clients to accept prices in this currency, despite *Shipyard*'s frequent lack of bargaining power.

The interviewee in *Auto 2* mentioned the possibility of using dual sourcing based on suppliers using the two different currencies (EUR and USD) as a sort of hedging. This manager added a recent example recalling the frustrated effort to find a copper supplier that would accept payment in EUR as an alternative to its South American supplier that was paid in USD. This would also benefit *Auto 2* in terms on transit time and avoiding the hassle at customs with its imports from Brazil. Furthermore, given the extended lead times and their lack of regularity, using the Brazilian supplier resulted in the need for added safety stocks of copper. Given the price of copper and its variation, the interviewee explained that the only reason why using this supplier was not a motive for greater concern was the fact that it was not a material that the company used in a relevant scale. Still, all these factors (such as currency exchange rates fluctuation, irregular lead times, high value of safety stock, customs formalities) were an incentive for the interviewee to keep looking for an alternative in Europe.

Long and, most of all, unpredictable transit times was a concern for all companies except *Pharma*. Coupled with the pressure to keep stock levels down, the possible problems with cargoes from distant sources have the potential to impact supply chain efficiency severely: delays forcing production stoppage, cargo damage, unexpected costs, among others. The fact that this was not a major concern for *Pharma* is not really surprising, bearing in mind that this company deals with air cargoes most of the times because the quantities involved are minute when compared to the shipments of the other companies studied. By the same token, financial costs associated to stock in transit were also irrelevant, regardless of the Incoterm and payment mode contracted.

For *Plastic*, the fact that the company imports goods from the Far East means that it is exposed to the possibility of delays in cases where the normal transit time is already approximately 35 days. This threat of delay may well be aggravated if problems come up with the execution of the payment mode contracted. Therefore, it is important to ensure that the

final partial payment (60%-70%) due upon shipment is promptly made, thus avoiding further delays. This timely payment ensures that the documents are swiftly sent *via* courier service, in order to avoid the risk of having the shipment stuck at the European port where the customs formalities are carried out. Needless to say that such payment arrangements are only used, according to the interviewees, when Plastic has a long-standing relationship with that supplier. The use of Cash Against Documents (CAD) payment arrangements in, thus explained, an option to avoid lengthy and troublesome procedures associated to the use of Letters of Credit (LC), as the previous experience of *Plastic* has shown.

The experience of *Plastic* is also useful to exemplify the attempt to control issues linked to transportation and its transit times through the convenient choice of Incoterm in the contract. In those cases where the product comes from the Far East, the company's option is to contract the purchase in FOB[19] terms (Free On Board), in order to control the carrier and ensure better information throughout the transit. Past experience with carriers engaged by the suppliers revealed deficient tracking of the shipments, with added unpredictability of transit times and lack of information. Moreover, *Plastic* learnt with its experience that, given the responsibility to contract carriage, the supplier often took advantage of that to over-charge for transportation.

Metallic, as opposed to *Plastic*, did not feel the need to control transit times by directly contracting the carrier. In most cases, ensuring that the supplier knew that the carrier was required to provide timely tracking information would suffice. Occasionally, the need could arise for *Metallic* to suggest the use of a specific carrier, whenever it was felt, or the experience so indicated, that the choice of carrier by the supplier could be ill-fated. Having said that, the interviewee said that the best way to ensure timely deliveries was to link payment to different *milestones*.

The experience of two different companies in the same sector, *Auto 1* and *Auto 2*, concerning the way they deal with transport from the suppliers may shed some light on the relevance of scale, bargaining power and the availability of human resources in the firm's capacity to exert some control over the carrier to reduce risks associated to unpredictable transit times. Whereas *Auto 1* takes upon itself the responsibility for contracting the carrier, contracting most

[19] The use of FOB was expressly referred by the interviewees and is, therefore, reproduced herein despite the fact that the shipments concerned involved containerized cargoes.

of its shipments from its suppliers on EXW[20] (Ex-Works) basis, On the contrary, in the case of *Auto 2*, despite the differences in the use of Incoterms by European suppliers and overseas ones, the company typically contracts D terms with suppliers, thereby relinquishing the power to control the carrier. In both cases, the fact that the suppliers could leverage their scale, and the consequent bargaining power, to obtain lower freight rates was relevant but not decisive. In fact, as the interviewee in *Auto 2* confessed, even without that benefit of lower freight quotations they would most likely rather leave to the supplier the responsibility for engaging the carrier, due to lack of internal human resources (beyond the lack of bargaining power) to deal exclusively with contracting carries. According to the interviewee, this is a common practice in the lower tiers of the auto industry.

The interviewees in *Pharma*, *Plastic* and *Food* referred the effects of possible lack of forecast accuracy, although for different reasons. For *Plastic*, the economic context and the strong dependency from the construction activity, in particular the housing sector, was the main cause for concern. It was also the explanation for poor forecast accuracy to be a reality and a reason for extreme concern. The interviewee in *Pharma* stressed the highly erratic demand of some of its products, aggravated by the also highly erratic world demand of many of the raw materials it sourced, exposing the company to difficulty in having accurate forecasts. In this case, however, as it has been referred, the industry typically works with relatively large safety stocks that keep greater worries at bay. The interviewee in *Food*, expressed moderate concern with this risk, expressing the belief that this particular type of risk results as much of in-house forecast inefficiency as of the lack of predictability of demand, hence he believed that it should be controllable to a minimum.

Finally, a few notes are considered useful to highlight some findings concerning the issues derived from the relationship between buyer and supplier, particularly resulting of the different balances of bargaining power between them. These relational issues are, essentially, behavioural phenomena, typical in the context of relationships of the principal-agent type (e.g., bounded rationality, agent opportunism - Williamson, 1975, 1981), as discussed above in the theoretical background section when TCE and Agency Theory were mentioned. To be more specific, the issues that are yet to be addressed are those that may result in risk associated to the

[20] The use of EWX was expressly referred by the interviewee and is, therefore, reproduced herein despite the fact that it often refers to shipments from outside the EU, which means that (most likely or, at least, probably) they were not executed as true EXW shipments.

opportunism of the supplier.

The first aspect that is relevant and justifies some attention concerns the consequences of the number of available suppliers. One could be led to believe that the fact that a company has a single supplier could, by itself, expose the buyer to opportunistic behaviour. However, further consideration of this possibility would easily reveal the fact that, more than how many suppliers the company has and the number available suppliers, it is the likelihood of changing to a new supplier without serious disturbance of the operations that is relevant. The interviewee in *Pharma* provided a clear example for that when remarked that there was no need to keep alternative suppliers for a product like *paracetamol* because there is great availability of such a product and the prices are very likely similar. In such a case having two suppliers for the purpose of fulfilling legal requirements should be enough and the company usually only tries to secure two suppliers, one European and one from Asia, usually from India.

Plastic is, in many cases, unable to have alternative suppliers, particularly when there are non-standard products involved, products that are often designed by *Plastic*. Usually, in such cases, the company ask three different producers for their quotations and chooses one of them. The need to grant those suppliers access to *Plastic*'s tools, which often have valuable proprietary designs, is detrimental to the possibility of maintaining alternative suppliers. *Shipyard* is also a clear example of the effect that the nature of the products has in the possibility of maintaining alternative suppliers, as there was a clear difference between *warehouse products* and, for example, the case of engines that have a much smaller number of alternative suppliers.

Beyond the number of suppliers, the importance of the product also has impact on the relationship with suppliers. The interviewee in *Pharma* exemplified this with the case of cardboard suppliers for packaging. In this case, there is usually an annual meeting with the supplier to verify whether the contractual terms are aligned with the market conditions. On the other hand, when it comes to raw materials, there are frequent meetings with each supplier, often every quarter, with a view to discussing new products, continuous improvement, among other issues. The interviewee's opinion was that a closer relationship implies lower risk levels. However, precautions are taken to avoid allowing this proximity to reach a point that could become harmful:

"Whenever we choose a new supplier we analyse its annual turnover and we try to make sure

that the volume of our purchases to that supplier will not exceed 40% of its volume".

Plastic has rather long-standing relationships with some of its suppliers and the interviewees were very sure that this contributes to lower risk levels, particularly in those cases where there are personal relationships between the shareholders of both companies. For the same sort of reasons, the interviewee in *Auto 1* considered that some of the cases with added risk were those of 2nd tier suppliers that the company was compelled to use by its customer, some of which they hardly knew.

Food also recognised that there were some products that were considered strategic and that, in those cases, negotiations with suppliers were conducted on different terms, accepting that there would have to exist added profit sharing with the supplier. According to the interviewee, that benefit sharing is fundamental to keep the supplier interested in the buyer's business. However, this interviewee stressed the importance of maintaining, even in these cases, alternative suppliers to avoid excessive dependency.

For *Shipyard*, in some cases, the proximity, the trust and, consequently, the lower risk result of the fact that the market for the relevant products is quite small and *everybody knows each other*.

Focusing specifically on the subject of supplier opportunism, the interviewees in *Pharma*, and *Food* provided examples of situations in which the opportunism of suppliers is supported by a concerted strategy of different players in the market and different ways to fight back. In fact, all these interviewees stressed that the likelihood of opportunism does not depend on the number of available suppliers alone but on how real the competition between them is. *Pharma* had until recently experienced some vulnerability to this opportunism due to the fact that it dealt directly with distributors and traders as it did not have enough purchasing volume to go directly to the source. In that context, some Portuguese distributors, most likely operating in some sort of collusion strategy, had unjustifiable margins but *Pharma*, by streamlining its supply channels and adopting direct procurement, managed to reduce that exposure to opportunism.

Both interviewees in *Metallic* and in *Auto 1* recalled the effect that aggregating purchase volume had in reducing this supplier opportunism in cases where the problem was not some informal coalition of potential suppliers but simply an uneven distribution of bargaining power due to insufficient scale of the buyer.

In the case of *Auto 1* this was addressed through the use of what the interviewee called "*corporate suppliers*", through the centralized procurement of the group's headquarters. The same effect was achieved by *Metallic* for several companies of the group (including *Shipyard*) through the centralized negotiation for the whole group.

The opportunism of the supplier can arise in different forms. The first that comes to mind is over-pricing, but it is also frequently materialised in longer lead times or in the frequent postponement of the promised delivery dates. Adequate planning can accommodate longer lead times, as the interviewee in *Metallic* mentioned, provided that they are accurate. However, he also recalled a case in which *Metallic*'s lack of bargaining power before a giant foundry in India became apparent when the purchase volume forecast used in the negotiation turned out to be quite smaller: the delivery date was pushed back several times until the order was finally cancelled by *Metallic*.

This first set of interviews brought some insight into the relevance of different risks experienced by the companies where the interviews were carried out. Having analysed the information gathered in this group, several risks stood out as being more relevant in this group of companies from different industrial sectors. This analysis has been carried out, and so have the interviews in this group, without particular focus on a single product but rather considering the companies' operations in general terms. That does not mean that the interviewees did not consider specific products in the answers, but only because they represent an example within their experience. This is quite different from analysing the risks experienced by companies in relation to a single product. This was the purpose of the second set of interviews in which the focus was set on a single product, or better still on a given commodity, with a view to detecting whether there are relevant differences in the case of commodities. Some conclusions can be drawn from this first set of interviews, namely concerning the relevance of risks such as quality related risks, risks associated to transit times, disruption risks or risks associated to supplier dependency and supplier opportunism. However, these will be analysed later as they are compared to the findings in the second set of interviews.

5.2 – Supply chain risk experience in the steel supply chain

5.2.1 – The cases selected

Steel S is a group of metal works companies that produce stainless steel equipment and structures for companies operating in several sectors such as the chemical and petrochemical industries, the pharmaceutical industry, the food industry, the renewable energy sector and the cargo transportation sector. The group produces 3 sub-groups of products spread across the different companies: equipment for product storage under pressure for industries such as the chemical and petrochemical industries; wind turbine towers; and tanks for road carriage of fuel, gas and chemicals. These sub-groups have different needs and their purchasing practices reflect those differences. The production in these sub-groups is also further divided into standard products and special products that are produced according to clients' requirements and specifications. The steel purchases of this group of companies amount to approximately 20.000 tonnes/year and the interviewee buys approximately 1.500 tonnes of that quantity for the company that he works for. Steel purchases represent 65% of the cost of the final product and a very meaningful percentage of the total purchase volume of the group that the interviewee could not say precisely.

The interviewee has been with this group for the entirety of his professional career of 28 years. At the time of the interview he was the head of purchasing at one of the group's companies but, until a few years before that date and for several years, he had the same role at a different company within the group where he was in charge of purchasing a considerably greater amount of steel. Due to the interviewee's knowledge of steel purchasing experience of the whole group, the interview focused aspects concerning the whole group and not his present company alone.

Steel M is, in fact, the same organization that in the first stage of the research was called *Metallic.* In the first part of the research it was used to obtain information from the point of view of a large buyer of a great diversity of products and the information gathered referred to supply risk management in general whereas here it is focused on the supply chain of steel alone.

The interviewee is the same person who was interviewed for the first leg of the research,

although he is now head of procurement of two of the business units of the group. This approach is expected to afford some further opportunities to establish some comparisons whilst ensuring that it is not a matter of different points of view of different interviewees that explains those differences. Despite the fact that there was an opportunity to interview the present head of the procurement centre of *Metallic* (now *Steel M*) a deliberate choice was made to interview the same manager.

As the organization and the interviewee are the same that have been reported above, it becomes unnecessary to repeat the details that were then provided regarding their profiles. However, it is useful to provide details specifically concerning the steel supply chain of *Steel M*. This is one of the largest metal works groups in Portugal with its activity spreading from the metallic structures for the construction industry, to shipbuilding, solar and wind energy structures, with projects completed or on-going in most continents across the globe. Within the context of Portugal, it is a major steel buyer, averaging a total of 50.000 tonnes of steel purchased yearly,. However, the purchasing intervals vary for reasons better explained in the following sub-section, therefore refer thereto for the details. According to the interviewee, this annual purchase volume is hardly enough for the organization to have any bargaining power before the producer. When compared to large stockists, the company is, according to the interviewee, almost irrelevant.

Steel L is a group of metal works companies and its core activity is manufacturing steel pipes although it also has other types of steel-based products in the group's portfolio. The group's plants are scattered over three continents - Europe, Africa and South America – and in its local units alone its annual steel purchase volume amounts to 200.000 tonnes. The importance of steel for this group can be seen in the fact that it represents 90% of its costs and the procurement of supply is centralized in one of the group's Board of Administration members. The interviewee is in direct contact with that Board member, he has been with this Group for over 5 years as an assessor to the Board but had no prior experience.

The group maintains an average of 10 alternative suppliers but has one supplier that the interviewee considered "*the main supplier*". One aspect that distinguishes the company from the other two is the fact that it occasionally buys a full ship of steel, going directly to the producer.

This interviewee in *Steel L* was the only one who asked for the list of questions in advance and a basic script of the interview, with the topics to be addressed, was provided by email.

Although one might have expected this to allow greater accuracy of the information transmitted by the interviewee, the fact is that it may have been somewhat detrimental to the quality of the information collected. However, this will be discussed later herein.

5.2.2 – Risk in steel supply chains: discussion of the information collected

The analysis of the information gathered with the interviews revealed the risks that represented the greatest causes for concern from the point of view of the companies chosen, in so far as their steel supply chains are concerned. To maintain the coherence of the analysis in the two stages of this research, the starting point for interpretation of the information in the interviews was the same list of risk events used in the first leg. However, the settings were different because the first stage focused on companies that operate in different sectors and their supply chain risk management experiences were analysed in general terms rather than focusing on specific products purchased, whereas in the second stage different companies were analysed but focusing on a common single type of product.

Consequently, some changes had to be made and, as the need for some of these changes became quickly apparent, this allowed their implementation from the outset and their incorporation in the script for the interviews that was somewhat different from the one used in the first stage (Annex 6). This also meant that, although the basic list of risks has been preserved as a starting point, it was anticipated that it could prove necessary to add new risks. In fact, one of the very first drivers for the present research had been, as explained before, the fact that most of the literature focusing on supply risk management in the case of commodities focused on what was referred as "price risk", a risk that did not come up – at least named as such - throughout any of the interviews carried out in the first stage, with the exception of casual references to price variation of different products (e.g. the case of copper in *Auto 2*) although they were never expressly referred to as being a risk. However, in the end, in this second stage of interviews no new risks were added, except for commodity price volatility, due to the fact that no new risks were discoverable in the accounts of the experience of the interviewees.

The findings of this set of interviews are summarized in Table 9 and they will be reported following the template adopted for the first part, i.e. by addressing the most relevant risk

identified, linking them, whenever possible, to the strategies used and illustrating the companies' experiences.

Table 9 – Risk events identified in steel supply chains

Risks events associated to ⬇	Steel S	Steel M	Steel L
Commodity price volatility			×
Culture			
Currency	×	×	×
Disruption	×	×	×
Forecast accuracy	×		×
Inventory and tools ownership			
Legal issues			
Oil price increases	×		
Quality	×	×	×
Security			
Supplier's financial situation			
Supplier's opportunism	×	×	×
Survival			
Transit time			×

In the first set of interviews, disruption had been understood as an interruption of the operations due to facts internal or external to the firm. In those interviews, this sort of risk event was frequently linked to suppliers' inability to deliver the goods. Furthermore, it was then said that this was often associated to long transit times in those cases where companies had their sourcing in distant zones of the globe. In the case of steel supply chains, this seems to be the most relevant concern for the companies studied. However, the reasons for this greater relevance, and the degree of concern involved, depend on different factors that are worthy of being further explored here. Before that, however, a caveat is deemed important to make clear that Table 9 illustrates the identification of risks that emerged from the analysis of the interviews but it merely counts risks mentioned. It does not add anything that can express their relevance,

be that from the point of view of probability or of impact. This, as it will be further explained later, is relevant, hence the caveat, because one might be led to understand from the fact that two risks were identified in the same number of cases that they are equally relevant, which is not the case.

Although *Steel M* imports 50.000 tonnes of steel annually, this quantity is unevenly distributed by several different kinds of steel and not on a regular basis. Bearing in mind that the group's activity is typically a project-based one and it is very much focused on, though not limited to, public tenders, the patterns of demand are quite irregular, if we can use the term pattern at all. Consequently, the irregularity of the company's needs, and the nature of its operations – the fact that they are mostly project-based – means that the company cannot have precise consumption estimates to negotiate with suppliers until there is a confirmed project. Despite the fact that they may appear to be a considerable quantity, those 50.000 tonnes of annual consumption, are, in fact, *a risk factor*, as the interviewee explained:

> *"These 50.000 tonnes may seem a large quantity and we may be large final consumers, so to speak, before the stockists or the trader, but before the large steel mills we are insignificant."*

The interviewee further explained why, even though the company purchases those quantities, it is unable to secure availability of steel by keeping it in stock:

> *"…for every project the requirements for supplies are as per project specifications, therefore there is no opportunity to maintain an anticipatory stock to ensure the availability of materials. I may even use an estimated value in my conversations with the producer but until I do have a project I cannot place an order, so I cannot make stock beforehand."*

For this reason *Steel M* cannot go directly to a foundry bypassing traders and large stockists. Another reason concerns planning restrictions because the steel that is required for a given project is neither needed all at once nor is it always of the same type. Consequently, lack of scale is a notorious problem, one that was expressly mentioned in two of the interviews carried out. Beyond the express references, the lack of scale was also behind the common concerns with problems such as extended lead times, late deliveries, or some sort of opportunistic behaviour of the supplier.

The interviewee in *Steel L* was the only one that expressed no concern directly associated to the lack of scale, although it also recognized its insufficient lack of true bargaining power before its suppliers. In this case, however, benefiting from the fact that it is a large steel buyer, even for international standards, *Steel L* - as the interviewee explained - has direct access to its main suppliers and privileged direct communication channels between *Steel L*'s Board of Administration and the suppliers' Boards.

In the case of *Steel S*, on the other hand, the manager interviewed was clearly aware of his company's irrelevance before its large suppliers. In fact, this lack of bargaining power was clearly identified as the main source of concern for two reasons. First, downstream, the company's clients are, in most cases, larger than *Steel S* and they are usually bound by large project-based contracts that include heavy penalties for delays. Upstream, however, *Steel S* also has suppliers that are huge multinational companies that by no-means accept the same sort of penalties in their contracts. Therefore, whenever delays occur, the company faces the risk of having to pay heavy penalties to clients and is unable to reflect those penalties on the suppliers who have failed to meet the contracted timings. Secondly, whenever delays occur - and they do occur frequently, for reasons to be explained later – *Steel S* has no leverage whatsoever to put pressure on the supplier. In any event, putting pressure on the supplier would always be pointless given the size of *Steel S*'s orders that could never make a full cargo for a ship and would always have to wait for the supplier to have a full ship bound for the same port.

This is a problem that *Steel M* also has to face frequently. Due to the size of the company's orders, it is occasionally forced to wait for the supplier's to have a full ship cargo. Moreover, in the case of *Steel M* this problem is aggravated by the fact that, whereas *Steel S* maintains an average stock of steel for 6 months, depending on the type of steel, *Steel M* cannot afford to keep steel in stock as a general rule, due to the fact that it works on a project-basis and, according to the interviewee,

> *"(…) no two projects have equal requirements when it comes to steel, and, even if the steel could be identical, it is not uncommon for the client to say that he wants the steel to come from a supplier within a certain radius of the project site. Some times we understand this requirement but it often seems to be some sort of protectionism in favour of that supplier."*

On the contrary, *Steel L* does not seem to have extreme concerns with delays caused by

the fact that the supplier is waiting for other orders to complete a full ship. This is not surprising bearing in mind that it frequently has either a full ship cargo or close to that. Knowing that other manufacturers have to wait for the ship to be fully loaded to sail, the interviewee ventured to guess that

> *"(...) it is quite possible that when other companies see their cargoes being delayed at the port of shipment, they are in fact waiting for the ship to have our cargo on board. It is quite possible that their supplier is using whatever freight space is left on the ship after our cargo is on board."*

Apparently, the fact that *Steel L* buys far more steel than the other two companies do – four times the purchase volume of *Steel M* and tenfold the purchase volume of *Steel S* - has an impact on the time that *Steel L* has to wait for the steel to be shipped. However, this company also has to cope with the possibility of delays with the cargo. According to the interviewee, the offer of service by shipping companies for their steel cargoes has been severely cut and there are currently noticeably fewer ships available to bring cargo to the Portuguese ports used by these companies.

The interviewees in the other two companies referred to this issue as well. The interviewee in *Steel S* said that

> *"(…) most delays are linked to shipment, although things are changing a bit. We used to have a weekly ship sailing from Antwerp that would ship cargo from Belgium and from Germany. However, when the economic crisis emerged in Portugal, that turned into a monthly ship and later on it turned into a "pending confirmation monthly ship". This means that if the steel was ready within the estimated production time but the ship sailed last week, I will have to wait three more weeks or even more."*

Steel S was the only case in which a strategy to cope with this type of risk event was expressly referred. Bearing in mind the large safety stock that the company keeps, this would be rather surprising if it were not the fact that the interviewee was referring mostly (although not exclusively) to special orders, i.e. orders for products that *Steel S* does not keep in stock. According to the interviewee, this was the reason why he currently asks for CIP quotations (instead of the CIF terms usually contracted) for those orders that the suppliers say that have a

production lead time of (e.g.) 2 months and a shipping date said to be *"according to ship's availability"*. In such cases, as he has reasons to fear that shipment might be delayed due to want of available ship, he arranges for the steel to be delivered by truck directly to the buyer's plant. This way, should a ship be available, it is always possible for the cargo to be delivered to the relevant Portuguese port by ship and subsequently be carried by truck, also contracted by the seller, to the buyer's plant.

Again, it is important to stress that the interviewee referred that this was a problem only relevant with special orders and that with standard raw materials it was not critical due to the average stock for 6 months of steel demand. In times of a *"critical market"*, as the interviewee called it, the company can even keep a 9 months stock of steel for standard products. The interviewee justified this rather high stock level with different reasons. One of those reasons is the obvious need to ensure product availability, but one of the most important considerations is the need to ensure the benefit of scale, both from the point of view of economy of scale (*via* purchase price and transport) and front the point of view of bargaining power. Buying steel about 5 times a year, the interviewee preserves some of the benefits of scale but also believes to be reducing his exposure to the delays of any of his suppliers. Of course that, as the interviewee recognizes, this does not avoid the possibility of a given shipment being late and the fact that it is not feasible to arrange for a substitute order with another supplier. However, as the interviewee believes, it does reduce the impact of each supplier, preserving some scale and the availability of product clearly compensates for the capital invested in stock.

In the case of *Steel M*, it is not uncommon for larger orders to be split between two suppliers to reduce the risk of problems caused by a supplier's delay. When this is the case, the interviewee in *Steel M* does not feel that the price is affected:

> *"(…) when I buy from a stockist, he usually has stock and he charges the same whether I buy more or less. It really doesn't matter, unless I have a project to launch in 3 months and ask the stockist to give me a price for, say, 1.000 tonnes. In this case, he will most likely take that volume, add it to other orders that he might have and go to a steel mill for that product. In such a case, I may benefit from the price he gets, when compared to the price of the product that he usually keeps in stock. But this is not what normally happens. In most cases I buy steel that he keeps in stock and he has his margins already defined and charges me the same irrespective of the size of my order."*

Contrasting with *Steel S*, *Steel L* has considerable less stock of raw materials. According to the interviewee in the latter company, orders are placed on average on a monthly basis and the company keeps approximately 2 months of stock. This is obviously linked to the fact that the company buys at a much larger scale, which clearly allows a much greater splitting of the steel orders. On the other hand, this company keeps considerable levels of stock when it comes to finished products, which is explained, according to the interviewee, with the importance of product availability from a competitive strategy point of view.

The interviewee in *Steel M* expressed similar concerns in relation to the possibility of experiencing problems associated to transport that cause a disruption of the operations. However, in the case of this company, notwithstanding the fact that this is reason for concern, it seems that the problem is dealt with considering longer lead times and placing the orders earlier.

Similarly to the case of *Steel S*, the interviewee in *Steel M* also distinguished the cases involving steel with special requirements and those in which the product is of a common type. In the latter case, the national stockists usually keep some stock and it is uncommon for the delivery to be performed later than contracted. On the other hand, delays sometimes occur with orders for non-standard products that the stockists do have to buy or when an order is placed to a trader who has not bought product in advance anticipating demand for it. These delays, however, are not usually linked to the insufficient availability of transport, according to the interviewee, but rather to problems of a procedural nature, linked either to the customs formalities, or to the payment mechanisms used.

The interviewee in *Steel M* could not be absolutely sure as to the exact cause of those delays because the process is controlled by the supplier, be that a producer, a trader or a stockist. The interviewee was referring to orders that are delivered on a *door-to-door* basis and in which import customs duties and formalities are the responsibility of the supplier. Sometimes, in such cases, the steel is detained at the Portuguese port whilst waiting for the customs formalities to be dealt with by the trader or stockist. Trying to control this operation is not an option, according to the interviewee who admitted that

> *"(…) we are not very good at dealing with customs formalities, we lack the expertise and the vocation".*

In some other cases, the interviewee believes that the problem might result of payment arrangements gone wrong. When *Steel M* buys directly to producers, they frequently demand the use of letters of credit (hereinafter LC) or first demand bank guarantees (hereinafter DG) as part of the payment arrangements. When the company buys through traders or from stockists, it does so on open account terms (usually payment is due in 90 days), hence, in such cases, *Steel M* does not have to deal with LCs or DGs. Yet, the trader or the stockist may have to apply for an LC or a DG himself as part of the payment terms contracted with the producer. This, however, is only a possibility admitted by the interviewee, but he stressed that he did not know whether this is the case. Either way, the use of these instruments may be the cause for different difficulties such as the difficulty in obtaining those financial instruments from banks (a problem that has increased with the Portuguese bail-out, as confirmed by the interviewee), the delays caused by bank procedures or other reasons that the interviewee could not quite put his finger on:

> *"Sometimes, I am told that the BL hasn't arrived yet but I find that rather strange in the case of shipments from the Far East, with several weeks transit times, and in this era of fast communication."*

Although some delays are possibly associated to the payment procedures, the interviewee in *Steel M* is convinced that, in most cases, it is just a typical case of inefficiency caused by bureaucracy. To avoid dealing with bureaucracy, *Steel M* frequently contracts the purchase in DDP terms, thereby ensuring that all of the potentially cumbersome formalities and the responsibility for contracting carriage are transferred to the supplier. However, the interviewee is perfectly aware that this is a double–edged sword: the supplier takes full responsibility and bears all risks, but *Steel M* relinquishes any control over the operation, exposing the company to any inefficiencies that the suppliers arrangements may have. Although the interviewee acknowledges this problem, he is unable to take control of the logistics of the purchase, even when he buys directly to the producer instead of buying from a stockist. The reason for that lies in the fact that the group seldom places an order large enough to charter a full vessel.

Even if it were possible for *Steel M* to contract the carriage and contract the purchase in FOB terms, it would most likely have less control over the operation than intended, due to the issues associated to the terms of the contracts with the steel producers discussed further below. Should *Steel M* contract only some space on a ship, the cargo would usually have to wait for the

ship to have a full cargo load as no carrier will usually sail with dead freight, if he can still gather more cargo. As the interviewee says, whatever problems a stockist or a trader faces to bring the steel to *Steel M*, this company would also face them if it were to take that responsibility upon itself. Therefore, all things considered, the interviewee prefers to relinquish the power to control the operation and rely on contract penalties to induce the supplier to make use of its best efforts to meet his delivery obligations, rather than taking up the cargo EXW or on some F term and transferring to *Steel M* the burden of facing whatever happens until the cargo reaches its facilities. The problem is that whereas the contracts with suppliers for other products may included penalties for delays, the terms contracted with steel suppliers will most likely include no such penalties, as it will be discussed later.

For *Steel M*, the unavoidable nature of most of these delays, either caused by logistics reasons, by customs procedures or by bank delays, is aggravated in the case of steel by the fact that this product is usually incorporated in the project in its early stages. Therefore, the interviewee considers any delay that affects a consignment of steel truly worrisome due to its impact on the rest of the project. This is further aggravated by the fact that several milestones populate the contractual arrangements of the projects and they are conditions for partial payments to be received. If those milestones are not met, the company does not receive those partial payments (Table 10) but still has to its suppliers in the contracted dates.

Table 10 - Typical patterns of shipyard stage payments (Source: H. Clarkson newbuilding department *in* Stopford, 2009, p. 208)

Stage in production	Payment due
Signing of contract	10 per cent
Steel cutting	22.5 per cent
Keel laying	22.5 per cent
Launching	22.5 per cent
Delivery	22.5 per cent

To try to mitigate this sort of problem, *Steel M* has been negotiating with different suppliers the use of a credit cap for certain projects, in order to establish that, for that product, the company will not have its supplies withheld due to payments that have not been made. Of course that this *"credit line"* is frequently support by some sort of guarantee that *Steel M* has to provide the supplier with, such as a letter of comfort by a third party or by the holding company (the *"SGPS"*) in favour of a smaller company of the group.

Whenever shipping documents are delayed, all interviews referred that, besides the disruption of the operation, the unexpected demurrage charges, port charges and other sorts of expenses are recurrent consequences. The interviewee in *Steel M* said that in about 50% of the deliveries by ship (as opposed to orders fulfilled from the stockist's warehouse) the same always happens:

> *"(…) we know that the ship is there, the steel is there but the BL is yet to arrive and we cannot put our hands on the steel and the ship is charging demurrage".*

None of the interviewees referred to transit times as a reason for extreme concern and even when directly questioned, at the end of the interview, they confirmed that lack of relevance. This is somewhat expectable bearing in mind that, when it comes to steel, all of these companies have their suppliers mostly in Europe. Although, as explained above, there are problems associated to the carriage of steel, these derive of procedural issues relating to the documents, of the lack of transport or of its irregular availability, of the impossibility of having full ship cargoes and the consequences thereof, rather than of unpredictable transit times.

The only interviewee that spontaneously mentioned problems with transit times was the interviewee in *Steel L*. This, however, was due to the fact that the group often buys a full ship of steel from China and in these cases transit delays can happen with greater frequency. Yet, he clarified that the frequency was still low and was not reason for concern, unlike the potential impact of those delays:

> *"When we buy 10.000 tonnes of steel from China we are talking about a full ship and it is a full ship of cargo that is delayed. But this does not happen often and, in any event, we manage the situation with stock."*

Figure 13 - Steel coils being loaded on board a ship (Source: Kyle Telechan, The Times)

For that reason, any possible delays are attenuated by the fact that the *Steel L* maintains what the interviewee considered large stock levels, both of raw material and finished products. Interestingly, the interviewee considered 2 months of stock a considerable figure while *Steel S* maintains 6 moths plus of stock with no apparent reason for concern.

In the first stage of this research several companies expressed concerns with problems arising from lack of quality associated to suppliers. Based on the information transmitted by all of the interviewees in the second stage, this does not seem to be an issue causing special concern. However, this does not mean that quality is not paramount when it comes to steel and that the lack thereof is not a risk. In fact, the importance of quality justifies the contractual impediment of buying steel in certain countries (such as China and Korea) that clients often put in contracts, for instance in the case of *Steel M*. The numerous steel grades, properties and standards are clearly identified in international steel trade and the characteristics and the quality of the product are usually certified. Furthermore, all interviewees stressed that their suppliers were all certified companies. The interviewee in *Steel S*, for example, is adamant with regard to the requirement that the steel he purchases is duly certified:

"I cannot conceive the possibility of buying steel that does not come certified."

Hence, the generalization of the use of product certification is the reason why none of the interviewees had any serious complaint regarding past experiences with quality problems.

There was only one episode worthy of mention experienced by *Steel M* some years ago, when the group had a large order that it was directly placed to a producer in China. In this case, *Steel M* received a cargo of steel from China that was damaged although it had all the certificates that it was supposed to. However, in that case the damage occurred prior to the passage of risk *as per* contract (it was a CIF purchase), in fact, it was a clear matter of production defects. Consequently, the supplier had to take responsibility for the damage, or rather the defects. It would seem that the episode did not cause relevant damages to *Steel M*, but the interviewee agreed that the consequences of the delay could have been reduced if the company had opted for arranging a pre-shipment inspection of the steel. Yet, this is something that usually *Steel M* does not require from its suppliers, although the interviewee admitted that it should perhaps be considered for larger shipments.

This contrasts with *Steel L* that frequently asks its suppliers to quote CFR in order to keep the possibility of contracting insurance, bearing in mind that it usually gets good insurance quotations and its underwriter's service includes the pre-shipment inspection of the cargo at the passage of risk. In spite of that incident, the interviewee in *Steel M* clarified that this happened with a Chinese supplier but it can happen with a supplier from any other country. As an example he said that he had the opportunity to visit several steel mills in India and that he saw some plants that were absolutely *first class*, with every single piece of steel being individually verified, but he also saw others that were clearly sub-standard.

The same interviewee also referred that quality concerns may sometimes lead to delays. For example, when an European stockist in, e.g., the Netherlands has a certain type of steel but that specific lot has not been certified and tested according to the requirements in *Steel M*'s project, the product must be re-tested and re-certified which often causes delays. Another example that he referred is when the company has steel available and it is certified as being of the quality established by the client but the classification was not verified by the organization established in the contract with *Steel M*'s client. This means that a re-classification will be necessary and this takes valuable time. However, this is not to be considered a problem of quality but rather another cause for delay.

Both *Steel S* and *Steel M* referred that the fact that sometimes their purchase forecasts lack accuracy can increase their exposure to delays caused by the failure of the supplier to meet the contracted delivery date. As the interviewee in *Steel M* said, when he approaches a

supplier anticipating the need for steel for a certain project, he puts forward a figure that he is not always certain whether it is a final one, be that in terms of quantities of standard steel or of steel with special requirements. In other instances, he may have to negotiate prices for steel for contracts of longer duration and has to do so based on anticipated needs. In either case, the actual needs sometimes prove to be short of the anticipated volume. The interviewee believes that this does not interfere with the scheduling of the order on the producer's planning hence no delay is thereby caused. However, he also acknowledged that he felt this sometimes leads to the shipment being delayed as the producer gathers more freight to contract the carriage. In fact, the same interviewee, when he was interviewed in the first stage of this research, referred a case in which his company (*Metallic*), in a purchase made directly from a giant foundry in India, could not place an order large enough to meet the volume forecast used in the negotiation and this caused the delivery date to be pushed back several times until the order was finally cancelled by *Metallic*.

Apart from this impact through the shipment delay and, as a consequence, the possibility of disruption, forecast accuracy was not considered a source of problems by any of the interviewees. This is, perhaps, not too surprising if one recalls the following aspects: *Steel S* maintains considerably high stock levels; *Steel M* works mostly on a project basis and is, therefore, able to schedule the purchases of the most critical kinds of steel keeping some stock for those that are more common to most projects; and *Steel L*, benefiting of the scale of its steel consumption, has an order cycle that makes it easier to adjust the orders placed to the needs anticipated on a shorter term.

In the first set of interviews, one of the main concerns expressed by most of the interviewees was the financial situation of some suppliers. The context of the interviews, bearing in mind their timings and the industrial sectors concerned, can explain - as it has been done above - the reasons for this relevance, which is a clear evidence of the contextual nature of supply chain risk. In the second set of interviews, none of the interviewees spontaneously mentioned this as a cause for concern. A supplier's bankruptcy does not seem to be a risk event that comes to their mind when they reflect on the risks that their steel supply chains may be exposed to. A possible explanation for this could be the fact that a few years of financial crisis have turned the possibility of financial distress of a supplier into a "normal event", so to speak. In other words, the fact that the financial crisis increased the likelihood of this risk could have changed companies' perception by turning a turmoil-causing event into something quite banal, an event that they are prepared to tackle. Another possible explanation could be the possibility of

the first waves of bankruptcies having purged the market by excluding the suppliers that were financially more fragile.

These explanations, however, are purely speculative and possibly even farfetched, particularly if one considers that there might be more plausible ones. Indeed, if one considers the fact that most steel suppliers are large companies that dwarf any numbers that the financial reports of companies studied could contain, it is perhaps not surprising that the interviewees are not concerned with the financial situation of their steel suppliers. On the other hand, the fact that there is no integration of any sort between the operations of the companies studied and their steel suppliers, nor is there any sort of dependency of their operations on the suppliers condition is also probably relevant. This can be easily understood if we recall the differences between the relationship that exist between a company like *Auto I* and its suppliers (typical in the auto industry) and the relationships of any of the companies in the second set of interviews and their steel suppliers. Even if there could be any reason for concern, these companies would have to wait for external signs or public knowledge of the financial difficulties of the steel supplier, as the interviewee in *Steel S* said:

> *"I usually ask my suppliers to provide their financial reports in order to assess the risk they represent. Sometimes I even do it in the context of a negotiation, or I get it myself, so that, when they tell me that things are tough and they have to raise their price, I can show them the profits they reported are much greater than ours. Of course that if I ask a company like Arcelor, or any other of that type, for its financial data they will laugh on my face."*

Considering the fact the global nature of commodities markets, it would not be surprising to discover that these steel importers are exposed to the effects of currency exchange swings of the exchange rates EUR/USD. However, none of the interviewees expressed considerable concern with exchange rates, although the interviewee in *Steel L* admitted that the group keeps a close watch on the EUR/USD exchange rate changes and adopts some strategies to cope with them. The fact that in all three cases most suppliers are located in Europe could possibly explain this observation. In fact, with the exception of *Steel L*, currency exchange rates swings were only discussed because they were mentioned in the risk event checklist used at the end of each interview. Furthermore, the fact that they do not seem to be very relevant was reinforced by the opinions expressed by the interviewees at that moment.

Despite this apparent lack of relevance, expressed in the opinion of the interviewees, it is submitted that the influence of exchange rates in the price of steel is by no means irrelevant, even in the case of steel bought from European suppliers. It is true that payment is contractually established in EUR, consequently the amount paid does not change unless the contract contains revision clauses. Hwever, the exchange rates affect, among other products, iron ore, scrap and freights, and thereby the production costs for steel suppliers. The interviewees did not completely disregard the relevance of the exchange rates for their businesses, but only because some particular circumstances exposed that influence. The interviewee in *Steel S* had experienced some freight rates volatility due to currency exchange variation, particularly in a couple of consignments that he had recently contracted to Japan as seller. He was particularly surprised with the fact that shipping companies were giving him quotations valid for only a few days, whenever he insisted on having freights quoted in EUR.

The interviewee in *Steel M*, in turn, acknowledge the relevance of exchange rates in those cases where the company had business units or projects in countries where payments were made in USD rather than EUR. Obviously, if the interviewees buy more products than just steel, it is more likely that they have experienced the impact of exchange rates. In fact, the interviewee in *Steel M* has significant experience buying all sorts of products that are necessary in the shipbuilding business. Some of those products are considerably expensive (e.g. engines, navigational equipment or sewage treatment plants for ships) and are often not paid for in EUR. However, the USD/EUR exchange rate is established in the contract and, whichever way it has swung, the change will be reflected on the contract with the client. Should significant changes occur, they are usually accommodated by suitable revision clauses included in the contract.

A strategy to manage this sort of risk event is the use of speculative buying of currency to anticipate exchange swings. This has been discussed earlier, following the experience shared by the interviewee in *Food*, concerning a past job at a different company. In this set of interviews, however, none of the interviewees acknowledged that exchange rates fluctuations were a problem and, consequently, none confirmed the use of such a strategy just as they did not acknowledge the use of forward buying of steel or of financial instruments of any sort. It is curious, however, to read what a corporate governance report published by one of the companies, expressly refers under the title "risk management"[21].

[21] The source for this excerpt is not disclosed to preserve the identity of the organization.

"Currency risk reflects the possibility of registering gains or losses resulting from changes in the foreign exchange rates between different currencies. The Group's exposure to currency risk results from the existence of foreign based subsidiaries in countries with a currency other than the Euro, from transactions between these subsidiaries and other Group companies and from the existence of transactions with external parties made by the operational companies in a currency other than the reporting currency of the Group.

The Group's currency risk management policy ultimately aims to reduce the sensitivity of its results to exchange rate variations.

Subsidiaries, in their day-to-day operational activities, seek to use their local currency. Likewise, loans contracted by foreign subsidiaries are preferably denominated in their local currency.

Certain operational activities of the Group are exposed to changes in foreign exchange rates vis-à-vis their local currency. The prices of some raw-materials, namely steel and aluminium, are generally expressed or indexed to the US Dollar, which can have an impact on the Group's results. It is possible, to a large extent, to include these variations in the sales prices. The Group seeks to hedge this exposure by contracting foreign exchange derivative contracts in the subsidiary exposed to the said risk. Over the last two years, the contracting of derivative contracts underwent a fair increase in the Group (…)"

In spite of this information in the corporate governance report, the interviewee in this company could not be very assertive as to whether the organization did use financial instruments to manage risks associated to exchange rates or to steel prices. He did, however, recall this one project in the United Kingdom that involved exposure to the exchange rate of British Pound (GBP). In this case, the interviewee said he remembered that, because the currency in purchases was different from the currency in the company's billing for the project, currency risk was studied but he did not know whether any risk management financial instruments were actually used. As to whether the company made speculative purchases of steel, the interviewee was quite assertive:

"If our activity involved the systematic manufacturing of the same products, using the same steel, it could make sense to use those speculative purchases."

Whether this discrepancy between the governance report and the interviewee's account of the subject is the result of some mental reservation or just lack of information can only be guessed. However, the interviewee appeared to be extremely cooperative and open to sharing

his views and experience. Furthermore, there does not seem to be any reason why the interviewee could have wanted to withhold this information. It would seem, therefore, that the interviewee is unaware of the use of currency exchange risk and price risk management tools by the group, which is most likely decided on a different decision level. Of course, one can never shrug off the possibility of some mental reservation by the interviewees.

The interviewee in *Steel L* was the only one that clearly reported that, in order to manage these currency exchange changes, the company does a little more than just using contractual terms to link the exchange rate to an index or fixing that rate. According to the interviewee, it is not uncommon for the group to anticipate steel purchases when the steel market is favourable to the buyer or when the price is expected to increase and when the exchange rate is favourable. In such situations the stock levels are checked and an order can be anticipated or increased. However, the interview stressed that this option is not a risk-free one because if the forecast turns out to be inaccurate and the price goes down, or if an exchange rates swing reduces the stock's value the losses can be relevant. Still, the interviewee guaranteed that it is not the group's policy to go back on a purchase that has been negotiated if the circumstances change:

> *"If there is a great change in the circumstances we may try to re-negotiate the price but we do not cancel the order. Even though cancelling could translate into a benefit we value the relationship with our supplier and expect them to do the same if the situation is the other way around."*

Obviously, the fact that - as the interviewee admitted - it could often prove difficult to obtain an alternative shipment in time, bearing in mind the usual lead times in the industry, is an obvious barrier to such opportunistic behaviour for any buyer. A further practice reported by the interviewee in *Steel L* as being used to manage the currency changes is to establish the exchange rate in the contract and then the financial department negotiates better exchange rates with banks, but the interviewee avoided elaborating on this for lack of information that only the financial department had.

To sum up, exchange rate variations do represent a risk for all three companies, albeit most of their steel purchases are paid for in EUR. However, they all seem to have this issue under control.

With the exception of *Steel L*, the interviewees experience recurring difficulties derived from their lack of scale when faced with their steel suppliers. This has been mentioned before herein and in different occasions the interviewees clearly detected behaviour that can be classified as supplier's opportunism.

Steel L's position is somewhat different and the interviewee explained the lack of noticeable supplier opportunism with the approximately 200.000 tonnes/year that the company purchases, together with the fact that the list of steel suppliers is a rather short and stable one. The second reason is hardly enough to grant the client immunity to some sort of supplier opportunism. As it has been discussed when referring to the findings in the first stage, a short list of steady suppliers can, in itself and in certain circumstances, be an added factor of exposure to dependence and consequent supplier opportunism. Having said that, the purchase volume seems indeed to be high, when compared to the other two companies. Especially bearing in mind the fact that the interviewee in *Steel M* claimed that his company was one of the biggest Iberian steel buyers, if not European. Yet, *Steel M* buys an average 50.000 tonnes/year only, which does not seem much when compared to the purchase volume of *Steel L*. The fact is that the importance of steel purchasing in *Steel L* is such that it is the direct responsibility of a Board member and - according to the interviewee - there is a direct channel of communication between this Administrator and the steel suppliers' top-level executives:

> *"Our Administrator who is in charge of the steel negotiation can pick up the phone and place a direct call to Mr Mittal himself."*

Despite the belief that this interview expressed of the company's capacity to have a saying before the large suppliers, it is a little difficult to imagine this direct line of communication as having any significant impact. To put things under the right perspective a couple of numbers concerning the operations of two of the most important steel suppliers mentioned by all three interviewees can be useful when confronted to the 200.000 tonnes/year of steel purchase of *Steel L*:

- 11.9 million tons was the total quantity of Rolled steel production for customers by ThyssenKrupp in 2013 and this is by its Steel Europe business unit alone (ThyssenKrupp, 2014, p. 62), which means that the total annual steel purchases of *Steel C* amount to an

irrelevant percentage of the production of ThyssenKrupp in Europe of rolled steel alone;

- 27.2 million tonnes was the total of steel shipments for customers by ArcleorMittal's Flat Carbon Europe business area in 2013 (ArcelorMittal, 2014, p. 15), which probably makes the total annual steel purchases of *Steel C* ridiculously small for Mr. Mittal to personally deal with this customer.

In the present research, the concept of supplier opportunism in Manuj and Mentzer (2008b, pp. 199–200) has been adopted – *"a supplier's (…) ability to act opportunistically"* – and different type of behaviour already referred can be thus classified. Both *Steel M* and *Steel S* referred that they often have to wait for the steel to be delivered more than anticipated because the supplier is taking its time until it has a full ship cargo. To some extent, there is some taking advantage of its position here that can perhaps be qualified as opportunism. Knowing that the client has no alternative but to wait, the supplier has little to worry about, in so far as the risk of losing the client is concerned. In fact, the client is also in a position that it has hardly any choice but to accommodate such delays in its planning, either by placing the orders earlier or by keeping adequate stock levels. The fact that the purchase is most commonly contracted in such terms that the supplier engages the carrier (using an Incoterm of either the C or the D group) does not really make much difference in these circumstances, because, had the buyer contracted the carriage, he would most likely contract the same shipping line (for lack of alternative) and he would still have to wait for the ship to be full. Thus explained, these delays seem to be somewhat inevitable rather than a symptom of supplier opportunism. However, the risk of this being cause for a client to choose a different supplier is small because these delays will typically happen whichever supplier is used. Consequently, both interviewees in *Steel M* and *Steel S* expressed the feeling that the suppliers really take advantage of this situation to plan their production and schedule their deliveries at will.

The fact that, according to these interviewees, except for the odd purchase to a new supplier of some special product, these steel purchases are usually paid on open account terms, with a payment deadline 30 to 90 days (depending on the case) after the BL date, means that the supplier does not have any reason to be particularly concerned with meeting a certain estimated shipment date. If the contract were to establish payment with the use of a documentary credit in most cases the supplier would have to pay heed to the shipment date in the letter of credit. However, the use of LCs seems to be unnecessary in most cases, in the experience of both companies and it is not otherwise argued here.

Another problem that the interviewees in *Steel M* and *Steel S* mentioned and that can possibly be construed as a form of opportunistic behaviour was the fact that they had a clear feeling that there was some collusion between suppliers that resulted in prices fixed in a way to avoid competition between them. The fact that the supply market is highly concentrated in the hands of a few large corporations that have taken over several other companies, in an extreme example of horizontal integration, may explain, according to the interviewees, the lack of competition. Whether that is the case or not, the truth is that the fact that short-term demand for steel is highly inelastic and that, for these companies, there is no substitute for steel is, as referred earlier, a factor that favours the existence of supplier speculation (Geman, 2009a; Radetzki, 2008). The interviewee in *Steel S* was more eloquent in the way he described what he believed were orchestrated manoeuvres of suppliers to concert prices between them:

> *"I have 3 or 4 alternative supplier in Europe but I often wonder whether they are truly independent or are actually the same person. ArcelorMittal controls most suppliers, but those that are not controlled by Arcelor have even told me something like 'I can only give you a quotation next week because next week there will be a price meeting in Antwerp'. I believe this means that those that are not controlled by ArcelorMittal make some sort of price agreements between them. It seems that they take turns between them, rotating so that every two years a different supplier has the best price. I have even been told once 'these next two years it will be X that will have the best price'. Then there are those that have once been my suppliers but that now tell me that they will not be competitive and they won't even give me a quotation."*

The interviewee in *Steel S* had a few more reasons to worry with attitudes that can be seen as opportunistic. One example was the fact that, in market conditions of high demand, there have been situations in which he had to make a reservation for 20.000 tonnes of steel without even knowing what the price would be or the supplier would not guarantee the availability of product. However, according to this manager, this was in about 2005 or 2006, when steel demand from China was overwhelming. At the present moment, there is much less steel demand, therefore suppliers do not have that sort of attitude.

One final example of supplier behaviour that is arguably opportunistic that was referred by the same two interviewees occurs with what they both considered a form of supplier

protectionism sponsored by their customers. Sometimes, the project contains steel requirements demanded by the customer that cause their companies to have no option but to buy from the single supplier that has product that meets those requirements. When this happens, the request for a quotation contains specifications that are so peculiar that the supplier immediately understands that it is a one-supplier contest and he opportunistically quotes a higher price than he would if he thought he was not alone. Both interviewees suspect that in many cases this does not happen by chance but rather as some form of protectionism.

In most of the examples of opportunistic behaviour mentioned above, words such as possibly and arguably have been systematically added to the interpretation of the information received. The reason for this is that they are intended to express the serious doubt whether those examples do qualify as opportunistic behaviour. Given the abyssal difference of scale and of bargaining power between these companies and their steel suppliers (at least most of them), it is doubtful whether the use of the concept of opportunistic behaviour makes any sense.

Bearing in mind that most of those examples refer to procedures that seem to be generalized in the steel industry, it is difficult to imagine a different reality, given the differences between the scale of the operations of suppliers and customers and given the different responsibilities they take upon themselves. For example, keeping in mind the lack of scale of steel orders of these companies (except those cases where *Steel L* has enough cargo to charter a ship), it is obvious that their consignments will have to wait for the supplier to have a full ship. The fact that the supplier gives a date of shipment to the buyers and that, when this date is exceeded, the buyers consider that there is a delay does not mean that there is a breach of contract by an opportunistic supplier taking advantage of the fact that the buyer has no choice but to wait for delivery to be made. In fact, their contracts will usually be subject to the suppliers' standard terms of trade and these standard terms will most likely contain clauses granting the supplier the liberty to ship the cargo only when he has a full ship. For instance, the Tata Steel "Standard conditions of sale for Strip products from the UK" (Annex 1) included the following text in the clauses regarding time of delivery:

> *"2. Dates or periods for delivery are approximate and are given for information only and shall under no circumstances be essential terms.*
> *3. A delay in delivery, including delivery later than the date or dates provided in the Contract Documents, shall not constitute a breach of contract and shall not entitle the Buyer to avoid*

the contractor to any other remedy, unless the Seller has guaranteed the date of delivery in a warranty set out in the Contract Documents that expressly modifies the provisions of Condition 2 and this Condition 3."

Incidentally, the fact that clause 2 denies the nature of essential terms to stipulations regarding dates or periods of delivery, reinforced by the terms of clause 3, contractually denies the buyer any other possibility besides waiting for delivery to be performed. Of course, in theory the buyer could always seek an alternative supplier to deliver the steel to keep the buyer's operation running, but the lead-time for this new purchase would make it useless. Furthermore, the contract with the supplier whose delivery has been delayed is subject to English Law by clause 27(a), hence the nature of contractual dates and the consequence of any delays will depend on English Law. Under English Law, if a contract stipulation is deemed to be "essential", any failure to perform through the breach of such a clause grants the other party the right to rescission, regardless of the scale of the injuries caused and the trivial nature of the failure to comply. Conversely, if a stipulation is not considered of the essence of the contract, it will not entitle the other party to rescind unless the failure to perform is substantial. The question lies, therefore, on knowing whether a stipulation regarding time of delivery is essential in a specific contract. Just as it is the case in the contract used as example (in its clause 2), this clarification of the nature of time clauses might well be clarified in the contract, as explained in Treitel (1991, p. 826):

"The question whether a stipulation as to time is of the essence may be resolved by the terms of the contract itself. Time will obviously be of the essence if the contract expressly so provides. The same is true if the contract provides that, in the event of one party's failure to perform within the stipulated time, the other is to be entitled to rescind; or that the stipulation as to time is to be a condition. In the absence of any contractual provisions on the point, the question is often determined by rules of law which have classified certain commonly found stipulations as to time in certain types of contracts as either being, or not being, of the essence."

Treitel further clarifies that in contracts for the sale of goods, as it is the case,

(…) a stipulation as to the time at which the seller is to deliver the goods is treated as of the essence of the contract" (1991, p. 826).

However, the standard terms of sale of Tata expressly stipulate that dates are not to be considered essential, ergo should the shipment be delayed beyond the contractual delivery date, the buyer as little choice but to patiently wait for delivery and keep his fingers crossed. This is, most likely, the position of the companies studied when their suppliers delay delivery of the cargo (which for goods sold on CFR/CIF terms happens when the cargo is on board) until they have a full ship. Even if their contracts are not subject to English Law (which is unknown), they most probably contain clauses that are similar to the ones referred and the truth is that, in this specific context, it would be contrary to commercial convenience for the rules applicable to be different. A further example is provided by clause 4 of the Standard Terms and Conditions of Sale of the United States Steel Corporation (Annex 2) that also states that:

> *"Except with respect to payment of amounts due by Buyer to Seller hereunder, time is not of the essence hereunder. Each shipment is a separate sale. Seller reserves the right to ship all or any part of the goods from any shipping point other than the shipping point or points specified herein. Shipment in instalments is permitted (…) Seller will use reasonable efforts to comply with Buyer's requests regarding transportation, but Seller reserves the right to make alternate transportation arrangements, even if at a higher cost to Buyer, if the transportation specified by Buyer is deemed by Seller to be unavailable or unsatisfactory. Seller shall notify Buyer of any such change within a reasonable time."*

Bearing these examples in mind, it seems clear that, if the steel suppliers of the companies in this stage of the research use similar standard trading terms, they enjoy wide contractual liberties to the point that they might benefit of the prerogatives to substitute the transportation plans made by the buyer. If this is so, even contracting the carriage would be no guarantee for a buyer that he would control the logistics side of the operation and a buyer taking that responsibility could be under the illusion that it had that control.

The interviewee in *Steel L* classified his greatest concern as *extreme dependence of a single supplier*, but he was referring to the absolutely dominating market position held by ArcelorMittal and not to the possibility of relying too much on that supplier. Although he stressed that the company also looks for suppliers elsewhere (in countries such as Russia, China, Iran), he also complained of the extreme market dominance of ArcleorMittal. According to the interviewee, this does not reflect as much in the delaying of deliveries as it does in the way that the company

establishes market prices. This extreme concentration has been increased in Europe with the problems faced by Ilva[22], further reducing the number of alternative sources for *Steel L*. Again, it might be questionable to classify this as supplier opportunism, which contributes to cast some doubt on the convenience of the risk classification adopted, as it will be discussed further below. However, since the sort of problem discussed in the paragraphs above probably happens in some of the cases in the first group of interviews, with specific suppliers, but it could not be identified due to the fact that the suppliers were not considered individually, coherence begs that the application of the term opportunism is accepted here, as well.

Thus far, the risk events referred were either those most referred by the interviewees in this set of interviews or risk events that have proved relevant in the first stage and that were now analysed for the purpose of comparing the observations in the two sets of interviews. The remaining risk events in the list adopted for this research (Table 7) were considered irrelevant or were hardly referred. Some, however, deserve a few words and then, finally, there is the elephant in the room - price volatility risk, that is.

Problems with legal issues and security were not given much importance by any of the interviewees. There were only some incidental references by the interviewees in *Steel S* and *Steel L* to the Ilva case, and, more closely connected to security issues, the reference by the interviewee in *Steel S* to the demand by some clients that the steel use by the company did not incorporate iron form Ukraine due to the possibility of radioactive contamination.

There was also no special reference to the impact of oil price increases and even when directly questioned at the end of the interviews about its relevance none of the interviewees expressed significant concern with this possibility, with the exception of scarce comments about the impact on some intercontinental freight rates *via* the BAF surcharges. Apparently, the interviewees do not associate oil price increase to the extended transit times, either *via* slow-steaming or through the reduction of ship numbers in the regular service lines loops, be that as strategies to cope with rising fuel costs, with short demand and sinking freights,

22 The steelmaker Ilva was involved in an environmental scandal in 2012 when the Italian authorities ordered the closure and major refurbishments works at that producer's steel plant that was the largest in Europe. This was due to reported tumour incidence in the area of the plant, Taranto, that was 15% higher, 30% in the case of lung tumours, than the national average in Italy. The process, including accusations of gross negligence and corruption, had a strong impact in the steel market that rippled to other sectors such as the auto industry to which Ilva was a major supplier.

among other operational reasons. In the short term, along with putting ships in lay up or reactivating them, speeding up navigation or slowing it down (Table 11) is a valid strategy to balance supply and demand or to reduce the fuel bills in times of high bunker costs (Alderton and Rowlinson, 2013).

Table 11 - How speed affects fuel consumption for a panamax bulk carrier (source: Stopford, 2009, p. 235, adapted)

Speed knots	Main engine fuel consumption tons/day
16	44
15	36
14	30
13	24
12	19
11	14

Finally, what did the interviewees have to say about price risk? Surprisingly, they did not have much to say. One of the motivators for this research was the fact that most articles found on SCRM literature that focus on the case of commodities do so by focusing on commodities price volatility risk management, as explained previously in the literature review. Trying to ascertain whether, in the case of commodities, there are risk events that concern practitioners more than price risk does was one of the purposes of this research. Zsidisin and Hartley (2012, p. 22), for example, urge supply management professionals

> *"(…) to understand the various factors that influence commodity prices as well as key strategies that can enable them to effectively manage exposure to commodity price risk and create value for their organization."*

Despite the urgency of this calling, none of the interviewees expressed relevant concern with steel price volatility as a risk to watch out for. Even when expressly asked about the impact of steel price volatility, none of the interviewees acknowledged it as a factor that was on the radar

on the day-to-day supply chain management. Notwithstanding the extreme impact that steel purchases have on all of the companies in the steel transforming sector used for this research, the attention of all interviewees is focused on different risk events as described above.

The interviewee in *Steel M* explained that, despite the fact that steel has frequent price swings throughout a single year, these price variations do not cause much trouble and are easily accommodated into the project's budgeting and into the steel purchasing terms:

> *"If we are negotiating a few months ahead in time, with establish the price by reference to an index and all those variations happen in a softer way. However, as our projects operate mostly on a just-in-time basis, so to speak, the project is here today to start the construction in a month time, the order can be immediately placed and the price reflected on the project's budget for the client to accept."*

The only problem, he further explained, is when the steel is bought several months later and the price has changed. As the project's budget has been closed with *Steel M*'s client, the company will usually be unable to reflect the change in the contract. Fortunately, as the interviewee confessed, this is not common and although prices change frequently they do not change abruptly and dramatically. Moreover, the fact that price is associated to an index will usually smooth the impact of those price swings.

The interviewee in *Steel S* also referred to the relevance of steel price variation but only when expressly questioned about its impact. However, the company's position is quite similar to the position of *Steel M* in the sense that it also produces according to customers' requests. Therefore, when the company gives its quotation it takes the price of steel into account. If the contract is to be performed in the short term, the price swings that steel suffers will not be relevant because the order is immediately placed when the contract is closed. For contracts that are to be executed over a longer period of time, the company usually includes revision clauses that take into account the variation of two costs: labour and steel. Should either cost suffer an increase of 5% or more (this usually applies to steel only), the contractual price will be adjusted in accordance with that variation. In so far as the suppliers are concerned, the company has no choice but to withstand whatever price changes the steel market determines. However, this is not a real problem because the company has no long-term agreements for the purchase of steel. Due to the fact that he has no accurate numbers for the steel he will need in the long run, the interviewee in *Steel S* usually buys steel on spot terms and based on the market price at the time

he places the order.

The formation of market steel price is affected by all sorts of factors, most of which are far from being easy to grasp. To start with, steel is not a commodity in the sense that it is not traded as such in the Metal Exchange markets, so the price of steel purchased is established by this old school practice called negotiation (Fish, 1995). Of course that when a price is established through negotiation, the differences between the bargaining powers of the negotiators will be determinant for the outcome of the negotiation. This statement is an obvious simplification that disregards the multiple factors that can influence the outcome of a negotiation. However, in the case of these companies and their steel suppliers, it is not excessive to say that the roles of the two parties in the negotiation are clear: the customer presents specifications and quantities and the supplier dictates prices and receives the orders. Having said that, it is important to consider the factors that influence steel price and its variations, in order to try to understand the reasons why the interviewees did not seem to consider steel price variation worthy of their attention.

Steel is not as fungible as many other commodities are, because it can present itself in the market in different forms or shapes, with different qualities such as resistance, with different specifications, different treatments, different composition and different scopes. All of these differences will be reflected on price, but price will be influenced by many other factors exogenous to the product. According to Fish (1995), different steel markets have different pricing systems and in those markets there are some differences between pricing for the domestic market and for export. Although this author's explanation is almost twenty years old and the steel market has considerably changed in the meantime, due to increasing integration movements, the basic aspects of Fish's explanation for the European market, where most of the companies in this study have their sourcing, have been corroborated by the interviewees in *Steel S* and *Steel M* and seem confirmed, obviously not expressly, by the price list in Annex 3.

It is not within the scope of this research to disentangle all those mechanisms but what the cases exposed meet Fish's (1995) assertion that in Europe producers prepare a price list for their products and, as they cannot exceed the prices that they make public, they will invariably make those lists with prices that are well above the market prices. According to the same author, this practice is detrimental to the possibility of forecasting prices from the price lists that are publicised, as they do no reflect the actual prices charged. The price charged to the buyer - referring to the product alone, i.e. excluding, for instance, shipping – will usually depend on the

basis price (*"a price for a product in its simplest form from the rolling mill"* - Fish, 1995, p. 104) and of the full list of extra treatments that the finishing process includes, including

> *"(…) superior grades, cutting to size, rolling to various thicknesses, undertaking tests on the product, adding coatings in different thicknesses, creating specified surface finishes, etc."* (Fish, 1995, p. 104).

The interviewee's account also provided the idea that the negotiation was essentially centred on obtaining a discount rate based on the purchase volume and on the payment terms. In so far as the payments terms are concerned, in the case of European suppliers this is usually limited to the payment date, as the sale is made in open account terms, leaving little more to negotiate. The objective of this pricing policy, according to Fish (1995), is to simplify the negotiation. The impact of all the market factors that influence price is reflected in the short term in those extras, which allows producers to change their price lists only a few times a year, or even only once.

The market factors that affect steel price can be quite diverse, but the impact of most is only felt in the long term, be that the variation of supply and demand, gradual changes in economic long-term cycles, shocks (such as new technologies, environmental regulation, or new sites with meaningful new raw materials) or the gradual change of consumption patterns, for instance due to material substitution (Geman, 2009a). Many of these factors have a considerable degree of opacity to the steel buyer, as they are not always apparent and, even when they are visible, they only become so with a certain delay. A manager might even be aware of some of those factors but other factors may totally elude him. For example, a steel supply manager is most likely aware of freight rates evolution, since freight rates is something that he deals with on a daily basis and particularly bulk freight rates have been attracting a lot of attention due to their extremely volatility (Cullinane, 2005). Despite the fact that interdependence of freight and asset markets is well known (the concept of *shipping market cycle* referred by Cullinane, 2005), the interplay (discussed earlier herein) between of factors such as freight rates, new buildings in the shipbuilding industry, scrap value, is not immediately visible to any given steel buyer. This probably explains the reason why the interviewed managers do not deal with steel price changes as if they considered this a risk of utmost relevance.

However, despite a few comments of some of the interviewees that seem to think

otherwise, steel selling prices tend to react quickly when raw material prices change, but this is mostly due to the fact that distributors increase their orders to the producers when a rising cycle of raw materials is just beginning and reduce them as raw materials start to decline (ArcelorMittal, 2014). This reaction is one of the factors that influence steel price in a shorter term. Currency exchanges, on the other hand, seem to attract much more attention from the managers interviewed, even in the case of *Steel L*, the only company of this group that seems to adopt some strategies to manage the exposure to price fluctuations. This is explained by the fact that the currency used has a much more visible effect on the volatility of the cost of steel for the buyers. This is corroborated by the following explanation in Geman (2009a, p. 178) referring to metals pricing:

> *"Denomination of the price has a significant effect on volatility, since the denominating currency has volatility in its own right when expressed in terms of some other numéraire asset, and the relationship between numerator asset and denominator asset takes the form of correlation which then affects the volatility of the price. For example, medium-term copper prices denominated in US dollars have low volatility, due to the high proportion of dollar-denominated factor costs."*

The information gathered through the interviews seems to confirm that there are risk events that attract far more attention from steel buyers than steel price variation. The aspects referred above may afford some help in the effort to explain this observation, in so far as they may help to understand the reason why managers, despite being perfectly aware of its existence, seem disregard it in their risk management strategies. Another explanation may be in the fact that steel price swings are made almost irrelevant by the fact that these companies are able to pass it on to their customers. *Steel S* and *Steel M* either operate on a project basis or to respond to customers' orders, i.e. they do not produce in anticipation of demand. Consequently, when they quote a price, they do so on the basis of a certain price level for steel and they either order the steel immediately or they negotiate for a later delivery but immediately fix their price with their steel supplier. Arguably, this is one of the most important aspects that determine whether managers see CPR as a reason for concern. This does add up with Bartram's (2005, p. 177) explanation when this author says that

> *"(f)irms may also not show a significant commodity price exposure if they are able to pass the effect of commodity price fluctuations on to other firms with which they are linked in the value*

chain (suppliers, customers, etc.). The possibility of pass-through will depend on the market share of the firm and the overall competitive structure of the industry and markets in which it is doing business".

As for *Steel L*, the situation is slightly different because the company produces rather more standardized products and fulfils customer orders from stock, using stock to ensure product availability, which the interviewee identified as a source of competitive advantage. *Steel L*'s concern with the value of its stock of steel contrasts with the little concern that the value of the 6 months of stock seems to cause for the interviewee in *Steel S*. The simple fact that the company has such a stock level should be enough to cause concern with the possibility of its loss of value. Zsidisin and Hartley " (2012c, loc. 201) explain why CPR should be managed to avoid disturbances of different sorts:

"(t)he ability of suppliers to manage price volatility can further influence their ability to meet customer's requirements. If these price fluctuations are not well managed, issues such as requests for price increases, delays, and even supply chain disruptions can result, detrimentally affecting the overall cost structures and sourcing options of purchasing firms.

However, beyond avoiding disturbances, one would expect other factors to justify a different attitude towards CPR, even in cases where those price swings can be accommodated by the prices contracted with customers.

5.3 – A comparative analysis

The comparative analysis of the results of the set interviews focused on steel supply chain (the steel group) with the information that had been gathered in the first leg of this research (the first group) can afford some insight into some specific characteristics of supply chains focused on this commodity. By looking at the results as they have been described above and listed in their respective tables of risks, it is also possible to extract some information that derive from the different circumstances in the two groups of interviews. This section summarizes the most important aspects referred in the previous sections regarding the information collected in each

group of interviews, establishing the most important comparisons, some of which have already been advanced in those sections.

The first aspect that attracts some attention is the fact that the results table of the first group of interviews is more populated than the table in the first group, although the difference does not seem very noticeable. It is important to recall the caveat that a mere count afford no information whatsoever about the relevance of the different risks for company, both from the point of view of probability and of impact. However, this issue will be further addressed below. Having said that, different causes can probably explain that difference in the number of risks that were identified in the two stages.

The first reason that it is suggested is the obvious fact that, as the first set of interviews was not focused on a single sector but rather on sectors that were quite diversified, the context of the operations analysed is also necessarily more diversified. Several reasons explain this diversity, such as: there are different sectorial supply chains involved; the group includes different types of companies with different characteristics (such as size, technology and culture); the companies have different sourcing geographies; there are different degrees of complexity of the supply network of each company; the companies are in different tiers of the respective supply chains; they benefit of different degrees of bargaining power; the companies have different degrees of integration with suppliers; and their suppliers also have very diversified characteristics. All these differences can probably justify the added diversity of risks. Some of these aspects will surface further ahead in the discussion of specific differences.

Another reason for the different density of the two tables is the fact that the first set of interviews was not focused on a single product but rather on the generic view of the risks involved in the supply chains of the companies concerned, without special attention to any specific product, specific supplier or specific product supply chain. Hence, it is natural that a greater diversity of risks has been identified.

Finally, the fact that in the first group of interviews a greater number of risks have been identified is also probably due to the specific circumstances of the timing of the interviews. As the two sets of interviews were carried out in different economic scenarios, in different stages of the financial crisis of the past few years. Furthermore, in the first group, again, the number of sectors included is more diversified and included sectors that are really going through extreme

economic hardship. For example, there were two companies in the automobile industry, tier one and tier two suppliers of car makers, an industry that has been going through extremely difficult times for past five or six years. The same can be said about *Plastic*, a company that manufactures products for the construction sector and this is a sector that is going through a period of extreme hardship. This resulted, for instance, in a generalized concern in the first group of companies with the financial condition of suppliers, with the possibility of disruption due to different causes including suppliers' failure to meet contractual deadlines.

As it has been mentioned before, despite the greater number of risks were identified in the first group, the truth is that there is a small difference in the number of risks observed in the two groups. This could lead to the conclusion that the perception of risks was very similar in the two groups. However, those two tables do not reflect the relevance of the risk events as transmitted by the interviewee's experience. It is simply a risk count, one that does not distinguish the degree of relevance, for example. This assessment was not made by systematically asking the interviewees to grade their concern. However, the liberty that the interviewees enjoyed to express their views with the use of open-answer questions and a semi-structured interview, provided information-rich answers that, in most cases, afford considerable security to the interpretation of the relevance of each type of risk event. As a consequence, despite the fact that the difference of the number of risk event types identified does not seem great, it is possible to say that in the first group of interviews most risk events (with the exception of risk events associated to disruption and to supplier's opportunism) were given superior relevance by the interviewees, than they were in the interviews of the steel group. Hopefully, this has been noticeable in the analysis of the information gathered that has been made thus far and it will also come through in the remainder of this section.

Having made this introductory note, it is useful to scroll down, so to speak, the two lists in order to highlight the differences between the two sets of companies with a view to identifying what might be characteristic in the second set of companies. This will be done in the following paragraphs.

Almost all of the companies face risk associated to changes in currency exchange rates, however in both sets of interviews the interviewees were, in general, not too concerned with this problem. Different reasons explain this in different cases. The three companies in the steel group have most of their steel suppliers in Europe. Hence, exchange rates are usually not a

problem, so long as the contracts are celebrated with companies in the Euro zone or the contract establishes the Euro as contractual currency. For all the other purchases paid for in USD, the problem is normally avoided by contractually establishing an exchange rate. The only case in which this was said to be an issue worthy of special attention was in *Steel L* as the interviewee in this case said that the company's stock levels made this an issue that had to be considered, but he also said that managing this was seen as a common practice. In the first group, several companies were exposed to foreign currencies exchange rates, particularly to the USD exchange rate. Again, however, this seems to be kept under control through the use of adequate contractual clauses. This seems to show that there are no relevant differences between steel companies and the companies in the first group.

In all of the interviews in the two groups it was expressly referred that the risk of disruption of the company's operations was one of the greatest causes for concern. However, the causes behind that possibility were not always the same. The companies in the steel group have to face this problem mostly due to the fact that their consignments have to wait for the suppliers to have a full cargo for a ship, aggravated by the low offer of transportation services that result in delivery times that are long and tend to exceed the estimated delivery dates. They also referred to delays caused by customs procedures, late documents or bank delays. None of the interviewees in the steel group confirmed the information in Fish (1995) regarding the fact that steel producers sometimes delay overseas deliveries to give priority to domestic customers. Obviously, this does not cast any doubt on that information, but the fact is that these companies have no experience of that.

Companies on the first group of interviews also reported this sort of risk, although with a longer list of possible reasons. For example, *Pharma* had different reasons that were specific to the industry concerned, linked to the fact that the company's sources are affected by the evolution of global demand, aggravated by the fact that this demand is erratic. Managing this risk of disruption with stock was not a problem, thanks to the *"comfortable margins"* of the sector. Companies in the automobile sector also referred this possibility but resulting mostly of the supplier's inability to produce in time for delivery, a threat they manage both with safety stock and with dual sourcing.

The results regarding disruption, in both groups, are a good example of the difficulty in determining exactly where should we look at when analysing risk, and what we should consider a

source of risk, a risk event or a consequence thereof. Lets take disruption that is caused by shortage of product as an example. This can be caused by different reasons, including supplier failure to produce in time, problems during transit, and the cargo being held at customs longer than anticipated. Classifying this as a disruption risk might not be the best option from the point of view of risk mitigation. If a company is to consider this a risk and look for suitable preventive strategies it may end up using the wrong ones. Arguably, this is a side effect of using a classification that tries to group risk phenomena: the same event may, depending on the interpretation, be considered a risk or a source of risk. This discussion will be further explored later on but, for the time being, it is important to stress this difficulty as it is possible that the problem surfaces with other risks.

Forecast accuracy, which in this research is understood as demand forecast only (as mentioned in Table 7), was referred by three of the companies in the first group of interviews. However, it was considered particularly worrying in only one of the cases – *Plastic* – and for time related context reasons, i.e. the extremely recessive period that the housing sector is experiencing.

As for the steel group, only *Steel S* and *Steel L* expressed concern with risk events associated to forecast accuracy, although in the case of *Steel L* this concern was moderate. The strategy to cope with lack of forecast accuracy was the same in the two sets of interviews: safety stock. *Steel M*, working on a project basis, did not have particular reasons to worry about this. Bearing in mind the information transmitted by the interviewees and the information gathered from the literature concerning the trading arrangements that steel suppliers contractually impose based on their bargaining power, it is hardly surprising that these two companies have to rely on safety stock. Assuming that safety stock management in *Steel M* is not just somewhat more "casual", the differences between the stock levels of these companies can probably be explained by different reasons. One reason is the fact that there is greater predictability of demand in the case of *Steel L*, which, in fact, was confirmed by the interviewee as he did say that forecast accuracy was only a moderate reason for concern. The second reason, also confirmed by the interviewee in *Steel S* as being the main reason for the high stock level, was the need to ensure competitive production lead times. A final example of a possible reason for the different levels of stock between *Steel S* and *Steel L* is linked to the very significant differences in their steel consumption that resulted in *Steel L* being able to ensure economies of scale with a greater order frequency than *Steel S* that had to aggregate its needs for a greater period of time to

ensure those economies of scale.

Some types of risk events do not make sense in the case of the steel group and one of them is risk events associated to inventory and tools ownership. Some of the companies in the first group had suppliers that produced components that would be incorporated into the buyer's products. In some of those cases, those suppliers used tools or casts that were subject to proprietary design and ownership of the buyer. Those companies – *Plastic*, *Auto 1* and *Auto 2* – were well aware of the possibility of facing problems such as difficulty in retrieving their tools at the end of the contract, or having a rogue supplier using their tools for purposes other than those envisaged by the buyer when it entrusted its tools to the supplier. Obviously, so far as their steel suppliers are concerned, the companies in the steel group face no such problems.

Risk events associated to legal issues have been added to the risk events classification in Manuj and Mentzer (2008b, pp. 199–200), used as the basis for the risk events classification in this research, to accommodate the information received in *Pharma* and in *Auto 1*. These two cases have not been explained above due to the fact that only those two interviewees had expressly mentioned this type of risk events, therefore they were not considered relevant. In short, in the case of *Pharma* this concerned the legal requirements that the pharmaceuticals industry has to observe in its activity in so far as sourcing practices are concerned, namely, certification of suppliers according to legal requirements, legal requirements for pharmaceutical products legal approval, and restriction to the introduction of changes in the list of legally approved suppliers. In the case of *Auto 2* this type of risk event referred to an isolated case the company had experienced linked to a particular situation involving transit restrictions in the Beijing area at the time of the Beijing Olympics, back in 2008. In the steel group, none of the interviewees expressed relevant concern with these risk events associated to legal issues. However, they did mention the problems associated to trade limitations with Russia, due to the Ukrainian crisis, but, as none of the companies imported from Russia, they were unanimous as to the lack of reasons to be concerned.

Truth be told, some doubts subsist as to whether a problem that was referred by all the interviewees in the steel group should have been classified as it was or should rather have been considered as a legal issue. The interviewees mentioned problems with customs bureaucracy (as well as with bank procedures and with and transport documents) as a cause for their steel consignments to be delayed. This was classified as risk events associated to disruption but it

could arguably be considered risk events associated to legal issues. However, the option was made to consider that legal issues referred to unpredictable legal requirements or unpredictable incidents that were aggravated by legal requirements, rather than normal legal procedures that were usually lengthy ones. Again, a choice was made to adopt this classification but it is hardly based on strong conviction and, furthermore, it is another example of the difficulties associated to the option of classifying events into categories.

Only three companies in the first group and *Steel* S, in the second, referred oil price increases. The fact that most of the steel purchases of the companies in the steel group involve transits within European waters can explain this lack of relevance, because short journeys will result in relatively low transportation expenses, as opposed to those they would have if they had their sources in other continents. It is also understandable that transportation costs are considered cause for concern in the case of *Food*, a company that purchases mostly full ship cargoes of agricultural commodities and it is known that the impact of transportation costs in this type of cargo is most relevant, as it can be seen in Figure 12. Despite the fact that only a few companies acknowledged the relevance of risk events associated to oil prices increase, usually due to their impact in transportation costs, *via* the increasing freight rates and the BAF charges, one can wonder whether this could have been referred more often if the interviewees had associated oil prices to other complaints they had, such as increasing transit times and reduction of ship numbers in the regular lines' service loops, thus reducing the transport service offer. Again, another example of the difficulty resulting from the use of a classification coupled with the often difficult task of isolating the cause, which frequently results in misidentifying a consequence as cause.

There was not a single company, in both groups, that failed to highlight quality as a relevant issue. However, in almost all (if not all) of the companies concerned, risks associated to lack of quality are kept under control through the use of strategies such as certification and supplier auditing. If a distinction can be made between the steel companies and the companies in the first group of interviews, it lies on the fact that products sold in the international trade of steel are clearly typified, subject to generally accepted reference codes, and generally sold with the adequate certification. As a result, risk events linked to quality are not, apparently, a reason for special concern.

This clearly contrasts with some of the companies in the first group. In some of those

companies the interviewees clearly indicated this category of risk events as one of the most relevant. This was the case in *Pharma*, which is quite obvious, since the lack of quality could result in public health incidents or even loss of lives. The same is true for *Food*, although, possibly, with lack of quality having consequences slightly less dramatic. It is also worthy of special mention the case of *Auto 1* and *Auto 2*, again, not because the importance of quality is surprising but rather due to the confirmation of its relevance in a sector that frequently has lean production methodologies implemented. The impact of the lack of quality would jeopardize the efficiency of the supply chain, consequently the paramount relevance of quality in these supply chains is often enforced with heavy contractual penalties in the service level agreements (SLA).

Whereas in the first group of interviews most interviewees expressed concerns with the financial situation of suppliers, in the steel group none did. The reasons for this difference seem quite obvious and have already been explained. The first group included companies that had a considerable degree of dependence on their suppliers due to the close relationship that existed between the companies, with some degree of integration between their operations. Consequently, even though several interviewees referred that they maintained a dual sourcing policy to control this sort of risk event, the possibility of a supplier's insolvency had to be reason for concern. This concern was aggravated by the specific context of economic hardship of the past few years. Companies in the steel group, in contrast, deal with steel suppliers that are, in most cases, large international companies with extreme economic power and which, presumably, have financial robustness. Beyond this assumption, however, is the fact that there is no dependence between the companies in the steel group and their steel suppliers, as there is no such thing as integration between their operations and the customer could always find an alternative source, should the supplier disappear.

There was not a single company, in both groups, that did not refer facts or events that could be classified as opportunistic supplier behaviour. Opportunistic behaviour has been extensively referred in the literature and it has been discussed herein, both in the literature review and in the analysis of the information gathered with the interviews. Arguably, opportunistic behaviour is an unavoidable reality, so much so that TCE theories, as mentioned when the most relevant supporting theories were referred, even doubt that there can be such a thing as orchestrated strategies of different companies acting as one. Individuals within the firm or firms in their inter-firm relationships, often act pursuing their own selfish interest (Peck, 2005). In each and every interview there were accounts of suppliers using their bargaining power to force

contractual terms upon the buyers that reflected a clear shift of the scale of bargaining power in favour of those suppliers. As it as been referred previously, and TCE theories suggest the same, even in so-called partnership relationships there often room for opportunism. Interestingly, even managers who complain of opportunistic behaviour by their suppliers will often act in an opportunistic way, if given a chance to do so. An example of this is the fact that one of the interviewees (for obvious reason the company will not be identified) expressly said that

> *"I like win-win relationships, but, lets not be fools about, I like them as long as my 'win' is the one with the capital W."*

and this was probably the interviewee who was the most vocal about the importance of partnership relationships with suppliers.

In order to try to avoid this bargaining supremacy of the supplier, the interviewees have referred different strategies. Some (e.g., *Pharma* and *Food)*, referred the option of ensuring that there are always alternative suppliers, in order to avoid being at the mercy of the sole supplier, as well as the option of aggregating purchase volume, in order to be able to bypass intermediaries e go directly to the source. In the matter of dealing with supplier opportunism there is often some trade-off in the options made: aggregating purchase volume in one supplier potentially increases bargaining power and/or relevance for the supplier but increases exposure to supplier failure risk and/or dependence; conversely, splitting purchase volumes decreases exposure to supplier failure risk and/or dependence, but it also diminishes bargaining power and/or the buyer's relevance to the supplier. This is the reason why one of the interviewees in the first group of interviews – *Food* – referred that, even in those cases that a supplier was considered a strategic one and received the status of *"preferential supplier"*, it is important to maintain alternative suppliers qualified, in order to avoid excessive dependency. In an effort to distinguish characteristics that are specific to the case of companies in the steel group, it is suggested that supplier opportunism is a distinctive aspect of the relationship between steel producers and companies that have profiles similar to those that have been used for this research. Indeed, several examples of supplier behaviour, reported by the interviewees, that resulted in added difficulties for the buyers has been qualified herein as opportunistic behaviour, notwithstanding the doubt, expressed earlier, as to whether the use of the concept of supplier opportunism was suitable to qualify the steel suppliers' trading practices before their buyers. It is not possible to say that this is a problem that affects every company that is a steel buyer. In fact, it is conceivable that larger companies

(e.g., a major automobile maker, or a major shipbuilder) have stronger bargaining positions and, consequently, are less exposed to such opportunism. However, when compared to the cases in the first group of interviews (with the exception of *Metallic* that is in fact *Steel M* but considered in terms of all its purchases), it is plain to see that the steel group is far more exposed to this opportunism. Moreover, it is exposed to opportunism of suppliers of a product that can represent up to 90% of a company's costs, as referred by the interviewee in *Steel L*. This does not mean that the companies in the first group are not affected by supplier opportunism. For starters, they are surely exposed to it with regard to their steel purchases, should they have any. However, if they do not have their supply chain dominated by a single product (or a small number of them) and a single type of supplier (here, a steel supplier) it is possible that his bargaining power is variable, depending on the supplier concerned.

Risk events associated to transit time were frequently referred in the first set of interviews and much less so in the steel group, as only the interviewee in *Steel L* expressly mentioned it. There is not much to be said about this because the explanation lies in the simple fact that the sourcing origins of the companies in the steel group were mostly situated in Europe, whereas the companies in the first group referred to suppliers in a much wider geography. Greater distances carry along increased possibilities for delays to occur and delays with greater impact, due to their extension and – typically, although not necessarily – to the larger order quantities delayed.

Finally, it is not possible to compare the relevance of commodity price risk (CPR), and the way it is dealt with, in the two groups of companies because this was only considered in the second group of interviews. However, in so far as this risk is concerned, the purpose of this research was to analyse its relevance for a large importer of steel and not to compare the two realities. Commodity price volatility, in the risk event checklist in Table 9, has only been checked in the column that refers to *Steel L*. This means that it was the only case where this risk was considered relevant, according to the interpretation of the experience shared by the interviewees. However, it does not mean that there is no price volatility or that the price volatility is irrelevant for a company that has its operation focused on transforming steel. Yet, for these two companies, CPR is not relevant enough for the interviewees to spontaneously refer it as being a risk to consider. As it has been explained before, this is mostly due to the fact that both companies work, in general, on a project basis. Consequently, for each project they can establish the project's budget considering the relevant price for all the materials and other cost

components necessary. In this sort of activity, whenever a price is established bearing in mind costs that are expected to be potentially subject to meaningful variation, adequate clauses are inserted in the contract, such as adaptation clauses, hardship clauses, and indexation clauses. Thus, CPR is provided for in the contract, passing it on to the customer. Contrasting with the interviewees in *Steel S* and *Steel M*, the interviewee in *Steel L* did refer to CPR spontaneously, albeit expressing only moderate concern for the reasons that have already been suggested above.

The almost exclusive focus of commodities supply chain risk literature on CPR seems to indicate that this is the most relevant risk in those supply chains. However, bearing in mind the seemingly low relevance of CPR for the interviewees in the steel group, it seems arguable that its importance is relatively low in the case of steel, at least as perceived by practitioners. As it has been referred in the literature review, when the previous research on Commodities Supply Risk Management was analysed, the fact that some of the most reputed scholars refer almost exclusively to CPR must have a valid explanation that this research is not intended to question. However, the information gathered seems to corroborate the idea that there are other concerns that may override CPR in some cases. Furthermore, the attitude of some of the interviewees in the steel group towards the stock levels that they admitted that were high, also suggests that the companies are not too concerned with the risk of steel price volatility. In the case of *Steel L* this concern was said to be moderate and linked to the possibility of the value of the steel in stock being affected, whereas in the case of *Steel S* the fact that the company could, through its contractual terms, pass the consequences of that risk on to its customers seems to be a reasonable explanation for the lack of relevance of CPR. This was also the reason why the interviewee in *Steel M* did not consider CPR a reason for concern: it was accommodated in the project's budgeting and with the use of indexing clauses.

The analysis of these three companies that heavily depend on steel, of their experience and of their perception of CPR has highlighted the impact of the characteristics of their operations in the relevance they see in CPR when it comes to steel. This has become particularly obvious in the fact that the companies that operate on a project basis are in a better position than a company that has a standardized production, keeping stock of finished product to meet customer orders. Time and again, the relevance of context surfaced in the analysis of the information gathered in the two groups of companies and this is just another example of that relevance, a reminder of the contextual nature of supply chain risk management. On the other

hand, this analysis also led to the confirmation of the argument submitted that there are other risks, beyond CPR, relevant in commodities supply chains and that, in some cases, they can prove to be just as relevant, or even more relevant. These conclusions are directly linked to the main objectives that were set for this research from the outset, but the links between the findings of this analysis and the research objectives will be specifically addressed in the conclusions of this thesis.

Part 6 - Conceptual complexity in supply risk identification: managerial implications of a different approach

6.1 - Introduction

The analysis in the previous sections is grounded on the information collected through the interviews, with the purpose of extracting information from the interviewee's experience that could then be linked to a number of concepts. These concepts are grouped in a list of risk events that has been built by adopting the list in Manuj and Mentzer (2008b). This list has been used as the starting point for the analysis of the information gathered but, as it has been explained previously, it was adopted on the premise that it was subject to all the changes that could be suggested by the analysis of the information. The aim was to adapt the list to the facts rather than forcing the facts into fitting the list. Throughout the analysis of the interviews, some changes have indeed been made to that list. These are not dramatic changes and only those that were considered strictly necessary have been made, the most obvious of which was the introduction of commodity price volatility.

The analysis of the information proved extremely difficult due to different reasons. Some of these reasons concern the expectable difficulties in a process of information collection with the use of interviews. These difficulties will be further discussed in the limitations of the present research, however the fact that the difficulty associated to the interpretation of concepts had the greatest impact on the research results begs immediate attention. This fact was by no means a surprise, as the literature review and the earlier steps of this research had already exposed the extreme complexity and even confusion that concepts associated to supply chain risk management involve. Thus, one of the objectives of this research was, from the outset, to make a contribution to clarity, one that could assist managers of commodities supply chains in setting up a comprehensive approach to supply chain risk management.

As it has been referred in Part 2 of this thesis (Motivation and research objectives), this contribution is materialized through the suggestion of a framework to be used as a roadmap of sorts for supply chain managers to visualize an integrated approach to supply chain risk management. However, the goal of suggesting a framework was not established from the outset. The need for a framework was, at first, determined by the need to clarify concepts and to visualize the coherence between the different steps of supply chain risk management in

managerial practice, a need that at that point had a mere instrumental nature. Clarifying concepts and visualizing a coherent virtual supply chain risk management path were seen as something that had to be done before advancing any further. Hence, a preliminary framework was canvassed as the literature review evolved and an effort was made to clarify concepts, which also involved adopting a risk event classification for the analysis of the information gathered. The interviews and the analysis of the information thereby collected confirmed the initial intuition that clarity was fundamental to ensure the usefulness of thoughtful supply chain risk management efforts from a managerial point of view. Moreover, despite the effort for a clarification of concepts, the interviews and their analysis also revealed that the use of classifications did not contribute for that clarity nor was it adequate from a managerial point of view, for the reasons that are further explained below. Consequently, the initial objectives of the research were complemented with the purpose of suggesting a new approach to risk identification as the first stage for a complete risk management framework. The purpose of the following sections is, therefore, to explain that different approach and the resulting framework, highlighting the practical aspects that it is anticipated that its application might involve.

At this point, however, it is important to recognize, and to stress it, that this framework has been construed both from the analysis of the previous literature and from the difficulties experienced throughout this research, particularly with linking the concepts with reality and interpreting the information gathered in order to integrate it with the relevant concepts. Furthermore, it is also important to explain that this goal was limited, also from the outset, by the fact that the analysis carried out in this research was limited to the identification of risks and strategies alone, although the focus was not, from the beginning, on the systematic identification of strategies. Consequently, the stage of risk identification is the one that has been subject to deeper analysis and is the stage that the following sections will be focused on. The remaining stages of the framework will, in essence, incorporate contributions already existing in the existing literature but will also include suggestions and will be linked to the managerial experience collected with the interviews, whenever relevant links can be detected. Therefore, the stages beyond risk identification are suggested as a preliminary suggestion that might also serve the purpose of a starter for further investigation. Despite the fact that this research focuses on a specific commodity, which will, naturally limit the reach of this proposal, it will hopefully be applicable to different realities even if it must not aspire to be applicable to every single reality.

6.2 – A supply risk management roadmap for a commodity supply chain - merging theory and practice

6.2.1 – Risk identification

As mentioned before, this research aims at contributing to a comprehensive supply chain risk management approach that risk managers can use as guidance in supply chain risk. Hence, this framework is suggested with a view to being used as a tool, rather than a theoretical exercise, so that it is visually clear and of immediate understanding. It hopes to be useful for a supply chain manager, whose risk management role involves a set of tasks that evolve from risk identification to constant risk monitoring, in a never-ending loop that demands, among other aspects, a team-based approach (Knemeyer *et al.*, 2009; Manuj and Mentzer, 2008b), as it has been discussed previously herein. This need for a team-based approach derives from the possibility of individual decisions being ill-founded, either by lack of knowledge regarding the vast plethora fundamental aspects potentially relevant (e.g., customs procedures, quality special requirements, financial impact), or due to the abovementioned limits of *"bounded rationality"* (Simon, 1979, p. 502), or even to some deviant behaviour pursuing personal objectives.

Earlier, when the most relevant risk classifications found in the literature were presented, it was acknowledged that the existence of different classifications causes confusion but, despite those difficulties and confusion, it was considered that establishing a classification is also a way to avoid the cumbersome task of establishing a comprehensive *a priori* list of risks. Moreover, it was suggested that this effort of creating an exhaustive list might well be a useless effort, destined to be incomplete. An example of that is the list of supply chain risk categories and their triggers in Table 12, suggested by Tummala and Schoenherr (2011) that, despite the fact that it is quite detailed, leaves out several perils that supply chains often face. Nevertheless, it was then suggested here that the conceptual and practical benefits of establishing risk categories override the difficulties that can be met when trying to establish such a classification. As a consequence, a list of risk events was adopted for the analysis of the information transmitted by the interviewees. However, verifying that managers' risk perception does not fit into pre-established taxonomies and having experience extreme difficulties trying to establish the links between the information gathered and the categories of risk events adopted, has led to a change of heart regarding the

usefulness of such classification from a practitioner's point of view.

Table 12 - Supply Chain Risks Categories and their Triggers (source: adapted from Tummala and Schoenherr, 2011)

Risk Category	Risk Triggers
Demand Risks	Order fulfillment errors
	Inaccurate forecasts due to longer lead times, product variety, swing demands, seasonality, short life cycles, and small customer base
	Information distortion due to sales promotions and incentives, lack of SC visibility, and exaggeration of demand during product shortage
Delay Risks	Excessive handling due to border crossings or change in transportation mode
	Port capacity and congestion
	Custom clearances at ports
	Transportation breakdowns
Disruption Risks	Natural disasters
	Terrorism and wars
	Labor disputes
	Single source of supply
	Capacity and responsiveness of alternate suppliers
Inventory Risks	Costs of holding inventories
	Demand and supply uncertainty
	Rate of product obsolescence
	Supplier fulfillment
Manufacturing (Process) Breakdown Risks	Poor quality (ANSI or other compliance standards)
	Lower process yields
	Higher product cost
	Design changes
Physical Plant (Capacity) Risks	Lack of capacity flexibility Cost of capacity
Supply (Procurement) Risks	Quality of service, including responsiveness and delivery performance
	Supplier fulfillment errors
	Selection of wrong partners
	High capacity utilization supply source
	Inflexibility of supply source
	Poor quality or process yield at supply source
	Supplier bankruptcy
	Rate of exchange
	Percentage of a key component or raw material procured from a single source
System Risks	Information infrastructure breakdowns
	Lack of effective system integration or extensive system networking
	Lack of compatibility in IT platforms among SC partners
Sovereign Risks	Regional instability
	Communication difficulties
	Government regulations Loss of control
	Intellectual property breaches
Transportation Risks	Paperwork and scheduling
	Port strikes
	Delay at ports due to port capacity
	Late deliveries

Additionally, the lists of risk events observed highlights the fact that the use of classifications goes a short way in afford a clear view of reality. This really comes through in the fact that in both groups "disruption" was considered relevant in every single case. This fact is by

no means surprising, bearing in mind that "disruption" is too large a bag to transmit and idea to the external observer of what is in fact inside. Too many different causes hide behind "disruption", which removes any possible interpretation from the use of this term in practice. Simply put, academics may deal with taxonomies, but managerial practice, on the other hand, does not see reality as risk categories but as facts of day-to-day life. A manager does not deal with farfetched categories (some more so than others), he deals with documents delayed, suppliers failing deadlines, defective products, strikes, earthquakes, lost cargo, theft, and so on. True, some of these facts are more frequent than others but, still, they are all facts of day-to-day life. Ignoring this and trying to impose a categorization that the manager fails to immediately understand, a taxonomy that begs explanation, however brilliant the theoretical conception that surrounds it is, will be a sure step to ensure that it will never leave the bookshelf to be put into practice. That said, some classifications in the literature could have a practical use in this framework, an instrumental role that will be referred further below.

With this perspective in mind, it is suggested that supply chain managers look at their supply chains and refer to risk events, with a mind-set that is similar to what we can refer to as an insurance perspective. Earlier, when the concepts of Risk and Supply Chain Risks were discussed (3.5.2 – Risk and supply chain risk), the concept of hazard in the context of Insurance Law was explained in the following terms, using the words of Thoyts (2010, p. 5):

> *"(A hazard) is something that affects the probability of a risk occurring. Something that a layman would regard as 'dangerous' is indeed almost certainly a hazard. For example, if a car has defective brakes, it is self-evident that the probability of a collision is increased. However, if a car is fitted with an ABS braking system, this will also affect the probability of a collision, in this case making it less likely. This is also a hazard"*

However, the expression "hazard", as it has also been referred, is often used in the literature as being synonymous of risk. Yet, reading the definition above, hazard is, in fact, synonymous of "risk driver" according to the definition of Ritchie and Brindley adopted in this research:

> *"(…) factors with a significant impact on risk exposure, but also as factors providing an opportunity to improve performance" (2009b, p. 306)*

In the context of insurance, risk and peril are two distinct concepts, a distinction that has

also been referred herein:

> *"(…) if a risk is seen as the broad threat, a peril is the precise means by which the risk could come about. Therefore, if the risk is physical damage to a building, then fire, storm, flood and earthquake are all perils" (Thoyts, 2010, p. 5).*

Perils will, consequently, be phenomena such as a strike, an accident happening to a ship, documents that are delayed in transit, port congestion, all of which lead to risk of delay.

This distinction is not a frivolous one because it has an impact on the approach to supply risk management hereby suggested. Looking at a risk category such as, for instance, "delay risks" (one of the categories proposed by Tummala and Schoenherr, 2011 (Table 12) will it cross the manager's mind the possibility of facing delays with bank procedures? Possibly, if the manager has had previous experience with the payment mechanism concerned, otherwise he might have no clue as to which risks are associated to those procedures. The suggestion here is that, by analysing each step of the supply chain and of the relevant procedures, the manager can systematically ask what can happen. Every step of the way he can detect the gaps in his knowledge and consider where to seek assistance.

Managing supply disruptions in a systematic way will usually involve (a) identifying causes for potential disruption or other type disturbances and setting up mechanisms to avoid those causes or their effects; (b) using the resources that have been created to deal with the disruption or other disturbances should they occur (Behdani et al., 2012). Identifying risks is among the activities involved in the former, which frequently receives designations such as supply chain risk management or supply chain risk analysis (Behdani et al., 2012). As suggested by different authors, even if using different terms, this stage involves *"perceiving hazards, identifying failures and recognizing adverse consequences"* (White, 1995, p. 36, see Figure 6 above). This is also reflected on the first stage of the proposed framework in Figure 14 and the interviews carried out were an exercise that aimed at driving the interviewees into making the sort of assessment that this stage would normally involve, albeit in very different circumstances, with much less thought process involved and without the team-effort that has been referred above.

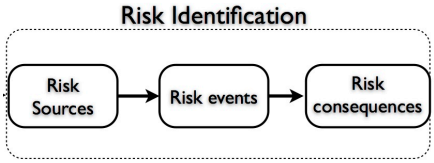


Figure 14 - Risk identification (proposed SRM framework)

To be more precise, the attention was focused on the first step of this stage, the step that has been called "Risk Sources" and that can be further analysed or detailed as shown in Figure 15 - Risk sources (proposed SRM framework). The purpose of highlighting these elements within "Risk Sources" is to suggest different aspects that may help a manager using this framework as reference to keep a lookout for all the relevant risk sources. Here, using the concept of peril as it is used in Insurance Law has the purpose of attracting attention to those facts of life that managers deal with on their daily business. This is how someone who is exposed to a certain risk looks at the world - with an insurance perspective, so to speak - so much so the organization can buy insurance to protect it from some of the perils that may be behind the risk that the supply manager perceives.

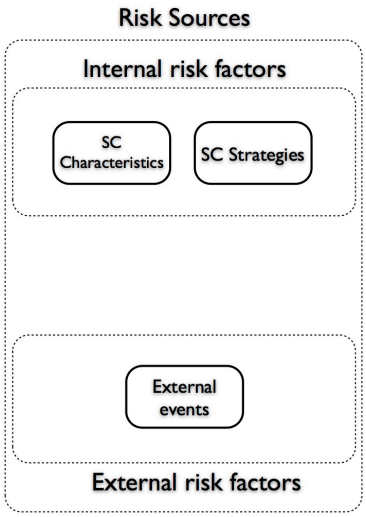


Figure 15 - Risk sources (proposed SRM framework)

The analysis of the risk sources can benefit of the use of some classifications that can be found in the literature. As it has been suggested before, in spite of the suggestion herein that using risk classifications can cripple risk analysis, some classifications in the literature could have a

practical use. With the purpose of identifying where the risk comes from, Rao and Goldsby (2009) suggest sets of sources of supply chain risk, which include the sources for risk associated with the decision maker as referred below (Figure 16).

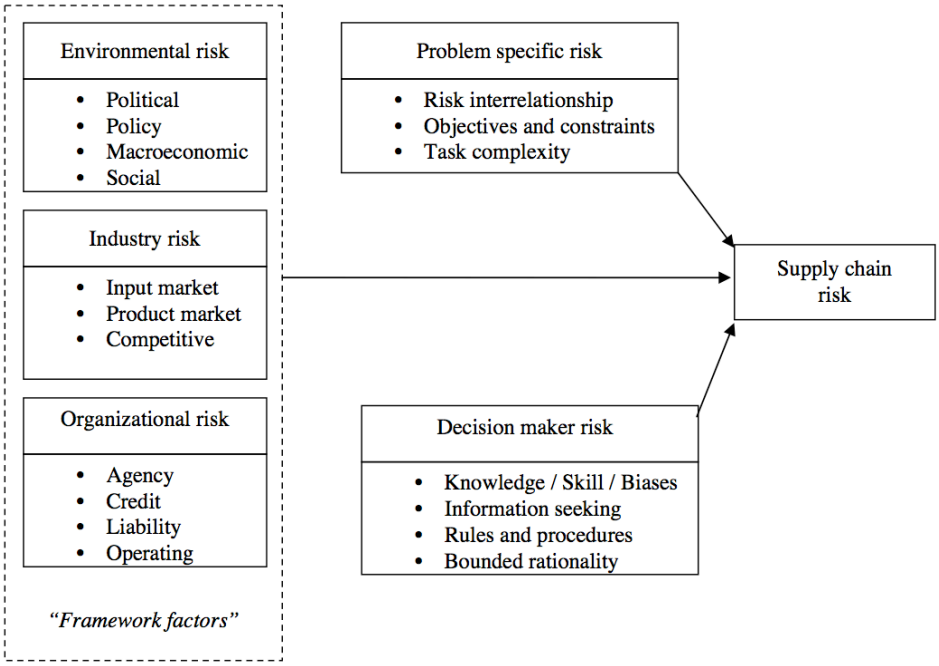


Figure 16 - Sources of supply chain risk (source: Rao and Goldsby, 2009)

Another example is the distinction between internal and external risks as suggested by different authors (e.g., Christopher and Peck, 2004a; Cucchiella and Gastaldi, 2006) leads to the distinction between internal risk factors and external risk factors in the framework suggested in this thesis, a distinction that is also made with a practical purpose.

Wu et al. (2006) also consider this distinction useful to help managers get a clear idea about risk location and to adequately adopt the right strategies to cope with each risk, to avoid it or mitigate it. Distinguishing between internal and external risk factors highlights the fact that some risk factors may be within the reach of company's power of intervention, as they are internal to its supply chain, while it may not be within the company's power to interfere with other risks, external to its supply chain. In practical terms, this might translate into the choice of different risk mitigation strategies. For instance, if a list of strategies such as the one in Manuj and Mentzer (2008a, 2008b) is adopted (Table 13), some strategies are probably more tailored

(although not exclusively) to be used with internal risks factors - such as Control with quality issues – while others are probably more suitable for external risk factors, such as hedging or avoidance with market related risk factors.

Table 13 - Risk mitigation strategies, adapted from Manuj and Mentzer (2008a e 2008b)

Strategy	Description
Postponement	"Postponement entails delaying the actual commitment of resources to maintain flexibility and delay incurring costs" (Manuj and Mentzer, 2008a, p. 142, citing Bucklin, 1965)
Speculation	Speculation (also called selective risk taking) is a demand-side risk management strategy that is the opposite of postponement (Manuj and Mentzer, 2008b also citing Bucklin, 1965)
Hedging	"In a supply chain context, hedging is undertaken by having a globally dispersed portfolio of suppliers and facilities such that a single event (like currency fluctuations or a natural disaster) does not affect all the entities at the same time and/or in the same magnitude" (Manuj and Mentzer, 2008a, p. 142).
Control/Share/Transfer	"Control, share or transfer of risks take the form of vertical integration, contracts, and agreements" (Manuj and Mentzer, 2008b, p. 209).
Security	"Global supply chain security encompasses information systems security, freight breaches, terrorism, vandalism, crime, and sabotage. Security strategy is aimed at increasing a supply chain's ability to sort out what is moving, and identify unusual or suspicious elements" (Manuj and Mentzer, 2008b, p. 210).
Avoidance	"Avoidance strategy Type 1 is used when the risks associated with operating in a given product or geographical market, or working with particular suppliers or customers is considered unacceptable (…) Avoidance strategy Type 1 is geared toward driving overall probabilities associated with risk events of a decision to zero by ensuring that the risk does not exist" (Manuj and Mentzer, 2008b, p. 210).
	"Avoidance strategy Type 2 takes the form of pre-empting adverse events (…) In avoidance strategy Type 2, reducing the frequency and probability of a risk event is of concern. This usually arises when managers have no option but to venture into high uncertainty demand or supply markets" (Manuj and Mentzer, 2008b, p. 211).

The same is valid for the already mentioned distinction in Wu *et al.* (2006) that crosses different pairs of classifications of risks internal/external, controllable/uncontrollable and totally/partially (Table 14), resulting in increased refinement of the classification of the risk factors. The practical use of these classifications lies, for example, in the fact that whether a given risk factor is controllable or not may well prove fundamental for different decisions, such as: whether to contract a surveyor; whether to buy a specific insurance coverage; whether to draft specific penalty clauses; whether to drop a supplier or a market.

Table 14 - Risk classification in Wu *et al.* 2006)

Type of strategy	Description
"Internal Controllable"	Refers to the internal risk factors that originate from sources that are most likely controllable by the company
"Internal Partially Controllable"	Refers to the internal risk factors that originate from sources that are partially controllable by the company
"Internal Uncontrollable"	Refers to the internal risk factors that originate from sources that are uncontrollable by the company.
"External Controllable"	Refers to the external risk factors that originate from sources that are most likely controllable by the supplier company.
"External Partially Controllable"	Refers to the external risk factors that originate from sources that are partially controllable by the supplier company.
"External Uncontrollable"	Refers to the external risk factors that originate from sources that are uncontrollable by the supplier company.

Likewise, the distinction between systematic and unsystematic risks (e.g., Ritchie and Brindley, 2007b) might prove useful from point of view of the odds that the manager might be facing in his efforts to deal with the risk factors concerned, in the sense that if a risk factor is a systematic one, unless some meaningful changes are introduced ("systemic changes", if the term is admissible) he is likely to face them time and again. However, it is important to recall what has been said before about the possibility of the same risk factor being systematic or unsystematic in different scenarios. This classification might also prove useful in a later stage of this model when it comes to risk assessment.

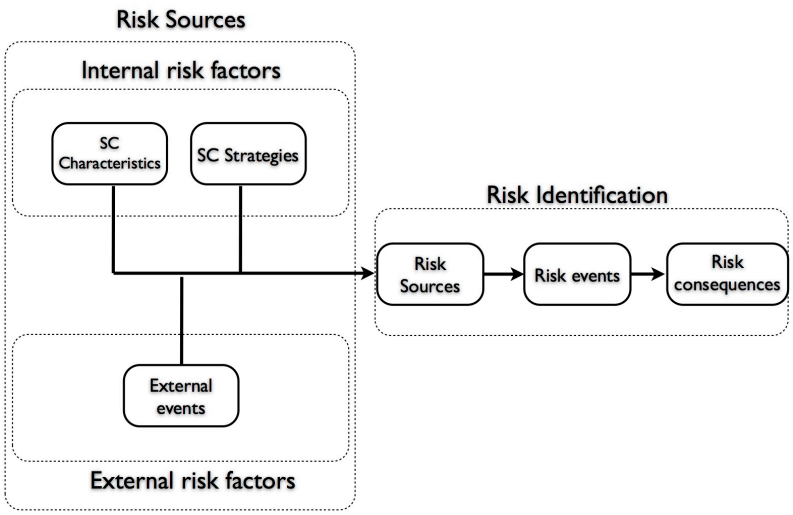


Figure 17 - Risk Sources and Risk Identification (proposed SRM framework)

Ritchie and Brindley (2007b), building on a risk source list suggested by Ritchie and Marshall, 1993, *apud* Ritchie and Brindley, 2007b) identify seven risk sources that have already been referred in the literature review: environment characteristics, industry characteristics, supply chain configuration, supply chain members, organization's strategy, problem specific variables, and decision-making unit. In their essence, these risk sources can be considered included in the two sub-sets in the "internal risk factors" in the proposed model (Figure 16 above). Hence, it is this sort of aspects that a manager should consider in his effort to list the internal risk sources.

There will be cases that a manager might find it difficult to understand exactly what is a relevant risk factor, in other words, what is indeed a peril. The causes for this have their roots in the difficulty in establishing relevant causation. Causation is a complex problem that one can imagine that is determinant in many fields of knowledge and an example is Insurance Law:

> *"The legal theory of causation has always been regarded as one of the most troublesome areas of the law" (Hodges, 2013, p. 145).*

Taking into account that the experience of insurance theory is built on incidents that happen in international trade, each of them having most probably affected a supply chain somewhere, there is more pertinence in this reference than meets the eye. For example, it is well established in Marine Insurance Law[23] that, in order to establish whether a loss is covered by insurance, that only the immediate cause, not the remote one, is to be considered (Hodges, 2013). This might seem an obvious statement but the truth is that establishing this causal relationship is often anything but easy and it is this difficulty that a supply manager will also be faced with. It is, therefore, fundamental that a supply chain risk manager can adequately identify the relevant cause, if for no other reason to contract adequate insurance should he deem it necessary.

It is, obviously, not within the scope of this thesis to dwell on the obscure subject of Insurance Law. However, this reference to it is not a purposeless one as it is meant to stress that the importance of focusing on the right facts when considering what the relevant perils are. This

[23] The reference to Marine Insurance Law here takes into account the principles in English Law. However, bearing in mind that most of the relevant principles were establish decades or even centuries ago mostly by English courts, if any one particular insurance law is to be taken as reference, it must be the English one. In fact, one can almost say that the very history of the contract of insurance has a sort of before Lloyd's coffee shop and a after Lloyd's coffee shop division (Noussia, 2007).

is extremely important because the whole risk management system that a supply manager might set up will rest on this identification of the risk factors. Wrongly identifying a potential cause of loss might lead to adopting the wrong strategies, be that proactive, advance warning or coping strategies, to use the classification in Stecke and Kumar (2009). Establishing the real risk factor is the main task here. For instance, take a delay of shipping documents that causes a disruption of supply. If we take into account one of the many risk taxonomies we might come to the conclusion that we are before a disruption risk, for instance. But how is this helpful for a manager seeking to avoid such episodes? What this manager needs to know is what the cause for such delay is. What should the manager do to keep such delays from repeating? Is the problem in the carrier who issued the BL? Was it the courier service that failed to deliver the documents on time? Is an LC involved and the problem is in the bank used to issue or confirm it? Is it in the way that the supplier's documents been written? Was the payment mode wrongly selected? It is easy to imagine that each of these possibilities would lead to different strategies and adopting the wrong course would be, in the best scenario, a waste of resources.

An important argument in this research is that supply chain risk management is frequently crippled by insufficient knowledge about aspects involved in international trade procedures that can have a dramatic impact on the organization, should something go wrong. Risk identification, as it has been referred already, is critical to the risk management process: should identification of risks fail to be accurate or complete, all subsequent risk management activity will be ill-founded and the usefulness of such a risk management system will be the same usefulness of a poorly calibrated precision tool (Kern et al., 2012; Pettit *et al.*, 2010). If there are aspects of the operation of which the supply chain manager fails to have a sufficient grasp and if these aspects may have severe implications from the point of view of the company, there will be little use in setting up a risk management comprehensive approach with such poor foundations. Yet, the aspects that concern the contractual basis of supply relationships are too often too obscure for supply managers, and if one considers the perils that are associated to the contractual underlying relationships pertaining to the goods and to their carriage, the two groups of interviews carried out afforded different examples of insufficient knowledge about critical aspects.

The interviews afforded several examples of this knowledge gap. For instance, different interviewees had insufficient knowledge about basic, yet important, implications of the use of a given Incoterm, not to mention the implication of its combination with a given payment method. In fact, these issues proved to be fertile ground for doubts, misconceptions and even extreme

lack of knowledge. For example, there was clear confusion between an insurance covering carrier's liability and cargo insurance, not to mention lack of knowledge of the limitations of a typical insurance coverage associated to the use of a given Incoterm, there were doubts as to who is responsibility for expenses such as demurrage charges, or the extension of an "all risks" policy. By focusing on perils, this tool could assist a supply manager in gaining a better perception of the existing perils and of the degree of his supply chain's exposure to those perils.

This lack of awareness of these issues has hardly ever, if ever at all, been visited by previous research on supply chain risk management. Yet, a supply chain manager may have received formal education on, for instance, stock management techniques, forecast methods and many other subjects - that will surely provide him skills that are fundamental for their job - and lack adequate training on other areas that may prove important to identify particular threats. In such cases, managers will often rely on third parties, such as forwarders, customs agents, banks and lawyers to give them sound counsel on those matters. By doing so, more often than not, they will be relinquishing the power to decide and the decision may fail to have adequate scrutiny.

It has to be said, however, that the potential impact of this lack of knowledge and the erroneous identification of threats will always depend on the type of operation and of its context. It is not indifferent whether the company has regular trustworthy suppliers or, on the contrary, it operates in a spot market. It is not indifferent whether its purchases are in large volume and value *per* order, or rather small quantities and value. Likewise, it is also relevant if there is a standard practice implemented in the industry that results in the fact that superficial knowledge suffices. It is, therefore, not wise to cast a judgment that labels the lack of knowledge of a practitioner if one does not know the exact context of the operation.

Having said that, the fact remains that, time and again, there are situations in which sheer luck seems to be the only thing keeping companies from being faced with the consequences of that lack of knowledge. It might be true that in many cases the perils neglected are low-probability ones, however this is not truly comforting if one recalls the fact that it has been noted in the literature that the low-likelihood risks that are often forsaken by researchers and by companies in their risk protection plans are also high-impact ones (Chopra and Sodhi, 2004).

The submission herein is that analysing risk sources adopting this perspective would also

contribute to greater awareness of knowledge gaps. This would be achieved by taking supply managers, as they follow the trail of causation to the root of the problem, to consider perils (both high and low-probability ones) that they often overlook. This risk identification stage should lead to a list of possible risk events in which all the anticipated perils would be listed and in the next stage they would be attributed a classification based on the estimated probability and impact (this means that two tables should be made), as explained further below.

It is not fundamental to determine here the exact model of survey list to be used, nor the most adequate scales. In any event, as Hallikas et al. (2002) stress what really is fundamental is that the assessment model of risks is simple. Rather than aiming at establishing a an absolute value of risk the goal is to provide some guidance for the decision-making process with an estimation of the probability and the effect of risk based on subjective estimation. Consequently, while for example Hallikas *et al.* (2002) suggest a scale of 1 to 5, to represent the degree of the impact and the likelihood of the relevant risks, a scale with fewer levels can also be used (or more, such as suggested in Figure 21 or even simply a "high" and "low" classification as used, for instance, by Sheffi and Rice (2005). Naturally, risk identification as it is suggested will not avoid many difficulties that have been documented in the literature and reported herein. Historical experience of the risk manager will still have a preponderant role in the list of risk factors being anticipated and will also determine those that will be totally forsaken (Kern *et al*., 2012). They may still keep turning a blind eye to risk moved by their personal objectives and responding to poorly designed performance metrics (Zsidisin, 2007).

The method to establish the priority for the different risk events based on frequency and impact would obviously depend on the existing historical and future information. However, the fact that the same amount of information exists for two different types of phenomena does not necessarily mean that they would justify the same effort in estimating the probability and impact. It could possibly make sense to establish the latter first in order to decide whether the effort to determine the former is justified.

6.2.2 – Implications on the different stages of supply risk management

Just as it was referred for the first stage, it is important to bear in mind that this stage –

Risk Assessment - should also involve a team-based approach, in order to ensure that all the relevant information is taken into account and that all available talent within the organization is mobilized for the time consumed with the task to be as rewarding as possible.

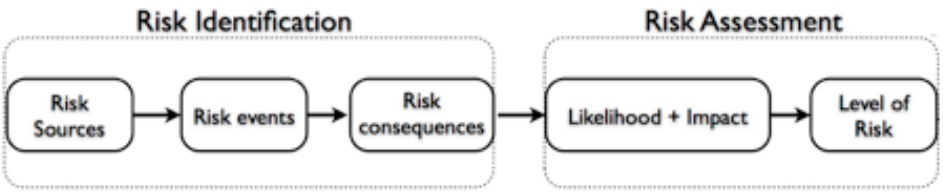


Figure 18 - Risk Assessment (proposed SRM framework)

The choice between different methods could depend on the information and resources available, including the team's skills. The existence of different suggestions in the literature has been reported earlier (3.5.5 - Supply chain risk management). Where risk assessment is involved and no objective information is available, techniques such as the Delphi method and focus groups of experts have already been suggested *"to aid in the derivation of probabilities"*, or the use of probabilities categories as suggested in the Military Standard MIL-STD-882C refered by Tummala and Schoenherr (2011, p. 10). Here, it is important to remember that, as suggested by March and Shapira (1987, p. 1411), it is often the lack of understanding, or trust, of probability estimates that drives managers to ignore low probability risks, disregarding their possible large impact. Consequently, it is important to ensure that these skills exist and this model is, once again, also an instrument to detect any lack of skills and suggest further training. Time and again, the benefit of using a team-based approach in these tasks has been referred herein, as it has in the literature (Knemeyer *et al.*, 2009; Manuj and Mentzer, 2008b). However, the contention here is that some of the necessary skills do not exist in the organizations, even if they gather a comprehensive task force for the job. Notwithstanding the possible exceptions, this is particularly so in smaller organizations as it was admitted by some of the interviewees.

Furthermore, the role of a supply chain risk manager is often a solitary one in the sense that, because a great deal of a manager's reflecting on supply risk issues contemplates low-likelihood scenarios (or, at least, so considered) more than actual events, it is not uncommon for this reflection to lack moments of formal analysis in the organization. This is particularly so in smaller organizations in which the lack of human resources leads to multi-tasking managers. A token of the fact that managers often feel the need for some joint thinking is probably in the fact

that there was great willingness from all the managers interviewed to cooperate with this research and, apparently, considerable openness to share their experience and discuss the topic. In some cases (*e.g, Auto 2*, *Shipyard* and *Steel S*), the interviewees expressly considered the opportunity of discussing this subject with an outsider as an opportunity for some useful reflection. An example of this is in the following words of one of the interviewees:

> *"Sometimes, we spend so much time of our day running around solving problems, that we lack the time to think about these issues. This is a one-man show job: we have to do what is in our job description and what was supposed to be in someone else's and we have no time to consider "what ifs". These are opportunities to think about problems that we do not usually see. I have been here for some time thinking about possible problems in our operation and I would hardly have the time to do that if I was busy with my after lunch usual routine: running around in the warehouse solving problems that shouldn't have occurred."*

A team-based approach is as much needed as it is often difficult to achieve. The same interviewee explained one of the reasons for this difficulty:

> *"We are going though some rough times, there are constant rumours about headcount cuts and of the production being moved to a plant in Eastern Europe. Everybody is too busy trying to put the blame on someone else for whatever goes wrong to be available for any sort of brain-storming about possible supply chain risks."*

Having established the level of risk, a decision has to be made whether to accept or avoid the risk (Figure 19).

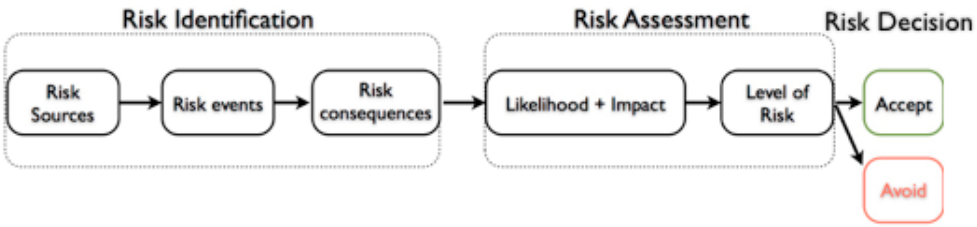


Figure 19 - Risk Decision (proposed SRM framework)

The decision will probably be influenced by different factors that have already been referred in this dissertation, one of the most important of which is, probably, the manageability of the different risk events. The risk classification suggested in Wu *et al.* (2006), as it has been referred above, might be useful to analyse the possibility of controlling the risk events listed, in order to

decide whether to accept them or not (Table 14).

At this point, it is important to recall that it is not within the objectives of this research to identify and select a specific set of risk mitigation strategies, therefore different strategies are occasionally referred from different proposals in the literature. Having said that, if the list of strategies in Manuj and Mentzer (2008a, 2008b) is used, a strategy of Avoidance Type 2 will probably be the sort of decision that it will be observed if the risk is considered unacceptable and unmanageable.

As it has been referred before, the manager's attitude before risk might be determinant to the risk level that is considered acceptable. These issues have been addressed by different theories already discussed, and are particularly relevant in the context of Agency theory, which is, to considerable extent and together with TCE, a theoretical background for the analysis in this thesis. A manager with increased risk aversion will typically, to state the obvious, be less willing to accept risk and probably take a Avoidance Type 1 of strategy adopting an option such as leaving a certain market, dropping a supplier, switching to a different material, choosing a different carrier, using an alternative payment mode, using a different port of discharge, using an alternative transport mode, using a different surveyor, and list could be endless. As Manuj and Mentzer (2008b, p. 210) explain,

> *"(…) strategy Type 1 is geared toward driving overall probabilities associated with risk events of a decision to zero by ensuring that the risk does not exist".*

Conversely, the same risk might be considered acceptable and is manageable by a manager who is a "risk taker". In this case, the choice of attitude will be somewhere in between an Avoidance Type 2 strategy and the acceptance of the risk without the adoption of any risk management strategy, the two extreme options in this case. Assuming that an Avoidance Type 2 strategy is to be used, it will probably materialize in a reduction of the exposure to the risk concern, but not in a total withdrawal from the specific market, nor in a total abandonment of a given supplier, and so on. In this case, the strategy implies reducing the exposure by reducing the frequency and probability of the risk events occurring and, consequently, their impact.

These examples of the use of these two types of Avoidance strategy are a good reminder of the importance of identifying the risk factors correctly. Identifying the specific perils correctly

will allow an adequate choice between either of these strategies or any other. This will be even more obvious if one considers the possibility of the risk manager choosing to manage the risk by transferring it to an insurer (*i.e.*, using a transfer strategy), as this will necessarily call for a clear identification of the perils concern, if the assured wants the insurance to serve its purpose. As a side note, there were several examples in the interviews of managers who were not sure about the sort of risk cover that their cargoes had whilst in transit.

The fact that the personality of the decision holder is determinant is another reason to use a team-based approach in this analysis, in order to prevent some sort of deviant behaviour by the decision holder, who, pursuing his selfish interests or out of sheer recklessness, may act as a gambler where sound management judgment would recommend a risk averse attitude. In fact, there might even exist risk sources that are associated to the decision maker as highlighted, for instance, by Rao and Goldsby (2009) when the authors list the supply chain risk sources (Figure 16). Within the list of relevant decision makers we must obviously include the supply chain risk manager.

Having established which risks are acceptable and which are not, and before the strategies are, in fact, chosen, it is important to bear in mind that not all risks will be dealt with the same degree of attention. This means that a prioritization of the risk events detected will be necessary, given the fact that resources are usually scarce and options must be made. It is only when the priorities have been defined that strategies can be selected. To establish this priority, the assessment that has been made, regarding the probability and impact of the different risk events, will be fundamental. That assessment will be more accurate, as it has been said, if it is founded on solid data analysis, but it is important to recall the reminder in Hallikas *et al.* (2002, p. 52) that

> *"(…) a qualitative analysis should not be neglected, because it provides information concerning the factors pertaining to the estimation and it provides a deeper understanding of the process."*

Having established that priority, different strategies will be selected with different purposes.

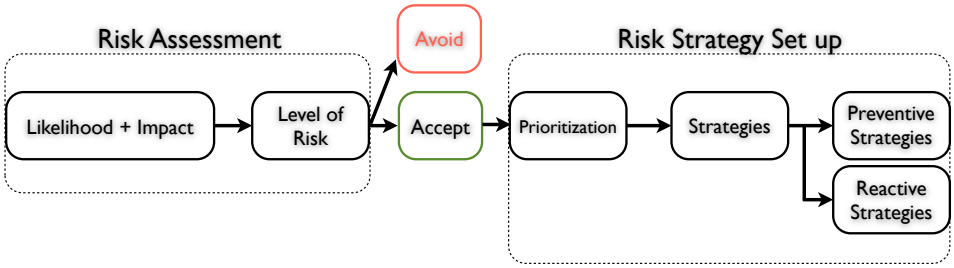


Figure 20 - Risk Strategy Set Up (proposed SRM framework)

Even though it is not with the objectives envisaged by this thesis to suggest a classification of strategies, nor to adopt one, it is useful to recall some of the classifications that have been referred in the literature review herein, in so far as they can highlight aspects that must be kept in mind. Ghadge *et al.* (2012, p. 324), for example, suggest a distinction between reactive and proactive strategies, based on the analysis of risk mitigation strategies they found in the literature. This distinction is used by other authors as well, even if the designation are slightly different, for instance Stecke and Kumar (2009) refer to "proactive strategies" and "coping strategies" but they had a third type referred to as "advanced warning strategies".

The basic distinction between the two types of approaches seems obvious but the fact that the classifications in the literature fall short in identifying specific strategies for specific risk events is a token of the limitations of the practical use of classifications. The suggestion in Stecke and Kumar (2009) goes to greater detail in identifying specific examples of what one can call a list of best practices, and lists of best practices is, essentially, what most authors suggest when they refer to flexibility, redundancy, robustness, visibility, among other concepts discussed in the literature review.

For the purpose of the suggested approach to risk identification, however, it is important to stress that a more accurate identification of the relevant perils will naturally favour a preventive or proactive approach, in other words, the more accurate the peril identification is the less the organization will probably have to make use of reactive strategies. The contention here is that the peril-based approach suggested would result in an increased preparedness to respond to risk events that do occur as it allows a better selection between preventive and reactive strategies.

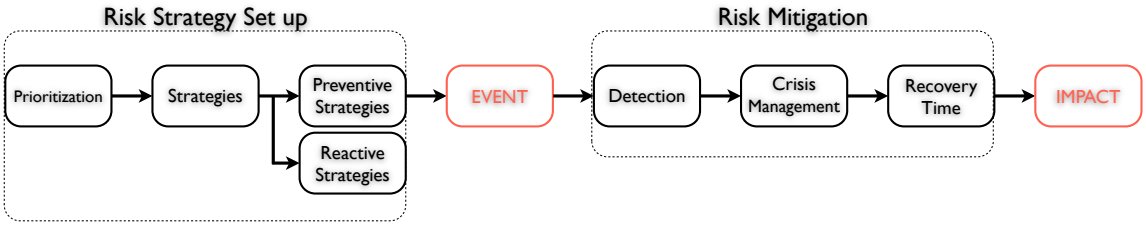


Figure 21 - Risk Mitigation (proposed SRM framework)

As it has been referred, considerable more attention is given in the literature to supply chain risk management strategies focusing on the pre-disruption approach (e.g., Hallikas et al., 2004; Norrman and Jansson, 2004; Wu et al., 2006; Manuj and Mentzer, 2008a; Knemeyer et al., 2009; Harland, 2013) and only few researchers have focused the post-disruption reaction (e.g., Blackhurst et al., 2005). This is due to the fact that, as one can easily anticipate, the preference goes to keeping disturbances from happening rather than having to cope with them and mitigate losses. This is also the perspective adopted here, but it is suggested that this concern will fall short of achieving its goals if it does not look for the specific perils that lurk along the supply chain, rather than building elaborate classifications that afford managers little help in their task. Even when one considers the last step of the proposed model - organizational learning (Figure 22) - this proposal seems to make added sense. Organizational learning is a continuous effort to benefit from previous experience to continuously improve the existing procedures of organizations and groups of organizations, therefore more accurately called inter-organizational learning. Organizations are people and their experience and memories are populated with perils and their consequences, not with classifications.

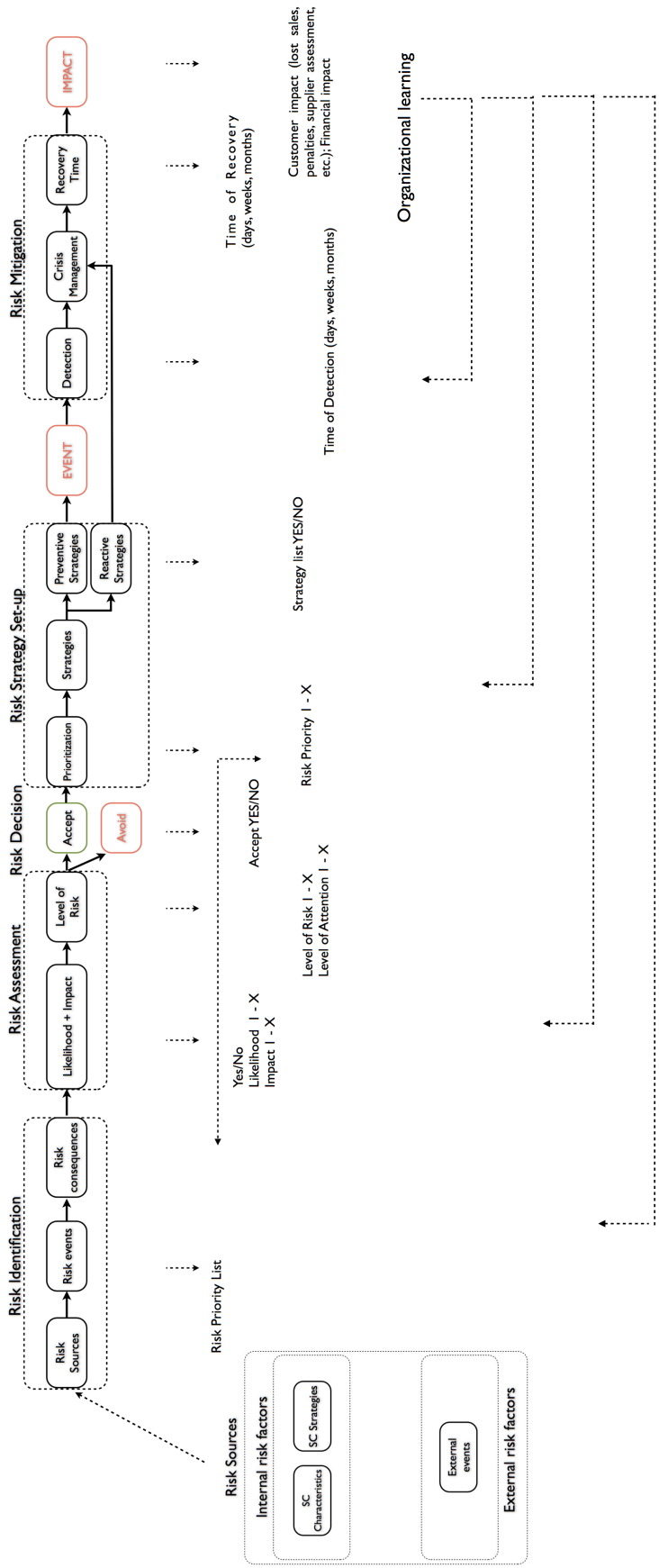


Figure 22 - Supply Risk Management framework

Part 7 - Conclusions and future research

7.1 – Conclusion and contribution to theory and practice

The goals of the research carried out and of the present thesis were spelt out in Part 2 of this thesis. There, a list of research question was formulated and to establish whether those objectives were met it is important to do so having those research questions as reference. Furthermore, it was also within the scope of this research, from the outset, to afford some help to managers of commodities supply chains in the task of setting up a comprehensive approach to supply chain risk management.

One of the facts that motivated this research was the fact that the rather scarce literature on supply chain risk management focusing the case of commodities is almost exclusively focused on CPR. This fact led to the question whether this was, in fact, the most relevant risk in the case of commodities. To answer, it would be necessary to ascertain which risks were in fact relevant in a supply chain focused on a commodity and, among these, which were the most relevant ones. To answer these questions a set on interviews was carried out in a group of companies that were considered "steel companies" for the purpose of this research, which means that they are mostly focused on transforming steel that they purchase.

The interviews revealed that, for the companies in the steel group in this research, CPR was not a relevant risk in the sense that it was not a reason for special concern. There was only one interviewee that referred this risk spontaneously and yet to consider it as a risk that did not justify more than moderate concern. This would seem to indicate that this risk is not particularly relevant in the case of a steel supply chain, however, as it was then explained, it would appear that steel price volatility is indeed relevant but in the case of these companies, particularly *Steel M* and *Steel S*, this volatility is neutralized, to great extent, by the fact that the companies operate on a project basis and, consequently, transfer that risk to their clients when they establish their price taking into account the cost of materials. This possibility of passing/ sharing the risk to/with the customer had already been suggested by Zsidisin and Hartley (2012a) in these authors' proposal of a process for creating a commodity price risk management strategy. Be that as it may, the fact remains that this risk does not seem to be a special cause for concern in the companies studied.

On the other hand, the experience of all steel companies in this research highlighted the fact that most of their risk-related problems in their supply chain management was caused by their feeble negotiating power *vis-à-vis* their steel suppliers, generally speaking large international firms. This fragile position translated into delays of deliveries that could potentially cause disruption of operations that the buyers had to manage either, or both, by keeping added safety stock or placing their orders earlier to accommodate those frequent delays.

Furthermore, the interviews in this group have revealed that there were concerns over the possibility of disruptions caused by other factors. One of the causes that was mot referred was the delay of the cargo caused by different procedural problems be that bank delays, customs related hindrances to the release of cargoes, delayed shipping documents, among others. Seldom, if ever at all, are some of these causes referred in the literature. Some of these causes are associated to procedures that are directly linked to payment terms or to contractual options, issues that it is possible that most researchers are not very familiar with, given their academic background, and the interviews have also revealed that even managers are frequently limited in the depth of their knowledge on these aspects. This is also a possible reason for the fact that some of these aspects are not adequately dealt with by the literature. Arguably, this is one of the relevant takeaway highlights of this research.

Although the reason above could also explain the fact that the literature on commodities supply chain risk focuses exclusively, or almost, on CPR, one has to assume that that focus has a different justification, and that there must be a valid reason for the most venerable scholars to focus exclusively on that risk. It would be unwise and a sign of extremely lack of scientific humility, so to speak, to cast such doubts without considering alternative reasons. For this reason, despite the fact that there was a previous point of view regarding this issue, this investigation had a set of research questions as a starting point. The option was to disregard that point of view in order to avoid a biased investigation that would recklessly question previous research.

This, it would seem, proved to be a prudent option as one of the interviewees (*Steel M*), made a remark, at the end of the meeting and when the interview had already formally ended, that can shed some light on this doubt. When the interviewee was told that the literature focused exclusively on CPR, whereas this risk seemed to be of little relevance for this interviewee, he offered the following possible explanation:

"We say that we buy steel but, in fact, we buy a great deal of varieties of steel. That concern with price risk is probably more relevant in a case where the company truly buys one commodity alone, and not many sub-types, which is a great volume of its purchasing. For example, I can imagine that if I was buying one kind of steel to make always the same thing, I could focus more on the price. Or if I was buying the ore to make the steel."

The last period in this manager's comment probably explains the great attention given to CPR in the literature and why that attention is not seen in the steel companies studied. Most of the examples in the literature concern primary commodities (in the sense referred in Radetzki, 2008, p. 7, already referred herein) such as oil (Cigolini and Rossi, 2010), coffee (Hartley and Zsidisin, 2012), sugar or grains (Zsidisin, 2005). The price of these commodities in the international markets is much easier to follow than that of steel, for the reasons explained above. Therefore, there might be an added incentive to monitor the raw material market price that a steel buyer does not have, since his only reference is the price of iron ore and steel derivatives. Possibly, those cases referred in the literature that are not primary commodities such as butter (Zsidisin, 2005) or plastic (Hartley and Zsidisin, 2012), involve companies that have the capacity to commit the necessary resources necessary to keep a closer watch on all the numerous factors that affect steel price, whereas the companies studied lack the necessary resource for that task. In short, it is possible that the realities addressed by the literature are just too different from the realities in the companies studied and it is not just a matter of researchers' profiles and background. Be that as it may, the fact remains that in the cases studied CPR appears not to be a major concern.

At the same time that this research revealed the experience of the interviewees regarding risks experienced, it also afforded insight into the causes of those threats and incidents. In some instances, some of those causes have been associated to contractual options, such as the choice of Incoterm. However, in most cases, if not in all of them, it has been suggested that there was hardly any alternative for the companies than to close their contracts in the existing terms due to their insufficient bargaining power to impose different solutions. It has to be said, however, that this research also revealed, occasionally, instances in which it seemed that there was insufficient knowledge regarding contractual solutions and their consequences. This was also considered an aspect that it could benefit from the adoption of the proposed approach to risk assessment that will be referred below.

This research has also afforded evidence of the way different companies deal with different

risks. It was not within the objectives established for this thesis to produce a list of strategies for risk mitigation, however, whenever it proved relevant, it was explained how these companies cope with different risks. In fact, it is possible to establish some patterns of the usage of some strategies for specific risk events. For instance, it became clear from the first group of companies that risk events associated to the lack of quality are dealt with what one could call a control strategy, to use the terminology in the classification in Manuj and Mentzer (2008a e 2008b). Another example is the use of adequate contractual clauses to deal with different risk events such as those associated to currency exchange rate fluctuation. This is often done by stipulating an exchange rate or indexing the exchange rate, or by using revision clauses to address price changes of a production factor, which was also referred in the case of CPR. This possibility is also already contemplated by the proposal in Zsidisin and Hartley (2012a) when the authors refer to the possibility of passing/sharing the risk to/with the supplier.

Having focused the study in two distinct groups of interviews it has been possible to highlight some differences between the two groups of cases, thereby distinguishing some particular characteristics in the case of steel supply chains, probably relevant in some cases where other commodities are concerned. One aspect was clearly paramount for the comprehension of the experience of the companies in the steel group: the fact that, when it comes to their steel purchasing, they deal almost exclusively with mammoth corporations with overwhelming bargaining power. This has different consequences that can be summarized in the fact that these steel buyers are mere terms-takers in their steel purchase contracts.

This research has also revealed that some risks are less relevant in the context of the companies of the steel group than they were to the companies in the first group and this has been explained with the deeper integration of the operation of the companies in the latter group with their suppliers and of the more complex nature of the products that they purchase. Consequently, risk events such as those associated to the financial situation of the supplier and to quality were much more relevant in the companies in the first group. However, the added relevance of former, compared to the steel group, is also explained by the fact that the steel suppliers are colossal companies, seemingly with great financial robustness.

As for the apparent equal relevance of risk associated to quality in the two groups of companies, the results reflected in Table 8 and Table 9 might be somewhat misleading. It is true that risk associated to lack of quality has been equally identified in the two groups of companies,

however in steel group quality problems are not as relevant as the number of observations might suggest in the sense that this risk is easily kept under control with the standard certification used in the industry. The added complexity of some of the products purchased by the companies in the first group of interviews, on the contrary, results in added reasons for concern, in spite of the generalized use of certification.

A type of risk event that was considered relevant in all cases was "disruption". However, as it has been referred earlier in this thesis, this is one of the most eloquent examples of the disadvantages of using risk classifications to analyse the reality of companies' operations. In the discussions around the subject of supply chain risk management the terminology and the concepts used are anything but crystal clear. This research aimed at making a contribution to managerial practice but this would always depend on the clarity of the concepts and the feasibility of practical application of its suggestions. Throughout the interviews carried out, it became obvious that, from a managerial point of view, the risk identification process would benefit of added clarity. The effort to simplify this process was jeopardized by the use of classifications in the literature that could be quite obscure for a manager. The information gathered through the interviews provided the opportunity to materialize a further contribution of this research in the proposal of a different approach to risk identification as the first stage for a a comprehensive approach to supply chain risk management.

Hence, a proposal for a different approach was made with the suggestion of the framework in Figure 22. However, bearing in mind that the focus of this research is limited to risk identification, the discussion of the application of that framework was deliberately focused on the aspects concerning risk identification, admitting, from the outset, that this discussion would not cover the whole framework with equal depth. The main driver for this suggestion emerged from the analysis of the interviews and the clear perception that the use of risk classifications was detrimental to the usefulness of supply chain risk management theory from a managerial point of view. Beyond the risk of producing misleading results, using risk classifications to identify risk events might prove a cumbersome task and, consequently, jeopardizing the use by practitioners of any framework that uses classifications for the identification of risk. With this concern in mind, this research suggests a framework for supply risk management that adopts an approach to risk identification that uses the concept of peril, as it is used in Insurance Law to identify the real cause of loss. This approach replicates a manager's thought process when he looks at his supply chain. The main task is to establish the real risk factor, which is critical to the risk management

process: should identification of risks fail to be accurate or complete, all subsequent risk management activity will be set on the wrong premises and the risk management system might become potentially useless.

This approach also introduces a whole new type of issues that have been absent in supply chain risk discussions. This research has shown that correctly identifying the relevant perils will expose threats that managers often fail to have solid knowledge to tackle. Introducing these issues is throwing a pebble in the waters of supply chain risk knowledge, probably little more than throwing a pebble in a vast ocean. Yet, it is a contribution to a better understanding of the risks that are present in supply chains. This approach and the framework suggested also help to highlight the areas of knowledge in which further training might be required. Thus, the focus on perils rather than on risk categories and the use of a framework based on this approach would also contribute to skilful managerial practice.

However, this thesis has also shown that reality might often defeat that purpose. For instance, if one takes the case of the companies in the steel group in this research as an example, it seems clear, given their lack of bargaining power, that it is not within the power of those companies to demand alternative arrangements from their steel suppliers. Consequently, it is probably not expectable that their managers invest too much time increasing their knowledge to acquire skills that they will never have a chance to use. Obviously, the same is valid for the companies in the first group whenever the same justification applies. On the other hand, as it has been referred above, many of these decisions would benefit from a cross-functional approach. Arguably, the supply manager may be excused from being equally savvy on all aspects of the operation and of being equally knowledgeable on all fields of expertise. His job description might require excellent analytical skills and almost none concerning, for example, the use of bank guarantees or payment modes. The problem is that even when the latter type of skills are necessary, the general idea is that reading ability suffices because it would seem that it is optimistically considered that anyone can read a contract. It is suggested that it has been demonstrated herein that, sometimes, things are a little more complicated than managers and organizations seem to think. Hopefully, if this thesis has fallen short of its goals, it has at least provided food for thought.

7.2 – Limitations of the research and suggestions for future research

Despite its possible merits, this research has a number of limitations. Some of these limitations are a natural consequence of the case study methodology adopted, others result of the way it has been implemented. On the other hand, those limitations may have different consequences: they can simply reduce the strength of the conclusions in this research; but they can also lead to new knowledge or open the door to further research.

The virtues of qualitative research approaches have been discussed in the section focused on methodology issues and shall not be repeated here. However, the common fragilities of a qualitative approach such as the one adopted in this research have also been exposed therein and some of those fragilities are also noticeable in this research and explain some of its shortcomings. Bearing in mind that this research involved observing the reality of the experience of a number of companies, in order to interpret that experience with the purpose of building theory, the adoption of a qualitative approach is arguably adequate. However, this sort of approach involves difficulties that have been stressed recurrently by different scholars (e.g., Miles 1979). In spite of the fact that due attention was paid to the cautionary remarks of those who question the qualitative approaches, some of the shortcomings of a qualitative research may affect this thesis. These shortcomings, however, do not question the fact that, because the focus of this research (i.e., commodities supply chains risk, specifically steel supply chains) was on a subject that is seldom addressed by the literature, the qualitative nature of this research was justified (Yin, 2003). Moreover, recalling the words of Vissak (2010) referred earlier, case study research can help to discover causal relationships, it can help to explain the "why" and "how" of a certain phenomenon or reality. This approach was implemented through the use of multiple case studies. This option was due to different factors, such as the need to ensure triangulation, to augment external validity and to avoid observer bias, thereby increasing the robustness of the conclusions (Vissak, 2010).

However, despite the effort to neutralize that observer bias, this is not totally achieved just by using multiple case studies and in this case a degree of bias has had consequences that, to some extent, had an impact in the final results. In fact, the very motivation behind the present research might have implied a dash of bias. As it was admitted, there was an *a priori* point of view regarding the fact that the literature on commodities supply chain was almost exclusively focused

on CPR, one that questioned the relevance of CPR and considered that other risks were also relevant. By itself the fact that this initial argument existed would not lead to bias, it could even lead to a different approach, one based on propositions that the research would try to confirm, or not. This was not the course set, however. Instead, a set of research questions was proposed and, with the benefit of hindsight, it can be argued that there was bias implicit in that set of questions. Although this did not contaminate the fieldwork, it diverted the attention to the wrong explanation for that focus on CPR, and this had an impact on the interpretation of the literature. Truth be said, this has been permitted by the lack of clarity of some of the literature that refers to different commodities and the way that companies deal with their price variations but does not care to explain the relevance of context, falling into misleading generalization. Eventually, that bias dissipated and this happened gradually as the information was being harvested through the interviews. In a sense, the original sin led to a truthful process of discovery.

In the end, it is believed that the process can be described as one of true theory building in continuous dialectical interplay between theory and data as proposed by Grounded Theory. The interviewees generously afforded

> *"thick, interesting, and easily readable descriptions and rich understandings (...) of phenomena in their natural settings"* (Vissak, 2010, pp. 371–372).

Yet, it is doubtful that the researcher has been capable to carry all that rich content to this thesis. Despite this possible shortcoming, it was the rich information collected that led to the possibility of suggesting an alternative approach to risk identification, as it became obvious throughout the interviews jus how inadequate the use of risk categories is to allow a fruitful interaction between theory and practice. Earlier, in the section regarding methodology, the subject and the purpose of this research were said to be a typical scenario for the application of methodological approaches influenced by Grounded Theory. As it was then referred, building theory from case studies frequently involves overlapping data analysis with data collection (Eisenhardt, 1989b) and the theoretical constructs emerge through a systematic analysis of evidence collected. In the beginning of this research there was, admittedly, a point of view regarding the relevance of other risks beyond CPR and the almost exclusive attention given to this risk in the literature. However, there was also an admission that it could be a biased point of view and an option was made to have a fresh start with a set of research questions. Although the results arguably confirm that the initial contention was correct, in so far as the relevance of other risks is concerned, they have

also shown that the initial intuition that there could be some sort of bias behind the relevance given to CPR in the literature is probably wrong because there are valid reasons for that added attention in specific contexts.

Despite the belief that the end result has its merits, for the reasons explained, it seems clear that the analysis would have benefited of added clarity in the interpretation of the results and of their greater robustness. This is due to different possible reasons. To start with, to some extent, flexibility and the opportunistic decision process characterize the strategy adopted. Despite the fact that this can be a valid and fruitful approach (Seuring, 2008), the fact is that external factors have interfered with the normal course of the case selection process in the second stage of this research. Having purported to adopt a theoretical sampling as explained in the methodology section, and even though the cases were indeed selected "purposefully" (as discussed in the methodology section), the truth is that the circumstances had an impact in the moment when it was considered that the point of theoretical saturation had been reached. Although the decision that this point had been reached was a conscious one, at a later stage it became noticeable that some issues could have been further explored and that this would have justified further interviews with other steel companies, in order to better understand, for example, the differences between some observations in *Steel L* and the other two steel companies. Unfortunately, this was not possible as it was only late in the interpretation of the information gathered that this became noticeable.

Having said that, it is possible that those differences had a different explanation, and this is the second possible reason for the lack of clarity and insufficient robustness. *Steel L* was the only case in which the interviewee asked for the questions to be emailed in advanced. The very script for the interviewees was a short number of direct questions and a group of topics, which had the purpose of avoiding excessive conducting of the interview's course by the interviewer. Even so, only a short set of topics was actually sent to the interviewee. However, it is quite likely that this resulted in the interviewee being much more deliberate in his answers, possibly even with some degree of mental reservation. In other words, this interviewee may have been less spontaneous than the others. This is always a risk whenever one expects the facts to be brought in by others. Furthermore, the fact that this interviewee did not have the seniority of the other two interviewees, hence much less experience, may have had some influence as well.

A final reason for the lack of clarity is the fact that this research adopted a risk event

classification as a tool for the interpretation of the information collect and, as it has been repeatedly argued herein, the use of classifications is frequently detrimental to clarity.

These are the less obvious shortcomings of this research, known only to the researcher and stated for the benefit of full disclosure. However, they are also some of the most relevant ones, if not the most relevant ones, with impact in the robustness of the conclusions. Naturally, there are also limitations resulting from the fact that there was not a longitudinal study within each company but only an interview in each organization. There is also the usual doubt as to whether the experience of the interviewees, as they report it, reflects the experience of the organization and this is reflected, for instance in the possible contradiction between the opinion expressed by one of the interviewees and the facts as stated by a governance report of the organization.

One final remark concerns the framework proposed. Even though it was clearly stated from the outset that the objective was to delve into the risk identification stage only, the usefulness of the framework proposed, or at least its value, is necessarily affected by the fact that the other stages are only dealt with superficially. However, the complete framework has been proposed with the express proviso that it was only meant to be a starter for future investigation. Hopefully, this can be taken into account both to accept this option and as hint for further research.

Having started this research from the intuition that there could be some bias in the literature that led researchers to highlight exclusively price risk in the case commodities supply chain risk management, the arrival point is quite different. Although it is not possible to generalize the conclusion that CPR is not particularly relevant, given the limitations of this research, it is suggested that it could prove useful to investigate to what extent this risk is truly manageable and how, by different companies in different contexts. Furthermore, it is anticipated that it could d be interesting to make such study in different commodities.

Finally, the relevance of context has been repeatedly stressed but it is arguable that some aspects that this research has highlight are, truth be told, not new and that this research has done little more than confirming what was known from the outset. In fact, that much was highlighted in the literature review, when the contextual nature of SCRM was discussed. However, this research may have suggested the relevance of contextual aspects that have been insufficiently

studied by previous research. This is, arguably, the case of relevance of the manager's profile supply chain risk detection and management. The relevance of the manager's profile and the team's composition has been referred before in the literature. For instance, research rooted on agency theory often focuses on theses aspects, as explained herein when the supporting theories were discussed. However, the interviews carried out also exposed the relevance of manager's skills when it comes to their shortcomings in risk identification and risk management. The team-based approach that has been often called for in the literature, albeit important is, it is submitted, often insufficient due to the fact that it is not uncommon for the team to have a generalized want of some relevant competences. These are issues that could benefit of further investigation and it is also suggested that it could prove useful to investigate the usefulness of a framework for supply chain management as a tool to ascertain knowledge gaps and the need for new skills.

References

Adhitya, A., Srinivasan, R., & Karimi, I. A. (2009). Supply chain risk identification using a HAZOP-based approach. *AIChE Journal*, *55*(6), 1447–1463. doi:10.1002/aic.11764

Alderton, P. M., & Rowlinson, M. (2013). The Economics of Shipping Freight Markets. In C. Grammenos (Ed.), *The Handbook of Maritime Economics and Business* (2nd ed., pp. 181–216). London, UK: Taylor & Francis. Retrieved from amazon.com

An airline buys an oil refinery. (2012). *The Economist*. Retrieved July 7, 2012, from http://www.economist.com/blogs/gulliver/2012/05/delta-air-lines

ArcelorMittal. (2014). *ArcelorMittal Annual Report 2013*.

ARNTZEN, B. (2009). *MIT CTL WHITE PAPER GLOBAL SUPPLY CHAIN RISK MANAGEMENT PART 1: DIFFERENCES IN ATTITUDES*. Cambridge, MA, USA.

Asbjørnslett, B. E. (2009). Assessing the Vulnerability of Supply Chains. In G. A. Zsidisin & B. Ritchie (Eds.), *Supply Chain Risk: a Handbook of Assessment, Management, and Performance A Handbook of Assessment, Management, and Performance* (p. 349). New York: Springer.

Assaf, M., Bonincontro, C., & Johnsen, S. (2006). *Global Sourcing & Purchasing – post 9/11: New Logistics Compliance Requirements and Best Practices*. Fort Lauderdale, Florida: J. Ross Publishing.

Aureli, S., & Salvatori, F. (2012). AN INVESTIGATION ON POSSIBLE LINKS BETWEEN RISK MANAGEMENT, PERFORMANCE MEASUREMENT AND REWARD SCHEMES. *Accounting & Management Information Systems / Contabilitate Si Informatica de Gestiune*, *11*(3), 306–334. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=82745621&site=ehost-live

Aven, T. (2010). On how to define, understand and describe risk. *Reliability Engineering and System Safety*, *95*(6), 623–631. doi:10.1016/j.ress.2010.01.011

Bandyopadhyay, K., Mykytyn, P. P., & Mykytyn, K. (1999). A framework for integrated risk management in information technology. *Management Decision*, *37*(5), 437–445. doi:10.1108/00251749910274216

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120. doi:10.1177/014920639101700108

Barrat, C., & Whitehead, M. (2004). *Buying for Business: Insights in Purchasing and Supply Management* (1st ed.). Wiley. Retrieved from https://books.google.pt/books?id=8jKDGjGo_24C

Barratt, M., Choi, T. Y., & Li, M. (2011). Qualitative case studies in operations management: Trends, research outcomes, and future research implications. *Journal of Operations Management*, *29*(4), 329–342. Retrieved from 10.1016/j.jom.2010.06.002

Bartram, S. M. (2005). The Impact of Commodity Price Risk on Firm Value - An Empirical Analysis of Corporate Commodity Price Exposures. *Multinational Finance Journal*, *9*(3/4), 161–187. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=33424543&site=ehost-live

Behdani, B., Adhitya, A., Lukszo, Z., & Srinivasan, R. (2012). How to Handle Disruptions in Supply Chains – An Integrated Framework and a Review of Literature. *SSRN Electronic Journal*, 1–48. doi:10.2139/ssrn.2114201

Belarmino, A.-D., Carlos, M., Santiago, G.-C., & Merrill, L. (2012). The impact of supply network characteristics on reliability. *Supply Chain Management: An International Journal*, *17*(3), 263–276. Retrieved from http://dx.doi.org/10.1108/13598541211227108

Beresford, A., & Pettit, S. (2009). Emergency logistics and risk mitigation in Thailand following the Asian tsunami. *International Journal of Risk Assessment & Management*, *13*(1), 7–21. doi:10.1504/ijram.2009.026387

Berger, P. D., Gerstenfeld, A., & Zeng, A. Z. (2004). How many suppliers are best? A decision-analysis approach. *Omega*, *32*(1), 9–15. doi:10.1016/j.omega.2003.09.001

Bernstein, P. L. (1996). *Against the Gods: The Remarkable Story of Risk*. New York: John Wiley & Sons.

Bernstein, P. L. (2000). The enlightening struggle against uncertainty. In J. Pickford (Ed.), *Mastering Risk, Volume 1: Concepts* (p. 336). London, UK: Financial Times/ Prentice Hall.

Black, F., & Scholes, M. (1973). The Pricing of Options and Corporate Liabilities. *The Journal of Political Economy*, *81*(3), 637–654. Retrieved from http://www.jstor.org/stable/1831029

Blackhurst, J., Craighead, C. W., Elkins, D., & Handfield, R. B. (2005). An empirically derived agenda of critical research issues for managing supply-chain disruptions. *International Journal of Production Research*, *43*(19), 4067–4081. doi:10.1080/00207540500151549

Blackhurst, J., Dunn, K. S., & Craighead, C. W. (2011). An Empirically Derived Framework of Global Supply Resiliency. *Journal of Business Logistics*, *32*(4), 374–391. Retrieved from 10.1111/j.0000-0000.2011.01032.x

Blackhurst, J., Scheibe, K. P., & Johnson, D. J. (2008). Supplier risk assessment and monitoring for the automotive industry. *International Journal of Physical Distribution & Logistics Management*, *38*(2), 143–165. doi:10.1108/09600030810861215

Blome, C., & Schoenherr, T. (2011). Supply chain risk management in financial crises - A multiple case-study approach. *International Journal of Production Economics*, *134*(1), 43–57. doi:10.1016/j.ijpe.2011.01.002

Blos, M. F., Hui-Ming, W., & Yang, J. (2010). Analysing the external supply chain risk driver competitiveness: A risk mitigation framework and business continuity plan. *Journal of*

Business Continuity & Emergency Planning, *4*(4), 368–374. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=57268829&site=ehost-live

Blos, M. F., Quaddus, M., Wee, H. M., & Watanabe, K. (2009). Supply chain risk management (SCRM): a case study on the automotive and electronic industries in Brazil. *Supply Chain Management: An International Journal*, *14*(4), 247–252. doi:10.1108/13598540910970072

Borge, D. (2002). *The Book of Risk*. New York: John Wiley & Sons.

Bowersox, D. J., Closs, D. J., & Cooper, M. B. (2006). *Supply Chain Logistics Management* (2nd ed.). New York: McGraw Hill Higher Education.

Bowman, E. H. (1980). A Risk-Retum Paradox for Strategic Management. *Sloan Management Review*, *21*(17-31).

Brach, M. A. (2003). *Real Options in Practice*. New Jersey: Wiley. Retrieved from https://books.google.pt/books?id=W8myu0D61C0C

Braithwaite, A., & Hall, D. (1999). Risky business? Critical decisions in supply chain management (Parts 1 & 2). *Supply Chain Practice (1)*, *Part 1: (2*.

Braunscheidel, M. J., & Suresh, N. C. (2009). The organizational antecedents of a firm's supply chain agility for risk mitigation and response. *Journal of Operations Management*, *27*(2), 119–140. doi:10.1016/j.jom.2008.09.006

Brindley, C. (Ed. . (2004). *Supply Chain Risk*. (C. Brindley, Ed.). Aldershot: Ashgate.

Bucklin, L. P. (1965). Postponement, Speculation and the Structure of Distribution Channels. *Journal of Marketing Research (JMR)*, *2*(1), 26–31. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5003536&site=ehost-live

Burt, D. N., Pinkerton, R. L., & Pinkerton, R. D. (1996). *A Purchasing Manager's Guide to Strategic Proactive Procurement*. AMACOM. Retrieved from http://books.google.pt/books?id=Q5PTAwAAQBAJ

Caniëls, M. C. J., & Gelderman, C. J. (2005). Purchasing strategies in the Kraljic matrix—A power and dependence perspective. *Journal of Purchasing and Supply Management*, *11*(2-3), 141–155. doi:10.1016/j.pursup.2005.10.004

Caniëls, M. C. J., & Gelderman, C. J. (2007). Power and interdependence in buyer supplier relationships: A purchasing portfolio approach. *Industrial Marketing Management*, *36*(2), 219–229. doi:10.1016/j.indmarman.2005.08.012

Cavinato, J. L. (2004). Supply chain logistics risks: From the back room to the board room. *International Journal of Physical Distribution & Logistics Management*, *34*(5), 383–387. doi:10.1108/09600030410545427

Cavinato, J. L., Kauffman, R. G., & of Purchasing Management, N. A. (2000). *The Purchasing Handbook: A Guide for the Purchasing and Supply Professional*. McGraw-Hill. Retrieved from http://books.google.pt/books?id=8ihZAAAAYAAJ

Chapman, P., Christopher, M., Jüttner, U., Peck, H., & Wilding, R. (2002). Identifying and managing supply chain vulnerability. *Focus*, *4*(4), 59–64. doi:Cited By (since 1996) 23 Export Date 2 January 2013

Cheng, S. K., & Kam, B. H. (2008). A conceptual framework for analysing risk in supply networks. *Journal of Enterprise Information Management*, *21*(4), 345–360. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=33329611&site=ehost-live

Chevalier-Roignant, B., & Trigeorgis, L. (2011). *Competitive Strategy: Options and Games*. MIT Press. Retrieved from https://books.google.pt/books?id=HgN4kKQGpzoC

Childerhouse, P., Disney, S. M., & Towill, D. R. (2008). On the impact of order volatility in the European automotive sector. *International Journal of Production Economics*, *114*(1), 2–13. doi:10.1016/j.ijpe.2007.09.008

Childerhouse, P., Hermiz, R., Mason-Jones, R., Popp, A., & Towill, D. R. (2003). Information flow in automotive supply chains -- identifying and learning to overcome barriers to change. *Industrial Management & Data Systems*, *103*(7), 491–502. Retrieved from 10.1108/02635570310489197

Chopra, S., & Sodhi, M. S. (2004). Managing Risk To Avoid Supply-Chain Breakdown. *MIT Sloan Management Review*, *46*(1), 53–62. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=14829790&site=ehost-live

Christopher, M. (2000). The Agile Supply Chain: Competing in Volatile Markets. *Industrial Marketing Management*, *29*(1), 37–44. doi:http://dx.doi.org/10.1016/S0019-8501(99)00110-8

Christopher, M. (2004). *Logistics an Supply Chain Management: Creating Value-Adding Networks* (3rd ed.). London, UK: Financial Times/ Prentice Hall.

Christopher, M., & Holweg, M. (2011). "Supply Chain 2.0": managing supply chains in the era of turbulence. *International Journal of Physical Distribution & Logistics Management*, *41*(1), 63–82. doi:10.1108/09600031111101439

Christopher, M., & Lee, H. L. (2004). Mitigating supply chain risk through improved confidence. *International Journal of Physical Distribution & Logistics Management*, *34*(5), 388–396. doi:10.1108/09600030410545436

Christopher, M., & Peck, H. (2004a). Building the resilient supply chain. *International Journal of Logistics Management*, *15*(2), 1–14. doi:10.1108/09574090410700275

Christopher, M., & Peck, H. (2004b). The Five Principles of Supply Chain Resilience. *Logistics Europe*, *12*(1), 16–21.

Christopher, M., Peck, H., & Towill, D. (2006). A taxonomy for selecting global supply chain strategies. *The International Journal of Logistics Management*, *17*(2), 277–287. doi:10.1108/09574090610689998

Cigolini, R., & Rossi, T. (2010). Managing operational risks along the oil supply chain. *Production Planning & Control*. doi:10.1080/09537280903453695

Clements, A. (2012). Analysis: Olympic legacy for supply chain. *Retail Week*. Retail Week: EMAP Publishing Limited. Retrieved from http://www.retail-week.com/in-business/supply-chain/analysis-olympic-legacy-for-supply-chain/5041990.article

Clemons, E. K., & Weber, B. W. (1990). Strategic Information Technology Investments: Guidelines for Decision Making. *Journal of Management Information Systems*, *7*(2), 9–28. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5748095&site=ehost-live

Coase, R. H. (1937). The Nature of the Firm. *Economica*, *4*(16), 386–405.

Cohen, M. A., & Huchzermeir, A. (1999). Global Supply Chain Management: A Survey of Research and Applications. In S. Tayur, R. Ganeshan, & M. Magazine (Eds.), *Quantitative Models for Supply Chain Management* (pp. 669–702). New York: Springer US. Retrieved from https://books.google.pt/books?id=cLH1gjnnqWoC

Cohen, M. A., & Kunreuther, H. (2007). Operations Risk Management: Overview of Paul Kleindorfer's Contributions. *Production & Operations Management*, *16*(5), 525–541. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=27883699&site=ehost-live

Cole, S., & Kirwan, B. (2009). Between the Corporation and the Household: Commodity Prices, Risk Management, and Agricultural Production in the United States. *American Journal of Agricultural Economics*, *91*(5), 1243–1249. doi:10.1111/j.1467-8276.2009.01291.x

Coleman, B. J., & Jennings, K. M. (1998). The UPS strike: lessons for just-in-timers. *Production and Inventory Management Journal*. Retrieved from http://dx.doi.org/

Coleman, L. (2006). Frequency of Man-Made Disasters in the 20th Century. *Journal of Contingencies & Crisis Management*, *14*(1), 3–11. Retrieved from 10.1111/j.1468-5973.2006.00476.x

Colicchia, C., & Strozzi, F. (2012). Supply chain risk management: a new methodology for a systematic literature review. *Supply Chain Management: An International Journal*, *17*(4), 403–418. doi:10.1108/13598541211246558

Conner, K. R. (1991). A Historical Comparison of Resource-Based Theory and Five Schools of Thought Within Industrial Organization Economics: Do We Have a New Theory of the Firm? *Journal of Management*, *17*(1), 121. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5978931&site=ehost-live

Cooke, P. N. C. (2011). Tsunami , floods and dual sourcing : whatever happened to risk management ? *Just-Auto*. Retrieved from http://www.just-auto.com/analysis/whatever-happened-to-risk-management_id118152.aspx

Corstjens, M., Maxwell, K., & Van der Heyden, L. (2008). Financial Risk and Return across the Grocery Supply Chain. *INSEAD Working Papers Collection*, (3), 1–48. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=48585932&site=ehost-live

Coyne, I. T. (1997). Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? *Journal of Advanced Nursing*, *26*(3), 623–630. Retrieved from 10.1111/1365-2648.ep4514143

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B. (2007). The Severity of Supply Chain Disruptions: Design Characteristics and Mitigation Capabilities. *Decision Sciences*, *38*(1), 131–156. doi:10.1111/j.1540-5915.2007.00151.x

Cranfield University - School of Management. (2002). *Supply Chain Vulnerability, report for Department of Transport, Local Government and the Regions*. Cranfield.

Cucchiella, F., & Gastaldi, M. (2006). Risk management in supply chain: a real option approach. *Journal of Manufacturing Technology Management*, *17*(6), 700–720. doi:10.1108/17410380610678756

Cullinane, K. (2005). *Shipping Economics*. Elsevier Science. Retrieved from http://books.google.pt/books?id=dK_nfJA6iTkC

D'Avanzo, R., & Van Wassenhove, L. N. (2003). The Link Between SUPPLY CHAIN AND FINANCIAL PERFORMANCE. *Supply Chain Management Review*, *7*(6), 40–47. Retrieved from http://search.proquest.com/docview/221213196?accountid=26357

Daft, R. L. (2010). *Organization Theory and Design* (10th ed.). South-Western Cengage Learning. Retrieved from https://books.google.pt/books?id=CmFjF5tNmuEC

Dana, J., & Gilbert, C. L. (2009). Managing Agricultural Price Risk in Developing Countries. In H. Geman (Ed.), *Risk Management in Commodity Markets* (pp. 207–237). Chichester, UK: Wiley. doi:10.1002/9781118467381

Danese, P., Romano, P., & Vinelli, A. (2004). Managing business processes across supply networks: the role of coordenation mechanisms. *Journal of Purchasing & Supply Management*, *10*, 165–177.

Dani, S. (2009). Predicting and Managing Supply Chain Risks. In G. A. Zsidisin & B. Ritchie (Eds.), *Supply Chain Risk: a Handbook of Assessment, Management, and Performance A Handbook of Assessment, Management, and Performance* (p. 349). New York: Springer.

Das, T. K., & Teng, B.-S. (2001). Trust, Control, and Risk in Strategic Alliances: An Integrated Framework. *Organization Studies*, *22*(2), 251. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=4877143&site=ehost-live

Degraeve, Z., & Roodhooft, F. (1999). Effectively Selecting Suppliers Using Total Cost of Ownership. *Journal of Supply Chain Management*, *35*(1), 5–10. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=11487642&site=ehost-live

Denton, S. (2011). Thai flood supply chain losses could reach $20bn. Retrieved from http://insuranceinsight.eu/insurance-insight/news/2127555/thai-flood-supply-chain-losses-reach-usd20bn

Diabat, A., Govindan, K., & Panicker, V. V. (2012). Supply chain risk management and its mitigation in a food industry. *International Journal of Production Research*, *50*(11), 3039–3050. doi:10.1080/00207543.2011.588619

Dubois, A., & Araujo, L. (2007). Case research in purchasing and supply management: Opportunities and challenges. *Journal of Purchasing and Supply Management*, *13*(3), 170–181. doi:10.1016/j.pursup.2007.09.002

Dubois, A., & Fredriksson, P. (2008). Cooperating and competing in supply networks: Making sense of a triadic sourcing strategy. *Journal of Purchasing and Supply Management*, *14*(3), 170–179. doi:10.1016/j.pursup.2008.05.002

Dubois, A., & Gadde, L. (2002). Systematic combining : an abductive approach to case research, *55*, 553–560.

Dubois, A., & Pedersen, A.-C. (2002). Why relationships do not fit into purchasing portfolio models—a comparison between the portfolio and industrial network approaches. *European Journal of Purchasing & Supply Management*, *8*(1), 35–42. doi:http://dx.doi.org/10.1016/S0969-7012(01)00014-4

Dul, J., & Hak, T. (2008). *Case Study Methodology in Business Research*. Oxford: Butterworth-Heinemann.

Dyer, W. G., & Wilkins, A. L. (1991, July). BETTER STORIES, NOT BETTER CONSTRUCTS, TO GENERATE BETTER THEORY: A REJOINDER TO EISENHARDT. *Academy of Management Review*, pp. 613–619. Academy of Management. Retrieved from 10.5465/AMR.1991.4279492

Eisenhardt, K. M. (1989a). Agency Theory: An Assessment and Review. *Academy of Management Review*, *14*(1), 57–74. Retrieved from 10.5465/AMR.1989.4279003

Eisenhardt, K. M. (1989b). Building Theories from Case Study Research. *Academy of Management Review*, *14*(4), 532–550. doi:10.2307/258557

Elkins, D., Handfield, R. B., Blackhurst, J., & Craighead, C. W. (2005). 18 Ways to Guard Against Disruption. *Supply Chain Management Review*, 46–53.

Ellegaard, C. (2008). Supply risk management in a small company perspective. *Supply Chain Management: An International Journal*, *13*(6), 425–434. doi:10.1108/13598540810905688

Ellis, S. C., Henry, R. M., & Shockley, J. (2010). Buyer perceptions of supply disruption risk: A behavioral view and empirical assessment. *Journal of Operations Management*, *28*(1), 34–46. doi:10.1016/j.jom.2009.07.002

Ellis, S. C., Shockley, J., & Henry, R. M. (2011). MAKING SENSE OF SUPPLY DISRUPTION RISK RESEARCH: A CONCEPTUAL FRAMEWORK GROUNDED IN ENACTMENT THEORY. *Journal of Supply Chain Management*, *47*(2), 65–96. Retrieved from 10.1111/j.1745-493X.2011.03217.x

Ellram, L. (1993). Total Cost of Ownership: Elements and Implementation. *International Journal of Purchasing & Materials Management*, *29*(4), 2–11. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9403293046&site=ehost-live

Ellram, L. M. (1995). Total cost of ownership. *International Journal of Physical Distribution & Logistics Management*, *25*(8), 4. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=1716138&site=ehost-live

Ellram, L. M. (1996). THE USE OF THE CASE STUDY STUDY METHOD IN LOGISTICS RESEARCH. *Journal of Business Logistics*, *17*(2), 93–138. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9706191110&site=ehost-live

Ellram, L. M., & Siferd, S. P. (1993). PURCHASING: THE CORNERSTONE OF THE TOTAL COST OF OWNERSHIP CONCEPT. *Journal of Business Logistics*, *14*(1), 163–184. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9707111001&site=ehost-live

Ellram, L. M., & Siferd, S. P. (1998). TOTAL COST OF OWNERSHIP: A KEY CONCEPT IN STRATEGIC COST MANAGEMENT DECISIONS. *Journal of Business Logistics*, *19*(1), 55–84. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=1403161&site=ehost-live

Ellram, L. M., Tate, W. L., & Billington, C. (2008). Offshore outsourcing of professional services: A transaction cost economics perspective. *Journal of Operations Management*, *26*(2), 148–163. doi:10.1016/j.jom.2007.02.008

Fabozzi, F. J., Fuss, R., & Kaiser, D. G. (2008). *The Handbook of Commodity Investing*. Wiley.

Faisal, M. N., Banwet, D. K., & Shankar, R. (2006a). Mapping supply chains on risk and customer sensitivity dimensions. *Industrial Management & Data Systems*, *106*(6), 878–895. Retrieved from 10.1108/02635570610671533

Faisal, M. N., Banwet, D. K., & Shankar, R. (2006b). Supply chain risk mitigation: modeling the enablers. *Business Process Management Journal*. doi:10.1108/14637150610678113

Fama, E. F. (1980). Agency Problems and the Theory of the Firm. *Journal of Political Economy*, *88*(2), 288–307. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5182754&site=ehost-live

Fawcett, S. E., Calantone, R., & Smith, S. R. (1996). An investigation of the impact of flexibility on global reach and firm performance. *Journal of Business Logistics*, *17*(2), 167–196. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9706191112&site=ehost-live

Fayezi, S., O'Loughlin, A., & Zutshi, A. (2012). Agency theory and supply chain management: a structured literature review. *Supply Chain Management: An International Journal*. doi:10.1108/13598541211258618

Fiksel, J. (2006). Sustainability and resilience: toward a systems approach. *Sustainability: Science, Practice, & Policy*, *2*(2), 14–21.

Finch, P. (2004). Supply chain risk management. *Supply Chain Management: An International Journal*, *9*(2), 183–196. doi:10.1108/13598540410527079

Fish, P. M. (1995). *The International Steel Trade*. Woodhead Publishing Limited. Retrieved from https://books.google.pt/books?id=JHcfUmx8NAC

Forrester, J. W. (1958). Industrial Dynamics: A major breakthrough for decision- makers. *Harvard Business Review*, *36*(4), 37–66.

Francis, V. (2008). Supply chain visibility: lost in translation? *Supply Chain Management: An International Journal*, *13*(3), 180–184. doi:10.1108/13598540810871226

Freedman, M. (2003). The genius is in the implementation. *Journal of Business Strategy*, *24*(2), 26–31. doi:10.1108/02756660310508164

Gaudenzi, B., & Borghesi, A. (2006). Managing risks in the supply chain using the AHP method. *The International Journal of Logistics Management*, *17*(1), 114–136. doi:10.1108/09574090610663464

Gelderman, C. J., & Semeijn, J. (2006). Managing the global supply base through purchasing portfolio management. *Journal of Purchasing and Supply Management*, *12*(4), 209–217. doi:10.1016/j.pursup.2006.10.002

Gelderman, C. J., & Van Weele, A. J. (2003). Handling measurement issues and strategic directions in Kraljic's purchasing portfolio model. *Journal of Purchasing and Supply Management*, *9*(5-6), 207–216. doi:10.1016/j.pursup.2003.07.001

Geman, H. (2009a). *Commodities and Commodity Derivatives: Modeling and Pricing for Agriculturals, Metals and Energy*. John Wiley & Sons. Retrieved from https://books.google.pt/books?id=b7KeK5hTE_YC

Geman, H. (2009b). *Risk Management in Commodity Markets: From Shipping to Agriculturals and Energy*. (H. Geman, Ed.). Wiley.

Gerring, J. (2007). *Case Study Research: Principles and Practices*. New York: Cambridge University Press.

Ghadge, A. S., Dani, S., & Kalawsky, R. (2012). Supply chain risk management: present and future scope. *International Journal of Logistics Management*, *23*(3), 313–339. doi:10.1108/09574091211289200

Giunipero, L., & Eltantawy, R. (2004). Securing the upstream supply chain: a risk management approach. *International Journal of Physical* …. Retrieved from http://www.emeraldinsight.com/journals.htm?articleid=846940&show=abstract

Glaser, B. G., & Strauss, A. L. (1967). *The Discovery of Grounded Theory*. Chicago: Aldine Publishing Co.

Gligor, D. M., Holcomb, M. C., & Stank, T. P. (2013). A Multidisciplinary Approach to Supply Chain Agility: Conceptualization and Scale Development. *Journal of Business Logistics*, *34*(2), 94–108. Retrieved from 10.1111/jbl.12012

Goentzel, J. (2015). Supply Chain Innovation Critical in Ebola Response. *Supply Chain Management Review*, 6–7. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=101387997&site=ehost-live

Goffre, J., Oswald, K., Scharbert, P., & Gross, M. (2007). *Managing Supply V olatility: Create a Competitive Advantage through Commodity Risk Management*. Düsseldorf.

Goulding, C. (2002). *Grounded Theory: A Practical Guide for Management, Business and Market Researchers*. Thousand Oaks, CA: Sage Publications.

Green, M. (2004). Loss/risk management notes: Survey: Executives rank fire, dis- ruptions top threats. *Best's Review*, *105*(5), 105.

Hallikas, J., Karvonenb, I., Pulkkinenb, U., Virolainenc, V.-M., & Tuominena, M. (2004). Risk management processes in supplier networks. *International Journal of Production Economics*, *90*, 47–58. doi:risk management; supplier networks; supply chain management

Hallikas, J., Puumalainen, K., Vesterinen, T., & Virolainen, V.-M. (2005). Risk-based classification of supplier relationships. *Journal of Purchasing and Supply Management*, *11*(2–3), 72–82. doi:10.1016/j.pursup.2005.10.005

Hallikas, J., Virolainen, V.-M., & Tuominena, M. (2002). Risk analysis and assessment in network environments: A dyadic case study. *International Journal of Production Economics*, *78*(1), 45–55. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=12128238&site=ehost-live

Harland, C., Brenchley, R., & Walker, H. (2003). Risk in supply networks. *Journal of Purchasing and Supply Management*, *9*(2), 51–62. doi:10.1016/S1478-4092(03)00004-9

Harland, C. M. (2013). Supply chain management research impact: an evidence-based perspective. *Supply Chain Management: An International Journal*, *18*(5), 1. Retrieved from http://links.emeraldinsight.com/journals.htm?articleid=17091264

Harland, C. M., Knight, L. A., Lamming, R. C., & Walker, H. (2005). Outsourcing: assessing the risks and benefits for organizations, sectors and nations. doi:10.1108/01443570510613929

Hartley, J. L., & Zsidisin, G. A. (2012). Managing the commodity roller coaster. *Inside Supply Management*, (August), 23–25.

Hauser, L. M. (2003). RISK-ADJUSTED Supply Chain Management. *Supply Chain Management Review*, *7*(6), 64–71. Retrieved from http://search.proquest.com/docview/221226701?accountid=26357

Heap, A. (2005). *China - The Engine of a Commodities Super Cycle*.

Hendricks, K. B., & Singhal, V. R. (2003). The effect of supply chain glitches on shareholder wealth. *Journal of Operations Management*, *21*(5), 501–522. doi:10.1016/j.jom.2003.02.003

Hendricks, K. B., & Singhal, V. R. (2005a). An Empirical Analysis of the Effect of Supply Chain Disruptions on Long-Run Stock Price Performance and Equity Risk of the Firm. *Production & Operations Management*, *14*(1), 35–52. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=17186642&site=ehost-live

Hendricks, K. B., & Singhal, V. R. (2005b). Association Between Supply Chain Glitches and Operating Performance. *Management Science*, *51*(5), 695–711. doi:10.1287/mnsc.1040.0353

Hendricks, K. B., & Singhal, V. R. (2012). Supply Chain Disruptions and Corporate Performance. In H. Gurnani, A. Mehrotra, & S. Ray (Eds.), *Supply Chain Disruptions: Theory and Practice of Managing Risk* (p. 336). London: Springer London. doi:10.1007/978-0-85729-778-5

Herod, A. (2000). Implications of Just-in-Time Production for Union Strategy: Lessons from the 1998 General Motors-United Auto Workers Dispute. *Annals of the Association of American Geographers*, *90*(3), 521–547. doi:10.1111/0004-5608.00207a

Hodges, S. (2013). *Law of Marine Insurance*. Taylor & Francis. Retrieved from https://books.google.pt/books?id=7IqNAgAAQBAJ

Hoek, R. I. Van, Harrison, A., & Christopher, M. (2001). Measuring agile capabilities in the supply chain. *International Journal of Operations & Production Management*, *21*(1/2), 126–148. doi:10.1108/01443570110358495

Holweg, M., Reichhart, A., & Hong, E. (2011). On risk and cost in global sourcing. *International Journal of Production Economics*, *131*(1), 333–341. doi:10.1016/j.ijpe.2010.04.003

Hopp, W. J., Iravani, S. M. R., & Liu, Z. (2012). Mitigating the Impact of Disruptions in Supply Chains. In H. Gurnani, A. Mehrotra, & S. Ray (Eds.), *Supply Chain Disruptions: Theory and Practice of Managing Risk* (p. 336). London: Springer London. doi:10.1007/978-0-85729-778-5

Hora, M., Bapuji, H., & Roth, A. V. (2011). Safety hazard and time to recall : The role of recall strategy , product defect type , and supply chain player in the U . S . toy industry. *Journal of Operations Management*, *29*(7-8), 766–777. doi:10.1016/j.jom.2011.06.006

Hult, G. T. M., Craighead, C. W., & Ketchen Jr, D. J. (2010). Risk Uncertainty and Supply Chain Decisions: A Real Options Perspective. *Decision Sciences*, *41*(3), 435–458. doi:10.1111/j.1540-5915.2010.00276.x

Huo, B. (2012). The impact of supply chain integration on company performance: an organizational capability perspective. *Supply Chain Management*, *17*(6), 596–610. Retrieved from 10.1108/13598541211269210

Index Mundi. (2012). Retrieved from http://www.indexmundi.com/commodities/?commodity=hot-rolled-steel&months=120

Ivanov, D., & Sokolov, B. (2010). *Adaptive Supply Chain Management*. London: Springer London. doi:10.1007/978-1-84882-952-7

Jensen, M. C., & Meckling, W. H. (1976). THEORY OF THE FIRM: MANAGERIAL BEHAVIOR, AGENCY COSTS AND OWNERSHIP STRUCTURE. *Journal of Financial Economics*, *3*(4), 305–360. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=12243301&site=ehost-live

Jin, B. (2004). Achieving an optimal global versus domestic sourcing balance under demand uncertainty. *International Journal of Operations & Production Management*, *24*(12), 1292–1305.

Johnson, M. E. (2001). Learning From Toys: LESSONS IN MANAGING SUPPLY CHAIN RISK FROM THE TOY INDUSTRY. *California Management Review*, *43*(3), 106–124. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=4685599&site=ehost-live

Johnston, H. R., & Vitale, M. A. (1988). Creating Competitive Advantage With Interorganizational Information Systems. *MIS Quarterly*, *12*(2), 153–165. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=4679810&site=ehost-live

Jüttner, U., & Maklan, S. (2011). Supply chain resilience in the global financial crisis: an empirical study. *Supply Chain Management: An International Journal*, *16*(4), 246–259. doi:10.1108/13598541111139062

Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics Research and Applications*, *6*(4), 197–210. doi:10.1080/1367556031000162701 6

Kahn, O., & Burnes, B. (2007). Risk and supply chain management: creating a research agenda. *The International Journal of Logistics Management*, *18*(2), 197–216.

Kaliski, B. S. (2006). *Encyclopedia of business and finance*. Macmillan Reference USA.

Kam, B. H., Chen, L., & Wilding, R. (2011). Managing production outsourcing risks in China's apparel industry: a case study of two apparel retailers. *Supply Chain Management: An International Journal*. Emerald Group Publishing Limited. doi:10.1108/13598541111171147

Kenealy, B., & Zolkos, R. (2014). EBOLA PANDEMIC BREAKS SUPPLY CHAINS. *Business Insurance*, *48*(17), 1. Retrieved from

http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=97748592&site=ehost-live

Kern, D., Moser, R., Hartmann, E., & Moder, M. (2012). Supply risk management: model development and empirical analysis. *International Journal of Physical Distribution & Logistics Management*, *42*(1), 60–82. doi:10.1108/09600031211202472

Khan, O., & Burnes, B. (2007). Risk and supply chain management: creating a research agenda. *The International Journal of Logistics Management*, *18*(2), 197–216. doi:10.1108/09574090710816931

Kilgore, J. M. (2004). Why Analytical Risk Mitigation is Critical To Supply Chain Design. *Inventory Management Report*, *4*(4), 7–11. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=12470962&site=ehost-live

Kiser, J., & Cantrell, G. (2006). 6 Steps to Managing RISK. (cover story). *Supply Chain Management Review*, *10*(3), 12–17. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=20544348&site=ehost-live

Kleindorfer, P. R., & Saad, G. H. (2005). Managing Disruption Risks in Supply Chains. *Production & Operations Management*, *14*(1), 53–68. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=17186641&site=ehost-live

Kleindorfer, P. R., & Van Wassenhove, L. N. (2004). Managing risk in global supply chains. In H. Gatignon, J. R. Kimberly, & R. E. Gunther (Eds.), *The INSEAD–Wharton Alliance on Globalizing* (p. 451). Cambridge: Cambridge University Press.

Knemeyer, A. M., Zinn, W., & Eroglu, C. (2009). Proactive planning for catastrophic events in supply chains. *Journal of Operations Management*, *27*(2), 141–153. doi:10.1016/j.jom.2008.06.002

Knight, F. H. (1921). *Risk, Uncertainty and Profit*. New York: Houghton Mifflin Company.

Kouvelis, Pa., Dong, L., Boyabatli, O., & Li, R. (2011). Integrated Risk Management: A Conceptual Framework with Research Overview and Applications in Practice. In P. Kouvelis, L. Dong, O. Boyabatli, & R. Li (Eds.), *The Handbook of Integrated Risk Management in Global Supply Chains* (pp. 3–12). Hoboken, NJ, USA: John Wiley & Sons, Inc. doi:10.1002/9781118115800

Kraljic, P. (1983). Purchasing Must Become Supply Management. *Harvard Business Review*, *September/*(83509), 109–117.

Kumar, S., DuFresne, C., & Hadler, K. (2007). Managing supply chain risks in US-China trade partnership. *Information Knowledge Systems Management*, *6*, 343–362.

Lambert, D. M., & Cooper, M. C. (2000). Issues in Supply Chain Management. *Industrial Marketing Management*, *29*(1), 65–83. doi:http://dx.doi.org/10.1016/S0019-8501(99)00113-3

Lavastre, O., Gunasekaran, A., & Spalanzani, A. (2012). Supply chain risk management in French companies. *Decision Support Systems*, *52*(4), 828–838. doi:10.1016/j.dss.2011.11.017

Lavastre, O., Gunasekaran, A., & Spalanzani, A. (2014). Effect of firm characteristics, supplier relationships and techniques used on Supply Chain Risk Management (SCRM): an empirical investigation on French industrial firms. *International Journal of Production Research*, *52*(11), 3381–3403. Retrieved from 10.1080/00207543.2013.878057

Leat, P., & Revoredo-Giha, C. (2013). Risk and resilience in agri-food supply chains: the case of the ASDA PorkLink supply chain in Scotland. *Supply Chain Management*, *18*(2), 219–231. Retrieved from 10.1108/13598541311318845

Lee, C. F., & Lee, A. C. (2013). *Encyclopedia of Finance*. (C.-F. Lee & A. C. Lee, Eds.). Boston, MA: Springer US. doi:10.1007/978-1-4614-5360-4

Lee, H. L. (2002). Aligning Supply Chain Strategies with Product Uncertainties. *California Management Review*, *44*(3), 105–119.

Lee, H. L. (2004). THE TRIPLE-A Supply Chain. *Harvard Business Review*, *82*(10), 102–112. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=14599946&site=ehost-live

Leenders, M. R., & Fearon, H. (1997). *Purchasing and Supply Management* (11th ed.). New York: Irwin Professional Publishing. Retrieved from https://books.google.pt/books?id=uWOPAAAACAAJ

Levary, R. R. (2007). Ranking foreign suppliers based on supply risk. *Supply Chain Management: An International Journal*, *12*(6), 392–394. doi:10.1108/13598540710826317

Li, X., & Barnes, I. (2008). Proactive supply risk management methods for building a robust supply selection process when sourcing from emerging markets. *Strategic Outsourcing: An International Journal*, *1*(3), 252–267. doi:10.1108/17538290810915308

Li, X., Goldsby, T. J., & Holsapple, C. W. (2009). Supply chain agility: scale development. *International Journal of Logistics Management*, *20*(3), 408–424. Retrieved from 10.1108/09574090911002841

Lovallo, D., & Kahneman, D. (2003). Delusions of Success. *Harvard Business Review*, *81*(7), 56–63. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=10147066&site=ehost-live

Lu, Y. (2015). Supply Chain Risk Assessment Based on AHP and Fuzzy Comprehensive Assessment Mode: A Case Study of the Chemical Supply Chain. *International Journal of U- & E-Service, Science & Technology*, *8*(2), 227–234. Retrieved from 10.14257/ijunesst.2015.8.2.22

Lynch, G. S. (2012). Supply Chain Risk Management. In H. Gurnani, A. Mehrotra, & S. Ray (Eds.), *Supply Chain Disruptions: Theory and Practice of Managing Risk* (p. 336). London: Springer London. doi:10.1007/978-0-85729-778-5

Machowiak, W. (2012). Risk Management - Unappreciated instrument of Supply Chain Management Strategy. *RISIKOMANAGEMENT - EIN UNTERSCHÄTZTES INSTRUMENT DER STRATEGIE VON SUPPLY-CHAIN-MANAGEMENT.*, *8*(4), 277–285. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=82160149&site=ehost-live

MacNamara, J. (2001). *Structured Trade and Commodity Finance in Emerging Markets: What Can Go Wrong and How to Avoid It*. Elsevier Science. Retrieved from https://books.google.pt/books?id=kBCkAgAAQBAJ

Maier, A., & Chan, M. (2011). A country submerged. *The Magazine for Claims Managers - Munic*, 21–29.

Manuj, I., & Mentzer, J. T. (2008a). Global Supply Chain Risk Management. *Journal of Business Logistics*, *29*(1), 133–155. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=33382304&site=ehost-live

Manuj, I., & Mentzer, J. T. (2008b). Global supply chain risk management strategies. *International Journal of Physical Distribution & Logistics Management*, *38*(3), 192–223. doi:10.1108/09600030810866986

Maoz, Z. (2002). Case Study Methodology in International Studies: From Storytelling to Hypothesis Testing. In F. P. Harvey & M. Brecher (Eds.), *Evaluating Methodology in International Studies: Millennial Reflec- tions on International Studies* (pp. 455–75). Ann Arbor: University of Michigan Press.

March, J. G., & Shapira, Z. (1987). MANAGERIAL PERSPECTIVES ON RISK AND RISK TAKING. *Management Science*, *33*(11), 1404–1418. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=7160622&site=ehost-live

Markowitz, H. (1952). Portfolio selection. *J. Finance*. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=epref&AN=JF.G.GG.MARKOWITZ.PS&site=ehost-live

Mason-Jones, R., & Towill, D. R. (1998). Shrinking the supply chain uncertainty cycle. *IOM Control*, *24*(7), 17–22.

Masson, R., Iosif, L., MacKerron, G., & Fernie, J. (2007). Managing complexity in agile global fashion industry supply chains. *The International Journal of Logistics Management*, *18*(2), 238–254. doi:10.1108/09574090710816959

Mayring, P. (2002). *Einführung in die qualitative Sozialforschung – eine Anleitung zum qualitativen Denken (Introduction to Qualitative Social Research)* (5th ed.). Weinheim und Basel: Verlag Beltz.

McGhee, M., & Giermanski, J. (2007). How SOX and C-TPAT Impact Global Supply Chain Security. *Strategic Finance*, *88*(10), 32–38.

Mellewigt, P. D. T., & König, F. (2009). *The Uncertainty-Governance Choice Puzzle Revisited: Predictions from Transaction Costs Economics, Resource-Based Theory, and Real Options*

Theory. Wiesbaden: Gabler. Retrieved from https://books.google.pt/books?id=npWw4FFSSksC

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining Supply Chain Management. *Journal of Business Logistics*, *22*(2), 1–25. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=6352236&site=ehost-live

Merton, R. C. (1973). Theory of rational option pricing. *Bell Journal of Economics & Management Science*, *4*(1), 141. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5921812&site=ehost-live

Michel-Kerjan, E. o., Raschky, P. A., & Kunreuther, H. (2011). *Do Firms Manage Catastrophe and Non-Catastrophe Risks Differently?* (No. 2011-13). Philadelphia.

Miles, M. B. (1979). Qualitative Data as an Attractive Nuisance: The Problem of Analysis. *Administrative Science Quarterly*, *24*(4), 590–601. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=3980556&site=ehost-live

Miller, K. D. (1992). A FRAMEWORK FOR INTEGRATED RISK MANAGEMENT IN INTERNATIONAL BUSINESS. *Journal of International Business Studies*, *23*(2), 311–331. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9609035308&site=ehost-live

Miller, K. D., & Leiblein, M. J. (1996). CORPORATE RISK-RETURN RELATIONS: RETURNS VARIABILITY VERSUS DOWNSIDE RISK. *Academy of Management Journal*, *39*(1), 91–122. doi:10.2307/256632

Mills, A. J., Durepos, G., & Wiebe, E. (2009). *Encyclopedia of Case Study Research*. SAGE Publications.

Mitroff, I. I., & Alpaslan, M. C. (2003). Preparing for Evil. *Harvard Business Review*, *81*(4), 109–115. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9489166&site=ehost-live

Mizgier, K. J., Jüttner, M. P., & Wagner, S. M. (2013). Bottleneck identification in supply chain networks. *International Journal of Production Research*, *51*(5), 1477–1490. doi:10.1080/00207543.2012.695878

Monczka, R. M., Choi, T. Y., Kim, Y., & McDowell, C. P. (2011). *Supplier Relationship Management: An Implementation Framework*. CAPS Research - Institute for Supply Management and W. P. Carey School of Business at Arizona State University.

Morse, J. M. (1990). Strategies for sampling. In *Qualitative Nursing Research: A Contemporary Dialogue* (pp. 127–145). SAGE Publications.

Mudambi, R., & Ricketts, M. (2002). *The Organisation of the Firm: International Business Perspectives*. (R. Mudambi & M. Ricketts, Eds.). New York: Taylor & Francis. Retrieved from https://books.google.pt/books?id=QaiFAgAAQBAJ

Munich RE. (2011). *Munich Re Group Annual Report 2011*. München, Germany.

Myers, S. C. (1977). Determinants of corporate borrowing. *Journal of Financial Economics*, *5*(2), 147–175. doi:http://dx.doi.org/10.1016/0304-405X(77)90015-0

Nagali, V., Hwang, J., Sanghera, D., Gaskins, M., Pridgen, M., Thurston, T., … Shoemaker, G. (2008). Procurement Risk Management (PRM) at Hewlett-Packard Company. *Interfaces*, *38*(1), 51–60. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=31877958&site=ehost-live

Nahmias, S. (2009). *Production and operations analysis*. Boston: McGraw-Hill, Irwin.

Narayanan, V. G., & Raman, A. (2004). Aligning Incentives in Supply Chains. *Harvard Business Review*, *82*(11), 94–102. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=14874820&site=ehost-live

Natarajarathinam, M., Capar, I., & Narayanan, A. (2009). Managing supply chains in times of crisis: a review of literature and insights. *International Journal of Physical Distribution & Logistics Management*, *39*(7), 535–573. doi:10.1108/09600030910996251

Neiger, D., Rotaru, K., & Churilov, L. (2009). Supply chain risk identification with value-focused process engineering. *Journal of Operations Management*, *27*(2), 154–168. doi:10.1016/j.jom.2007.11.003

Nellore, R., & Söderquist, K. (2000). Portfolio approaches to procurement Analysing the Missing Link to Specifications. *Long Range Planning*, *33*(2), 245–267. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=11934996&site=ehost-live

Newman, I., & Benz, C. R. (1998). *Qualitative-quantitative Research Methodology: Exploring the Interactive Continuum*. Southern Illinois University Press.

Noorderhaven, N. G. (1996). Opportunism and Trust in Transaction Cost Economics. In J. Groenewegen (Ed.), *Transaction Cost Economics and Beyond* (pp. 105–128). Kluwer Academic Publishers.

Norrman, A. (2008). Supply chain risk-sharing contracts from a buyers' perspective: content and experiences. *International Journal of Procurement Management*, *1*(4), 371–393.

Norrman, A., & Jansson, U. (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management*, *34*(5), 434–456. doi:10.1108/09600030410545463

Norrman, A., & Lindroth, R. (2004). Categorization of supply chain risk and risk management. In C. Brindley (Ed.), *Supply Chain Risk* (pp. 14–28). London: Ashgate.

Noussia, K. (2007). *The Principle of Indemnity in Marine Insurance Contracts: A Comparative Approach*. Heidelberg: Springer Berlin Heidelberg.

Oke, A., & Gopalakrishnan, M. (2009). Managing disruptions in supply chains: A case study of a retail supply chain. *International Journal of Production Economics*, *118*(1), 168–174. doi:10.1016/j.ijpe.2008.08.045

Okochi, J. (2008). Commodity hedging: Best practices for modelling commodity exposures. *Journal of Corporate Treasury Management*, *2*(1), 42–46. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=35424087&site=ehost-live

Olsen, R. F., & Ellram, L. M. (1997). A Portfolio Approach to Supplier Relationships. *Industrial Marketing Management*, *26*(2), 101–113. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=12495747&site=ehost-live

Olson, D. L., & Wu, D. D. (2010). A review of enterprise risk management in supply chain. *Kybernetes*, *39*(5), 694–706. doi:10.1108/03684921011043198

Papadakis, I. S. (2006). Financial performance of supply chains after disruptions: an event study. *Supply Chain Management: An International Journal*, *11*(1), 25–33. doi:10.1108/13598540610642448

Park, Y., Hong, P., & Roh, J. J. (2013). Supply chain lessons from the catastrophic natural disaster in Japan. *Business Horizons*, *56*(1), 75–85. doi:10.1016/j.bushor.2012.09.008

Patton, M. Q. (2002). *Qualitative Research & Evaluation Methods*. SAGE Publications.

Paulsson, U., & Nilsson, C.-H. (2008). *Potential risk handling alternatives for supply chain disruptions in liquid food production: The case of V&S Vin & Sprit AB, the Sundsvall site.* Retrieved from http://lup.lub.lu.se/record/1388243/file/1388888.pdf

Peck, H. (2005). Drivers of supply chain vulnerability: an integrated framework. *International Journal of Physical Distribution & Logistics Management*, *35*(4), 210–232. doi:10.1108/09600030510599904

Peck, H. (2006). Reconciling supply chain vulnerability, risk and supply chain management. *International Journal of Logistics: Research & Applications*, *9*(2), 127–142. Retrieved from 10.1080/13675560600673578

Pedrosa, A. da M., Näslund, D., & Jasmand, C. (2012). Logistics case study based research: towards higher quality. *International Journal of Physical Distribution & Logistics Management*, *42*(3), 275–295. Retrieved from 10.1108/09600031211225963

Penrose, E., & Pitelis, C. (2009). *The Theory of the Growth of the Firm* (4th ed.). Oxford: OUP Oxford. Retrieved from https://books.google.pt/books?id=85FLx2NQlaoC

Pettit, T. J., Croxton, K. L., & Fiksel, J. (2013). Ensuring Supply Chain Resilience: Development and Implementation of an Assessment Tool. *Journal of Business Logistics*, *34*(1), 46–76. doi:10.1111/jbl.12009

Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). ENSURING SUPPLY CHAIN RESILIENCE: DEVELOPMENT OF A CONCEPTUAL FRAMEWORK. *Journal of Business Logistics*, *31*(1), 1–21. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=49739125&site=ehost-live

Pfeffer, J., & Salancik, G. R. (2003). *The External Control of Organizations: A Resource Dependence Perspective*. Stanford, CA, USA: Stanford Business Books.

Pfohl, H.-C., Köhler, H., & Thomas, D. (2010). State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice. *Logistics Research*, *2*(1), 33–44. doi:10.1007/s12159-010-0023-8

Pimpão, M., & Ferreira, L. M. D. F. (2012). An exploratory study on the use of the supply chain risk mitigating strategies of control and dual sourcing. In *Proceedings of the 4th World Production and Operations Management (POM) - 19th International Annual European Operations Management Association (EurOMA) joint conference* (pp. 1–10). Amsterdam, Netherlands, July 1-5th: EUROMA.

Poirier, C. C., & Quinn, F. J. (2004). How are we doing: a survey of supply chain progress. *Supply Chain Management Review*, *8*(8), 24–31.

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. *International Journal of Logistics Management*, *20*(1), 124–143. doi:10.1108/09574090910954873

Postrel, V. (2012). Delta's Oil Refinery Plan Flies Against Economic Sense. *Bloomberg*. Retrieved from http://www.bloomberg.com/news/2012-04-19/delta-s-oil-refinery-plan-flies-against-economic-sense.html

Poulakidas, A., & Joutz, F. (2009). Exploring the link between oil prices and tanker rates. *Maritime Policy & Management*, *36*(3), 215–233. doi:10.1080/03088830902861094

Prater, E., Biehl, M., & Smith, M. A. (2001). International supply chain agility tradeoffs between flexibility and uncertainty. *International Journal of Operations & Production Management*, *21*(5/6), 823–839.

Procurement Leaders. (2012). Earthquake hits Italian auto heartland. *Procurement Leaders*. Retrieved March 25, 2013, from http://www.procurementleaders.com/news-archive/news-archive/earthquake-hits-italian-auto-heartland

Pujawan, I. N., & Geraldin, L. H. (2009). House of risk: a model for proactive supply chain risk management. *Business Process Management Journal*, *15*(6), 953–967. doi:10.1108/14637150911003801

PwC, & UNISDR. (2013). *Working together to reduce disaster risk*. Retrieved from http://www.pwc.com/en_GX/gx/governance-risk-compliance-consulting-services/resilience/publications/pdfs/pwc-unisdr-report.pdf

Radetzki, M. (2008). *A Handbook of Primary Commodities in the Global Economy*. Cambridge: Cambridge University Press. Retrieved from https://books.google.pt/books?id=yH8srsDgGbwC

Rao, S., & Goldsby, T. J. (2009). Supply chain risks: a review and typology. *International Journal of Logistics Management*, *20*(1), 97–123. doi:10.1108/09574090910954864

Reuer, J. J., & Leiblein, M. J. (2001). Real options: let the buyer beware. In J. Pickford, C. Alexander, & F. T. B. Ltd (Eds.), *Mastering Risk: Concepts* (1st ed., pp. 79–85). Harlow, UK: Financial Times Prentice Hall. Retrieved from https://books.google.pt/books?id=GoeOG_iIB00C

Reuters. (2013). European safety agency to ground 787 in line with FAA. *Reuters*. Paris. Retrieved May 23, 2013, from http://www.reuters.com/article/2013/01/17/boeing-787-easa-idUSL6N0AM0E020130117

Rice, B. J. B., & Caniato, F. (2003). Building a Secure and Resilient Supply Network. *Supply Chain Management Review*, *7*(5), 22–30.

Riemer, K., & Klein, S. (2006). Network Management Framework. In S. Klein & A. Poulymenakou (Eds.), *Managing Dynamic Networks: Organizational Perspectives of Technology Enabled Inter-firm Collaboration* (pp. 17–68). Heidelberg: Springer. Retrieved from https://books.google.pt/books?id=u6PIC8TIlvEC

Ritchie, B., & Brindley, C. (2000). Disintermediation , disintegration and risk in the SME global supply chain. *Management Decision*, *38*(8), 575–583.

Ritchie, B., & Brindley, C. (2007a). An emergent framework for supply chain risk management and performance measurement. *Journal of the Operational Research Society*, *58*(11), 1398–1411. doi:10.1057/palgrave.jors.2602412

Ritchie, B., & Brindley, C. (2007b). Supply chain risk management and performance : A guiding framework for future development. *International Journal of Operations & Production Management*, *27*(3), 303–322. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=24943048&site=ehost-live

Ritchie, B., & Marshall, D. V. (1993). *Business Risk Management*. London, UK: Chapman Hall.

Ritchie, J., Lewis, J., Lewis, P. S. P. J., Nicholls, C. M. N., & Ormston, R. (2013). *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. SAGE Publications.

Routroy, S., & Shankar, A. (2014). A Study of Apparel Supply Chain Risks. *IUP Journal of Supply Chain Management*, *11*(2), 52–69. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=98188276&site=ehost-live

Ruamsook, K., Russell, D. M., & Thomchick, E. A. (2009). Sourcing from low-cost countries. *International Journal of Logistics Management*, *20*(1), 79–96. doi:10.1108/09574090910954855

Rumelt, R. P., Schendel, D., & Teece, D. J. (1994). *Fundamental Issues in Strategy: A Research Agenda*. Harvard Business School Press. Retrieved from https://books.google.pt/books?id=sVnhN8zhYLUC

Sachan, A., & Datta, S. (2005). Review of supply chain management and logistics research. *International Journal of Physical Distribution & Logistics Management*, *35*(9), 664–704. Retrieved from 10.1108/09600030510632032

Sarathy, R. (2006). Security and the Global Supply Chain. *Transportation Journal (American Society of Transportation & Logistics Inc)*, *45*(4), 28–51. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=22970347&site=ehost-live

Schlosser, M. A., & Zsidisin, G. A. (2004). Hedging Fuel Surcharge Price Fluctuations 2004. *Practix: Good Practices in Purchasing and Supply Chain Management (CAPS Research)*, *7*(May), 1–5. Retrieved from www.capsresearch.org

Schoenherr, T., Tummala, R., & Harrison, T. P. (2008). Assessing supply chain risks with the analytic hierarchy process: Providing decision support for the offshoring decision by a US manufacturing company. *Journal of Purchasing and Supply Management*, *14*, 100–111. doi:10.1016/j.pursup.2008.01.008

Schwartz, M. (2011). THE RACE TO MANAGE RISK IN THE AUTOMOTIVE SUPPLY CHAIN. *Supply Chain Europe*, *20*(3), 14–16. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=67118284&site=ehost-live

Seuring, S. A. (2008). Assessing the rigor of case study research in supply chain management. *Supply Chain Management: An International Journal*, *13*(2), 128–137. doi:10.1108/13598540810860967

Shapira, Z. (1995). *Risk Taking: A Managerial Perspective*. New York: Russel Sage Foundation.

Sharma, S. K., Bhat, A., & Routroy, S. (2014). An Empirical Study on Supply Chain Risk Management Strategies in Indian Automobile Industry. *IUP Journal of Supply Chain Management*, *11*(4), 7–24. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=100310809&site=ehost-live

Sheffi, Y. (2001). Supply chain management under the threat of international terrorism. *International Journal of Logistics Management*, *12*(2), 1–11. Retrieved from http://search.proquest.com/docview/235866128?accountid=26357

Sheffi, Y. (2005). *The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage*. MIT Press.

Sheffi, Y. (2007). Building a Resilient Organization. *The Bridge - National Academy of Engineering*, *37*(1), 30–36.

Sheffi, Y. (2009). Business continuity: a systematic approach. In H. W. Richardson, P. Gordon, & J. E. More (Eds.), *Global Business and the Terrorist Threat* (pp. 23–41). Cheltenham, UK: Edward Elgar.

Sheffi, Y., & Rice, J. B. (2005). A Supply Chain View of the Resilient Enterprise A Supply Chain View of the. *MIT Sloan Management Review*, *47*(1), 41–48.

Shi, D. (2004). A review of enterprise supply chain risk management. *Journal of Systems Science and Systems Engineering*, *13*(2), 219–244. doi:10.1007/s11518-006-0162-2

Simatupang, T. M., & Sridharan, R. (2002). The Collaborative Supply Chain. *The International Journal of Logistics Management*, *13*(1), 15–30. doi:10.1108/09574090210806333

Simatupang, T. M., & Sridharan, R. (2005a). An integrative framework for supply chain collaboration. *International Journal of Logistics Management*, *16*(2), 257–274. Retrieved from 10.1108/09574090510634539

Simatupang, T. M., & Sridharan, R. (2005b). Supply chain discontent. *Business Process Management Journal*, *11*(4), 349–369. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=20130997&site=ehost-live

Simon, H. A. (1979). Rational Decision Making in Business Organization. *American Economic Review*, *69*(4), 493–513. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=4505349&site=ehost-live

Sinha, P. R., Whitman, L. E., & Malzahn, D. (2004). Methodology to mitigate supplier risk in an aerospace supply chain. *Supply Chain Management*, *9*(2), 154–168. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=13094016&site=ehost-live

Smeltzer, L. R., & Siferd, S. P. (1998). Proactive Supply Management: The Management of Risk. *International Journal of Purchasing and Materials Management*, *34*(4), 38–45. doi:10.1111/j.1745-493X.1998.tb00040.x

Smith, R. (2002). *Global Supply Chain Performance and Risk Optimization: The Value of Real Options Flexibility Demonstrated in the Global Automotive Industry*. Wiesbaden: SPRINGER VERLAG NY. Retrieved from https://books.google.pt/books?id=OsrZZoyXMnAC

Sodhi, M. S., & Lee, S. (2007). An analysis of sources of risk in the consumer electronics industry. *Journal of the Operational Research Society*, *58*(11), 1430–1439. doi:10.1057/palgrave.jors.2602410

Sodhi, M. S., Son, B.-G., & Tang, C. S. (2012). Researchers' Perspectives on Supply Chain Risk Management. *Production and Operations Management*, *21*(1), 1–13. doi:10.1111/j.1937-5956.2011.01251.x

Sodhi, M. S., & Tang, C. S. (2012). *Managing Supply Chain Risk* (Vol. 172). Boston, MA: Springer US. doi:10.1007/978-1-4614-3238-8

Sørensen, L. B. (2004). How risk and uncertainty is used in Supply Chain Management: a literature study. . *Copenhagen: Copenhagen Business School*.

Souter, G. (2000). Risks from supply chain also demand attention. *Business Insurance*, *34*(20), 26. Retrieved from

http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=3391966&site=ehost-live

Stecke, K. E., & Kumar, S. (2009). Sources of Supply Chain Disruptions, Factors That Breed Vulnerability, and Mitigating Strategies. *Journal of Marketing Channels*, *16*(3), 193–226. doi:10.1080/10466690902932551

Stock, J. R. (1997). Applying theories from other disciplines to logistics. *International Journal of Physical Distribution & Logistics Management*, *27*(9/10), 515. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=163561&site=ehost-live

Stopford, M. (2009). *Maritime Economics* (3rd ed.). Taylor & Francis.

Strandenes, S. P. (2013). Economics of the Markets for Ships. In C. Grammenos (Ed.), *The Handbook of Maritime Economics and Business* (pp. 217–234). London, UK: Taylor & Francis. Retrieved from https://books.google.pt/books?id=rKdF2CrrlVoC

Strauss, A. C., & Corbin, J. (1998). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (2nd ed.). Thousand Oaks, CA: Sag Publications.

Supply Chain Times. (2011). Thailand floods disrupt production and supply chains. Retrieved from http://supplychain.asia/2011/10/thailand-floods-disrupt-production-and-supply-chains/

Svensson, G. (2000). A conceptual framework for the analysis of vulnerability in supply chains. *International Journal of Physical Distribution & Logistics Management*, *30*(9), 731. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=5518016&site=ehost-live

Svensson, G. (2002). A conceptual framework of vulnerability in firms' inbound and outbound logistics flows. *International Journal of Physical Distribution & Logistics Management*, *32*(2), 110–134. doi:10.1108/09600030210421723

Svensson, G. (2004). Vulnerability in business relationships: the gap between dependence and trust. *Journal of Business & Industrial Marketing*, *19*(7), 469–483. Retrieved from 10.1108/08858620410564418

Takahashi, Y. (2012). Lessons Learned: Japanese Car Makers a Year After Quake. *The Wall Street Journal - WSJ Blogs*. The Wall Street Journal. Retrieved from http://blogs.wsj.com/drivers-seat/2012/03/07/lessons-learned-japanese-car-makers-a-year-after-quake/?mod=google_news_blog

Tang, C. S. (2006a). Perspectives in supply chain risk management. *International Journal of Production Economics*, *103*(2), 451–488. doi:10.1016/j.ijpe.2005.12.006

Tang, C. S. (2006b). Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics*, *9*(1), 33–45. doi:10.1080/13675560500405584

Tang, C. S., & Tomlin, B. (2008). The power of flexibility for mitigating supply chain risks. *International Journal of Production Economics*, *116*(1), 12–27. doi:10.1016/j.ijpe.2008.07.008

Tang, C. S., & Zimmerman, J. D. (2009a). Development and Supply Chain Risks : The Boeing 787 Case. *Supply Chain Forum - An International Journal*, *10*(2), 74–87.

Tang, C. S., & Zimmerman, J. D. (2009b). Managing New Product Development and Supply Chain Risks- The Boeing 787 Case. *Supply Chain Forum - An International Journal*, *10*(2), 74–86.

Tang, O., & Nurmaya Musa, S. (2011). Identifying risk issues and research advancements in supply chain risk management. In *International Journal of Production Economics* (Vol. 133, pp. 25–34). Elsevier. doi:10.1016/j.ijpe.2010.06.013

The United Nations Office for Disaster Risk Reduction. (2013). UN Secretary-General warns: "Economic losses from disasters are out of control." Retrieved October 13, 2013, from http://www.unisdr.org/archive/33003

Thomsett, M. C. (2011). GLOBAL SUPPLY CHAIN RISK MANAGEMENT: VIEWING THE PAST TO MANAGE TODAY'S RISKS FROM AN HISTORICAL PERSPECTIVE. *Review of Management Innovation & Creativity*, *4*(9), 44–54. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=66136270&site=ehost-live

Thoyts, R. (2010). *Insurance Theory and Practice*. Taylor & Francis. Retrieved from https://books.google.pt/books?id=gpdaBwAAQBAJ

Thun, J.-H., Drüke, M., & Hoenig, D. (2011). Managing uncertainty – an empirical analysis of supply chain risk management in small and medium-sized enterprises. *International Journal of Production Research*. doi:10.1080/00207543.2011.563901

Thun, J.-H., & Hoenig, D. (2011). An empirical analysis of supply chain risk management in the German automotive industry. *International Journal of Production Economics*, *131*(1), 242–249. doi:10.1016/j.ijpe.2009.10.010

ThyssenKrupp. (2014). *2013-2014 Annual Report ThyssenKrupp AG*.

Tiwana, A., Keil, M., & Fichman, R. G. (2006). Information Systems Project Continuation in Escalation Situations: A Real Options Model. *Decision Sciences*, *37*(3), 357–391. Retrieved from 10.1111/j.1540-5414.2006.00131.x

Tiwana, A., Wang, J., Keil, M., & Ahluwalia, P. (2007). The Bounded Rationality Bias in Managerial Valuation of Real Options: Theory and Evidence from IT Projects. *Decision Sciences*, *38*(1), 157–181. Retrieved from 10.1111/j.1540-5915.2007.00152.x

Tomlin, B. (2006). On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks. *Management Science*, *52*(5), 639–657. doi:10.1287/mnsc.1060.0515

Treitel, G. H. (1991). *The Law of Contract* (11th ed.). London, UK: Sweet & Maxwell.

Trigeorgis, L. (1996). *Real Options: Managerial Flexibility and Strategy in Resource Allocation*. MIT Press. Retrieved from https://books.google.pt/books?id=Z8o20TmBiLcC

Trkman, P., & McCormack, K. (2009). Supply chain risk in turbulent environments—A conceptual model for managing supply chain network risk. *International Journal of Production Economics*, *119*(2), 247–258. doi:10.1016/j.ijpe.2009.03.002

Tummala, R., & Schoenherr, T. (2011, September 27). Assessing and managing risks using the Supply Chain Risk Management Process (SCRMP). *Supply Chain Management: An International Journal*. doi:10.1108/13598541111171165

Turnbull, P. W. (1990). A review of Portfolio Planning Models for Industrial Marketing and Purchasing Management. *European Journal of Marketing*, *24*(3), 7–22.

UNCTAD. (1998). *Documentary Risk in Commodity Trade*.

UNCTAD. (2003). *A primer on new techniques used by the sophisticated financial fraudster with special reference to commodity market instruments*.

UNISDR. (2009). *Reducing Disaster Risks through Science: Issues and Actions, The full report of the ISDR Scientific and Technical Committee 2009*. United Nations International Strategy for Disaster Reduction. Retrieved from http://www.unisdr.org/files/11543_STCReportlibrary.pdf

UNISDR. (2012). Towards a post-2015 framework for disaster risk reduction. Retrieved March 6, 2012, from http://www.unisdr.org/files/25129_towardsapost2015frameworkfordisaste.pdf

USCPSC, U. S. C. P. S. C. (2006). Sony Recalls Notebook Computer Batteries Due to Previous Fires. Retrieved from http://www.cpsc.gov/cpscpub/prerel/prhtml07/07011.html

Vachon, S., & Klassen, R. D. (2002). An Exploratory Investigation of the Effects of Supply Chain Complexity on Delivery Performance. *IEEE Transactions on Engineering Management*, *49*(3), 218. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=8511176&site=ehost-live

Van der Vorst, J. G. A. J., & Beulens, A. J. M. (2002). Identifying sources of uncertainty to generate supply chain redesign strategies. *International Journal of Physical Distribution & Logistics Management*, *32*(6), 409–430. Retrieved from 10.1108/09600030210437951

Van Der Vorst, J. G. A. J., Beulens, A. J. M., De Wit, W., & Van Beek, P. (1998). Supply Chain Management in Food Chains: Improving Performance by Reducing Uncertainty. *International Transactions in Operational Research*, *5*(6), 487. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=6633252&site=ehost-live

Van Mieghem, J. A. (2011). Risk Management and Operational Hedging: An Overview. In P. Kouvelis, L. Dong, O. Boyabatli, & R. Li (Eds.), *The Handbook of Integrated Risk Management in Global Supply Chains* (pp. 13–49). Hoboken, NJ, USA: John Wiley & Sons, Inc. doi:10.1002/9781118115800

Van Wyk, J., & Baerwaldt, W. (2005). External Risks and the Global Supply Chain in the Chemicals Industry. *Supply Chain Forum: International Journal*, *6*(1), 2–15. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=21182088&site=ehost-live

Vanany, I., Zailani, S., & Pujawan, N. (2009). Supply chain risk management: Literature review and future research. *International Journal of Information Systems and Supply Chain Management*, *2*(1), 16–33. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-77955712416&partnerID=40&md5=d4c7cb86c76066dbb3c8801d214097ad

Vissak, T. (2010). Recommendations for Using the Case Study Method in International Business Research. *Qualitative Report*, *15*(2), 370–388. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ875260&site=ehost-live

Vlajic, J. V, van der Vorst, J. G. A. J., & Haijema, R. (2012). A framework for designing robust food supply chains. *International Journal of Production Economics*, *137*(1), 176–189. doi:10.1016/j.ijpe.2011.11.026

Wagner, S. M., & Bode, C. (2006). An empirical investigation into supply chain vulnerability. *Journal of Purchasing and Supply Management*, *12*(2006), 301–312. doi:10.1016/j.pursup.2007.01.004

Wagner, S. M., & Bode, C. (2008). An empirical examination of supply chain performance along several dimensions of risk. *Journal of Business Logistics*, *29*(1), 307–325. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=33382313&site=ehost-live

Warrian, P. (2012). *A Profile of the Steel Industry: Global Reinvention for a New Economy* (Kindle Edi.). doi:10.4128/9781606494189

Whipp, L. (2011). Thai floods erode Toyota's profits. Financial Times. Retrieved January 9, 2012, from http://www.ft.com/intl/cms/s/0/74941cfa-09e4-11e1-85ca-00144feabdc0.html#axzz1izkiUSvc

White, D. (1995). Application of systems thinking to risk management: *Management Decision*, *33*(10), 35. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9605143183&site=ehost-live

White, G. L. (2002). A mismanaged Palladium stockpile was catalyst for Ford's write-off. *Wall Street Journal*, p. 6.

Wieland, A., & Wallenburg, C. M. (2012). Dealing with supply chain risks: Linking risk management practices and strategies to performance. *International Journal of Physical Distribution & Logistics Management*, *42*(10), 887–905. doi:10.1108/09600031211281411

Wijnolst, N., Wergeland, T., & Levander, K. (2009). *Shipping Innovation*. Amsterdam, Netherlands: IOS Press.

Wilding, R. (1997). *An investigation into sources of uncertainty within industrial supply chains: amplification, deterministic chaos and parallel interactions*. University of Warwick.

Wilding, R. (1998). The supply chain complexity triangle. *International Journal of Physical Distribution & Logistics Management*, *28*(8), 599. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=1438008&site=ehost-live

Williamson, O. E. (1975). *Markets and hierarchies, analysis and antitrust implications: a study in the economics of internal organization*. Free Press. Retrieved from https://books.google.pt/books?id=IFm3AAAAIAAJ

Williamson, O. E. (1981). The economics of organization: The transaction cost approach. *American Journal of Sociology*, *87*(3), 548–577.

Williamson, O. E. (1985). *The Economic Institutions of Capitalism*. Free Press. Retrieved from https://books.google.pt/books?id=MUPVLuiy9uQC

Williamson, O. E. (1988). Corporate Finance and Corporate Governance. *Journal of Finance*, *43*(3), 567–591. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=4652409&site=ehost-live

Wilson, M. C. (2007a). The impact of transportation disruptions on supply chain performance. *Transportation Research Part E: Logistics and Transportation Review*, *43*(4), 295–320. doi:10.1016/j.tre.2005.09.008

Wilson, M. C. (2007b). The impact of transportation disruptions on supply chain performance, *43*(August 2003), 295–320. doi:10.1016/j.tre.2005.09.008

World Bank. (2011). *Ugandan Coffee Supply Chain Risk assessment*. Retrieved from https://www.agriskmanagementforum.org/sites/agriskmanagementforum.org/files/Documents/UgandaCoffeeSupply10-final-web.pdf

World Economic Forum. (2012). *Global Risks 2012 - Seventh Edition*. Geneva, Switzerland: World Economic Forum. Retrieved from http://reports.weforum.org/global-risks-2012/

World Integrated Trade Solution - World Bank. (2013). Metal Importing Countries 2013. *Detailed Product Analysis*. Retrieved July 14, 2014, from http://wits.worldbank.org/detailed-product-analysis-visualization.html

Wright, G. (1980). Purchasing, Risk and Logistics: A Neglected Combination? *International Journal of Operations & Production Management*, *1*(1), 47–58. doi:10.1108/eb054659

Wu, T., Blackhurst, J., & (Eds.). (2009). *Managing Supply Chain Risk and Vulnerability*. (T. Wu & J. Blackhurst, Eds.). London: Springer London. doi:10.1007/978-1-84882-634-2

Wu, T., Blackhurst, J., & Chidambaram, V. (2006). A model for inbound supply risk analysis. *Computers in Industry*, *57*(4), 350–365. doi:10.1016/j.compind.2005.11.001

Wu, T., Blackhurst, J., & O'grady, P. (2007). Methodology for supply chain disruption analysis. *International Journal of Production Research*, *45*(7), 1665–1682. Retrieved from 10.1080/002075405003621 38

Yin, R. K. (1981). The Case Study Crisis : Some Answers. *Administrative Science Quarterly*, *26*(March), 58–64.

Yin, R. K. (1994). *Case Study Research. Design and Methods*. Thousand Oaks: Sage Publications.

Yin, R. K. (2003). *Case study research: design and methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Yin, R. K. (2009). *Case study research : design and methods [Kindle Edition]* (4th ed.). Thousand Oaks, CA: Sage Publications.

Yin, R. K. (2011). *Qualitative Research from Start to Finish*. New York: The Guilford Press.

Yuva, J. (2008). Shifting Globalization Into Reverse. *Inside Supply Management*, *20*(2). Retrieved from http://www.ism.ws/pubs/ISMMag/ismarticle.cfm?ItemNumber=18867

Zachariassen, F., & Arlbjørn, J. S. (2011). Exploring a differentiated approach to total cost of ownership. *Industrial Management & Data Systems*, *111*(3), 448–469. Retrieved from 10.1108/02635571111118305

Zsidisin, G. A. (2003a). A grounded definition of supply risk. *Journal of Purchasing & Supply Management*, *9*(5-6), 217–224. doi:10.1016/j.pursup.2003.07.002

Zsidisin, G. A. (2003b). Managerial Perceptions of Supply Risk. *Journal of Supply Chain Management*, *39*(1), 14–23. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=11487636&site=ehost-live

Zsidisin, G. A. (2005). Managing commodity spend in turbulent times. *Critical Issues Report - CAPS Research*, (June), 1–15.

Zsidisin, G. A. (2007). Business and Supply Chain Continuity. *CAPS Research - Critical Issues Report*, (January), 1–16.

Zsidisin, G. A., & Ellram, L. M. (2003). An Agency Theory Investigation of Supply Risk M anagement. *Journal of Supply Chain Management*, *39*(3), 15–27. doi:10.1111/j.1745-493X.2003.tb00156.x

Zsidisin, G. A., Ellram, L. M., Carter, J. R., & Cavinato, J. L. (2004). An analysis of supply risk assessment techniques. *International Journal of Physical Distribution & Logistics Management*, *34*(5), 397–413. doi:10.1108/09600030410545445

Zsidisin, G. A., & Hartley, J. L. (2012a). A Strategy for Managing Commodity Price risk. *Supply Chain Management Review*, *16*(2), 46–53.

Zsidisin, G. A., & Hartley, J. L. (2012b). Exploring Strategies for Managing Commodity Price. In *ISM North American Research Symposium* (pp. 1–13). Retrieved from http://www.ism.ws/education/content.cfm?ItemNumber=22211

Zsidisin, G. A., & Hartley, J. L. (2012c). *Managing Commodity Price Risk: A Supply Chain Perspective* (Kindle Edi.). doi:10.4128/9781606492635

Zsidisin, G. A., Melnyk, S. A., & Ragatz, G. L. (2005). An institutional theory perspective of business continuity planning for purchasing and supply management. *International Journal of Production Research*, *43*(16), 3401–3420. doi:10.1080/00207540500095613

Zsidisin, G. A., Panelli, A., & Upton, R. (2000). Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study. *Supply Chain Management: An International Journal*, *5*(4), 187–197. Retrieved from http://www.emeraldinsight.com/journals.htm?articleid=858208&show=abstract

Zsidisin, G. A., & Ritchie, B. (2009a). Supply Chain Risk Management - Developments, Issues and Challenges. In G. Zsidisin & B. Ritchie (Eds.), *Supply Chain Risk: a Handbook of Assessment, Management, and Performance* (p. 349). New York: Springer.

Zsidisin, G. A., & Ritchie, B. (2009b). *Supply chain risk: a handbook of assessment, management, and performance*. (G. Zsidisin & B. Ritchie, Eds.). New York: Springer. doi:10.1007/978-0-387-79933-9

Zsidisin, G. A., Wagner, S. M., Melnyk, S. A., Ragatz, G. L., & Burns, L. A. (2008, September). Supply risk perceptions and practices: an exploratory comparison of German and US supply management professionals. *International Journal of Technology, Policy & Management*. Retrieved from 10.1504/IJTPM.2008.020166

Zuber-Skerritt, O. (2013). *Professional Development in Higher Education: A Theoretical Framework for Action Research*. Taylor & Francis.

Annexes

Annex 1 – Standard conditions of sale for Strip products from the UK, Tata Steel

Standard conditions of sale
Tata Steel UK Limited
Effective 1 April 2012

Standard conditions of sale

Standard conditions of sale for deliveries worldwide effective on all orders accepted by Tata Steel and/or Tata Steel group companies (English Law) (the 'Conditions').

In these Conditions 'the Seller' means the company by which the goods are sold. Other terms used in these Conditions are defined in Condition 29.

Formation of contract

1. All contracts for the sale of goods by the Seller, however formed, incorporate these Conditions. Any term or condition in the Buyer's order or other documentation which is inconsistent with these Conditions shall be of no effect.

Time of Delivery

2. Dates or periods for delivery are approximate and are given for information only and shall under no circumstances be essential terms.

3. A delay in delivery, including delivery later than the date or dates provided in the Contract Documents, shall not constitute a breach of contract and shall not entitle the Buyer to avoid the contract or to any other remedy, unless the Seller has guaranteed the date of delivery in a warranty set out in the Contract Documents that expressly modifies the provisions of Condition 2 and this Condition 3.

4. Should the manufacture or processing of any of the goods, or the delivery of any of the goods at any of the Seller's sites or to the Buyer elsewhere, whether by the Seller, an associated company or an independent freight carrier, be prevented or hindered directly or indirectly by fire, the elements, war, civil commotion, strikes, lock-outs, industrial dispute, shortage of raw materials or fuel (notwithstanding that the Seller has taken all reasonable steps to procure such raw materials or fuel), shortage of labour, breakdown or partial failure of plant or machinery, late receipt of the Buyer's specification or other necessary information, acts, orders or regulations of Governments, decisions or directives of the Commission of the European Communities, delay on the part of any agent, sub-contractor or supplier, or any cause whatsoever beyond the reasonable control of the Seller or any of its associated companies concerned with the manufacture, processing or delivery of the goods then, notwithstanding any warranty set out in the Contract Documents expressly modifying Conditions 2 and 3, the time for delivery of the goods shall be extended for a reasonable period, and any such warranty shall be deemed to have been modified accordingly.

Cancellation of Delivery

5. If delivery of any goods is likely to be delayed by reason of any of the causes or events referred to in Condition 4, and:

(a) the Seller shall not have taken delivery, or shall not have completed the manufacture or processing, of the goods or the goods shall have been lost, destroyed or irreparably damaged after completion of manufacture or processing; and

(b) the delay is likely to continue for so long that the Buyer will need to acquire substitute goods from a source other than the Seller; and

(c) the Buyer shows to the reasonable satisfaction of the Seller that the conduct of the Buyer's operations is likely to be seriously affected by the likely delay in delivery of the goods or that the Buyer is in peril of being in breach of a contractual obligation to a third party as a result of such delay, then the Seller shall at the request of the Buyer agree to the cancellation of the delivery of those goods.

If any of the causes or events referred to in Condition 4 give rise to, or are likely to give rise to, a delay in delivery greater than 30 days, the Seller shall be entitled to cancel delivery of those goods and shall have no liability to the Buyer in relation to the sale of goods.

Means of Delivery

6. (a) The Seller reserves the right to supply the goods from any of its sites or any of the sites of any of its associated companies. Unless the Contract Documents specify otherwise, the method of carriage shall be at the Seller's discretion and at the cost of the Buyer. If the Contract Documents provide that the Buyer shall collect the goods from the relevant Seller site or if the Contract Documents make no provision about delivery and the Seller so elects, then the Buyer shall collect the goods without delay after being notified by the Seller that the goods are ready for collection. If the goods are not collected by the Buyer, within 3 days of being so notified, the Seller may despatch the goods itself at the Buyer's expense and risk (if an address for delivery of the goods has not been specified by the Buyer, to such address of the Buyer as the Seller may in its discretion decide) or store them at the Buyer's expense and risk, in which case the goods shall be deemed to have been delivered.

(b) The Seller reserves the right to charge to the Buyer any costs, charges or expenses incurred by the Seller, including, without limitation, any costs, charges or expenses incurred as a result of storage of the goods, vehicle or wagon detention or demurrage of ships, in each case, in consequence of any act or omission of the Buyer, or its servants or agents, including any failure of the Buyer to accept delivery of the goods, or as a result of any special requirement or stipulation not set out in the Contract Documents.

(c) Where the Contract Documents provide for delivery of the goods elsewhere than at the Seller's site or the site of one of the Seller's associated companies, the Seller will consider a claim by the Buyer in respect of loss or damage in transit only if the Buyer:

(i) gives notice to the Seller within 21 days after receiving an advice note or other notification of the despatch of the goods from the Seller, in the case of loss, or within 7 days after delivery of the goods in the case of damage; and

(ii) where the goods are transported by an independent freight carrier, complies in all respects with the freight carrier's conditions of carriage for notifying claims for loss or damage in transit.

(d) Any marine insurance required to be effected by the Seller under the Contract Documents shall, unless otherwise agreed in the Contract Documents, be 10% over the invoice price and shall cover the goods from the time when transit of the goods to the destination named in the Contract Documents commences, as provided and contained in the Institute of London Underwriters ('the Institute') Cargo Clauses, the Institute's War Clauses and the Institute's Strikes Clauses, current at the time of shipment.

(e) Except as varied by these Conditions or otherwise agreed in the Contract Documents, any terms defined in the relevant edition of Incoterms current at the date of the Seller's order acknowledgment, such as CIF and CFR, shall have the meaning assigned to them by such Incoterms when used in any of the Contract Documents.

Delivery in instalments

7. Each part delivery or instalment of the goods shall be deemed to be sold under a separate contract.

Specification and standards

8. Subject to the provisions of these Conditions, goods supplied by the Seller will, at the date of delivery, comply with any specification and standard specified by the Seller in the Contract Documents.

Warranties

9. (a) Unless the parties have expressly agreed in the Contract Documents to modify this Condition then, notwithstanding the provisions of Condition 8 above, any condition, warranty, statement or undertaking as to the quality of the goods or their fitness or suitability for any purpose however or whenever expressed or which may be implied by statute, custom of the trade or otherwise is hereby excluded, except to the extent such exclusion is prevented by law.

(b) Without prejudice to the foregoing, no statement or undertaking contained in any national Standard, National edition of a European Standard, ISO Standard, or other standard or technical specification as to the suitability of the goods for any purpose shall give rise to any legal liability of the Seller, except to the extent such exclusion is prevented by law. The Buyer shall satisfy itself that the goods are suitable for any product or application for which they are to be used before the goods are incorporated into such product or application.

Testing and Inspection

10. Where the Contract Documents provide for testing or inspection of the goods by or on behalf of the Buyer before delivery (whether at the Seller's site or elsewhere), then the Buyer shall inspect and/or test the goods within 7 days of being notified by the Seller that the goods are available for inspection or testing. If the Buyer does not inspect or test the goods within the time specified by the Seller in that notice or if within 14 days of such testing or inspection the Buyer does not give notice to the Seller stating that, and specifying the reasons why, the goods do not comply with the Contract Documents, then the Buyer shall conclusively be deemed to have accepted that the goods comply with the Contract Documents and shall not be entitled to reject the goods on the grounds of anything which such inspection or testing has or would have revealed.

Acceptance of goods

11. The Buyer shall be deemed to have accepted the goods and that the goods comply with the Contract Documents unless:

(a) the Buyer gives notice in accordance with Condition 10; or

(b) in the case of a defect in the quality or state of the goods or the goods otherwise not complying with the Contract Documents, which defect or non-compliance was apparent upon careful inspection or reasonable testing of the goods (or would have been had a careful inspection or reasonable test been carried out), the Buyer gives the Seller a notice specifying such defect or non-compliance within 21 days after receiving the goods and in any event prior to their use or re-sale and, after doing so, gives the Seller a reasonable opportunity to inspect or test the goods before they are used or resold; or

(c) in the case of a defect in the quality or state of the goods or the goods otherwise not complying with the Contract Documents, which defect or non-compliance was not apparent upon careful inspection or reasonable testing of the goods (or would not have been had a careful inspection or reasonable test been carried out), the Buyer gives the Seller notice specifying such defect or non-compliance immediately upon discovering it and in any event not more than 12 months after receiving the goods and, after doing so, gives the Seller a reasonable opportunity to inspect the goods. The Buyer shall not be excused from providing such opportunity by reason only that the goods have been incorporated into the goods or property of a third party or that the goods are located in, upon or under the premises or land of a third party.

Any dispute between the parties as to whether any goods are defective in quality or state or otherwise not in compliance with the Contract Documents shall be referred, in accordance with the provisions of the Arbitration Act 1996 or any statutory modification or re-enactment thereof for the time being in force, to a single arbitrator to be agreed between the Seller and the Buyer or in default of agreement to be nominated by the President for the time being of The Law Society of England and Wales.

Weight and Quantity

12. (a) Unless the Contract Documents specify otherwise, the Seller shall be entitled to select the basis on which to charge the goods, and such basis may include charging the goods on a calculated basis taking into account any usual industry standard tolerances applicable to such goods, including the weight, length, thickness, scrap loss and/or packaging of goods.

(b) The weight or quantity of the goods printed upon the Seller's advice or despatch note shall be final unless the Buyer shall have given notice to the Seller of any discrepancy in weight or quantity within 14 days after receiving the goods and shall have given the Seller a reasonable opportunity to witness the weight and/or quantity of the goods being verified before they have been used, processed or sold.

(c) Unless the Contract Documents expressly specify otherwise, delivery to the Buyer of a weight or quantity of goods up to 10% less than or greater than that which the Seller has agreed to sell shall under no circumstances be a breach of contract by the Seller or entitle the Buyer to reject the goods delivered.

Remedies

13. Provided that the Buyer has complied with the requirements of Condition 10 or 11 (as applicable), and subject to the provisions of Condition 16, if the goods (or any part of them) are, upon delivery, defective in quality or state or (save for discrepancy in weight or quantity) otherwise not in compliance with the Contract Documents, then, either:

(a) if the Seller and the Buyer agree, the Buyer shall accept the goods at an agreed value; or

(b) if the Seller and the Buyer do not so agree within 21 days after the Buyer gave notice to the Seller under Condition 10 or 11 (as applicable), the Buyer may return the relevant goods to the Seller upon which the Seller shall, at the Seller's option either:

(i) repair the goods at the Seller's expense;

(ii) repay the Buyer, or give the Buyer credit for, the invoice price of the goods (including freight) and any reasonable transport costs incurred by the Buyer in carrying the relevant goods from the place they were originally delivered to the Seller's site from which they were despatched or to such other place as the Seller may nominate; or

(iii) replace the goods by delivering replacement goods to the original place of delivery as soon as may be reasonably practicable.

Limitations on Liability

14. (a) The undertakings in Condition 13 are given in lieu of any other legal remedy the Buyer may have (whether in contract, tort or otherwise) and shall be the Buyer's sole remedy in respect of goods (or any part of them) being defective in quality or state or otherwise not in compliance with the Contract Documents.

(b) The liability of the Seller (and its associated companies) to the Buyer in respect of:

(i) such defects or non-compliance; and

(ii) in the event that the Seller is not entitled to rely upon the provisions of Condition 14(c) below, any loss, damage or expense whatsoever incurred or suffered by the Buyer (including, but without limitation, loss of profit, revenue or goodwill) howsoever such loss, damage, or expense may have been caused (including, but without limitation, any breach of contract, negligence or breach of any duty of the Seller whatsoever), shall for all purposes (including, but without limitation, under the relevant contract and in negligence or any other tort) be limited to whichever is the lower of the cost of: (a) making good the goods; (b) the repayment or giving of credit for the invoice price of the goods; or (c) the replacement of the goods in accordance with Condition 13.

(c) Under no circumstances shall the Seller (or any of its associated companies) be liable for any loss, damage or expense whatsoever incurred or suffered by the Buyer (including, but without limitation, loss of profit, revenue or goodwill) howsoever such loss, damage, or expense may have been caused (including, but without limitation, any breach of contract, negligence or breach of any duty of the Seller whatsoever) other than as set out in Condition 14(a).

(d) Nothing in these Conditions shall exclude or restrict the liability of the Seller for death or personal injury caused by the Seller's negligence or as otherwise prohibited by law.

(e) Conditions 14(a) to (d) (inclusive), Conditions 9(a) and (b) and Conditions 24(a) to (e) (inclusive) shall be construed severally and as separate contract terms. These Conditions shall survive the termination of the contract for whatever cause.

15. The Buyer agrees to indemnify and hold the Seller harmless from any and all claims, demands, proceedings and actions which may be made or brought against the Seller by any person, including (but not limited to) any purchaser of the goods or any product made therefrom, arising from the use of such goods or any products in which such goods are used or from any infringement of any patent, trade mark or trade name, copyright and the like, or from any latent or hidden defects in the quality of said goods or resulting products, or from the dangerous condition thereof, and the Buyer shall pay any and all costs, fees (including reasonable lawyers' fees) and expenses, judgments, awards and fines for and on behalf of the Seller as incurred or as they become due.

Non-prime goods

16. Goods sold as 'non-prime' or goods accepted by the Buyer pursuant to Condition 13 which the Seller and the Buyer agree to be 'non-prime' are sold in their actual state, as seen, without warranty and with all faults whether or not the goods have been inspected by the Buyer prior to delivery. Any statement, specification, description or other information provided by the Seller in respect of such goods is given in good faith but the Seller accepts no responsibility for its accuracy. Under no circumstances will the Seller be under an obligation to replace or make good such goods or be liable for any claim whatsoever in respect of them. If the Buyer shall re-sell such goods the Buyer shall ensure that a provision in similar form to this condition is incorporated in the re-sale agreement, unless, prior to reselling the goods, the goods or such part of them as the Buyer re-sells are first made to comply with a recognised specification or standard.

Retention of Title

17. (a) Subject to any Incoterms expressly incorporated into the contract by any of the Contract Documents, risk in the goods shall pass to the Buyer when the goods are delivered to the Buyer.

(b) The Seller and the Buyer expressly agree that:

(1) until the Seller has been paid in full (in cash or cleared funds) for the goods; and

(2) until all other monies due or which become due from the Buyer to the Seller on any account whatsoever have been paid in full (in cash or cleared funds),

the following provisions shall apply:

(i) legal and beneficial ownership of such goods remain with the Seller;

(ii) the Buyer shall have a right to possession (but not ownership) of such goods for the Seller and ensure that the goods shall be clearly marked and identifiable as being the Seller's property;

(iii) the Seller may recover all or any part of such goods at any time from the Buyer if they are in the Buyer's possession and any of the events in Condition 18 has occurred and for that purpose the Seller, its servants and agents may enter upon any land or building upon or in which such goods are situated; and

(iv) the Buyer has a right to dispose of such goods (as between it and its customers only) as principal in the ordinary course of its business with such right being terminable by the Seller giving to the Buyer notice at any time and being automatically terminated (without notice) upon the happening of any of the events referred to in Condition 18.

Each sub-Condition 17(b)(1) and (2) and sub-Condition 17(b)(ii), (iii) and (iv) shall be construed and have effect as a separate Condition and accordingly in the event of any of them being for any reason whatsoever unenforceable according to its terms, the others shall remain in full force and effect.

Termination and Suspension

18. The Seller shall be entitled without prejudice to its other rights and remedies either to terminate wholly or in part any or every contract between itself and the Buyer or to suspend any further deliveries under any or every contract in any of the following events:

(a) if any debt is due and payable by the Buyer to the Seller but is unpaid;

(b) if the Buyer has failed to provide any letter of credit, bill of exchange or any other security required by the Contract Documents provided that in such event the Seller's rights of termination or suspension under this Condition shall apply only in regard to the particular contract in respect of which the Buyer shall have so failed;

(c) if any guarantee or other security for trading in respect of the Buyer's obligations under the contract or under the Contract Documents is cancelled, suspended or amended in any respect;

(d) if, in the reasonable opinion of the Seller, the delivery (or any steps required in connection with the delivery) would involve a level of risk to the health or safety of any person that would constitute a breach, or potential breach, of any legal obligation by the Buyer and/or the Seller or would be excessive or unreasonable;

(e) if the Buyer has failed to take delivery of the goods under any contract between it and the Seller otherwise than in accordance with the Buyer's contractual rights or the Buyer is otherwise in breach of any such contract;

(f) if the Buyer becomes insolvent or enters into any composition or arrangement (including a voluntary arrangement) with its creditors or, being a body corporate, has passed a resolution for voluntary winding up except where solely for the purpose of reconstruction or if a petition has been presented for an order for its winding up or for a receiver (including an administrative receiver) or administrator to be appointed or if any such order or appointment is made or if, being an individual or partnership, the Buyer suspends payment of his or their debts in whole or in part or if an application has been made for an interim order or a petition has been presented for a bankruptcy order or if any such order is made or if the Buyer, whether or not a body corporate, shall carry out or be subject to any analogous act or proceedings under any law;

(g) the imposition of any new, additional or increased tax, public charge, freight, tariff or duty which may after the date of the quotation or contract be levied on or imposed on the goods to be sold, or upon any sale, delivery, or other action taken under or in connection with any contract to which these Conditions apply, or upon the export or import of such goods or materials required to produce the goods; or

(h) if the Buyer fails to comply with any request by the Seller for advance payment or security pursuant to Condition 21 below.

The Seller shall be entitled to exercise its rights of termination or suspension under this Condition at any time during which the event giving rise to such rights is continuing and has not been remedied and, in the event of a suspension, the Seller shall be entitled, as a condition of resuming delivery under any contract between it and the Buyer, to require prepayment of, or such security as it may require for the payment of, the price of any further goods.

If the Seller is entitled to exercise its rights of termination or suspension under this Condition, the Seller shall further be entitled by notice to the Buyer to treat all sums which are then due to the Seller under any contract between the Seller and the Buyer but which are not then payable, as being immediately due and payable.

Payment and pricing

19. The Buyer shall not be entitled to withhold payment of any amount payable for the supply of goods or otherwise under the Contract Documents to the Seller because of any disputed claim of the Buyer in respect of defective goods or any other alleged breach of the Contract Documents, nor shall the Buyer be entitled to set off against any amount payable for the supply of goods or otherwise under the Contract Documents to the Seller any monies which are not then presently payable by the Seller or for which the Seller disputes liability.

20. (a) The price payable by the Buyer for each delivery shall be the price set out in the Contract Documents to which shall be added any Value Added Tax and any other tax or duty relating to the sale or delivery of goods chargeable to the Seller and the freight and other charges as specified in the Contract Documents. Unless otherwise expressly stated in the Contract Documents, the price of each delivery (including such Value Added Tax, other tax or duty, freight and other charges) shall be paid in full and received by the Seller by no later than 30 days from the date of invoice. The Seller shall be entitled to charge interest on any sums not so paid. Such interest shall be calculated on a day-to-day basis on the amount outstanding at the rate of 8% above the arithmetic average for each day of the published base rate of the Central Bank for the currency in which the goods are priced or at any higher rate as the Seller would (but for this Condition) have been entitled to charge interest under any applicable legislation.

(b) The Seller shall further be entitled to recover from the Buyer all costs incurred by the Seller or on its behalf in recovering payment of any sum not paid in full when that sum is due and payable and the Buyer shall indemnify the Seller against all such costs.

(c) Payment shall be made in pounds sterling or otherwise in the currency specified in the Contract Documents. Subject to Condition 19, that amount shall not be subject to any discount or deduction except as agreed by the Seller in the Contract Documents.

21. The Seller may at any time, whether before the beginning of the performance of the Contract or after partial performance thereof, require from the Buyer, partly or wholly, a payment in advance or require a guarantee acceptable to the Seller that the Buyer shall satisfactorily fulfil his obligations towards the Seller. The Seller shall be under no obligation to justify his requirement for such payment in advance or guarantee.

Notices

22. (a) Except where expressly stated otherwise in any of the Contract Documents, a notice in respect of the contract shall only be effective if it is in writing. Email and notices given via the Seller's electronic data interchange system are permitted.

(b) Notices in respect of the contract or under any of the Contract Documents shall be sent to a party at its address or number and for the attention of the individual specified in the Contract Documents, provided that a party may change its notice details on giving notice to the other party of the change in accordance with this Condition.

Third Party Rights

23. The Seller and the Buyer agree that if any term of the contract or any term of the Contract Documents purports to confer a benefit on any person who is not a party to the contract (a 'third party'), that term shall not be enforceable by any such third party.

Entire Agreement

24. **(a)** The Contract Documents constitute the whole and only agreement between the parties relating to the subject matter of the contract.

(b) The Buyer acknowledges that in entering into the contract it is not relying upon any pre-contractual statement which is not set out in the Contract Documents.

(c) Except in the case of fraud, no party shall have any right of action against any other party to this agreement arising out of or in connection with any pre-contractual statement except to the extent that it is repeated in the Contract Documents.

(d) For the purposes of this Condition, 'pre-contractual statement' means any draft, agreement, undertaking, representation, warranty, promise, assurance or arrangement of any nature whatsoever, whether or not in writing, relating to the subject matter of the contract made or given by any person at any time prior to the date of this agreement.

(e) Where the Seller provides any information or advice to the Buyer in connection with the delivery of any goods other than as specifically required under the Contract Documents, the Buyer acknowledges that the Seller does not accept any responsibility for providing inaccurate, misleading or incomplete information or advice. The Buyer acknowledges that before relying on any information or advice which the Seller or any associated company may supply, the Buyer should satisfy itself of the accuracy and appropriateness of that information or advice.

No waiver

25. The rights of the Seller or the Buyer shall not be prejudiced or restricted by any indulgence or forbearance extended by either party to the other and no waiver by either party in respect of any breach shall operate as a waiver in respect of any subsequent breach. Any variation in the terms of the contract must be agreed between the parties in a Contract Document.

Severability

26. In the event that, for any reason, any provision in the contract is held to be void, unenforceable or otherwise invalid, all the other provisions of the contract, and the remainder of any provision where the effect of some part of it is held to be void, unenforceable or otherwise invalid, shall remain fully effective.

Governing Law and Jurisdiction

27. **(a)** The contract and the Contract Documents shall be governed by and construed in accordance with the laws of England.

(b) Subject to Condition 11:

(i) the courts of England are to have jurisdiction to settle any dispute arising out of or in connection with the contract and the Contract Documents; and

(ii) any proceeding, suit or action arising out of or in connection with the contract and the Contract Documents ('Proceedings') may be brought in the English courts.

(c) This jurisdiction agreement is for the benefit of the Seller. The Seller is therefore, subject to Condition 11, to retain the right to bring Proceedings in any court which has jurisdiction other than by virtue of this jurisdiction agreement. The Buyer has, subject to Condition 11, the right to bring Proceedings only in the courts of England and not in any other courts.

(d) The Buyer on entering into this contract irrevocably submits to the jurisdiction of the English courts and of any other court in which Proceedings may be brought in accordance with this Condition.

Data Protection

28. The Buyer hereby consents to the Seller using any information provided by the Buyer for any purposes connected with the supply of goods under the contract, including, without limitation, the carrying out of a credit check on the Buyer, arranging credit insurance, processing payment by the Buyer, enforcing the Buyer's obligations under the contract and carrying out its own obligations under the contract.

Definitions

29. In these Conditions, unless the context requires otherwise:

'associated company' means, in relation to the Seller, a company:

(a) which holds or controls, directly or indirectly through another person, entity or otherwise, more than half of the shares in the Seller; or

(b) in which any such company or the Seller holds or controls, directly or indirectly through another person, entity or otherwise, more than half of the shares,

and 'associated companies' means all of them.

«'Contract Documents' means, in relation to each contract for the sale of goods by the Seller to the Buyer:

(a) the Conditions;

(b) any order acknowledgement, advice, despatch note or other delivery documentation or invoice given by the Seller to the Buyer in respect of the contract; and

(c) any other document expressly accepted by the Seller as forming part of the contract,

and 'Contract Document' shall mean any one of them.

'goods' means, in relation to each contract, the goods referred to in the Contract Documents as being sold by the Seller to the Buyer and all obligations of the Seller (and its associated companies) in connection with the sale of these goods, including but not limited to design, manufacture, insurance, delivery, testing and installation and all references to 'delivery of the goods' shall be construed, where the context permits, to include a reference to performance of all such obligations.

Annex 2 – Standard Terms and Conditions of Sale (source: United States Steel Corporation, excerpt)

USS STANDARD TERMS AND CONDITIONS OF SALE

Governing Sales Made by United States Steel Corporation or United States Steel International, Inc.

1. Payments: Payments shall be made at par in legal tender of the United States of America, and directed to the payment address, lockbox or other means specified in Seller's invoice or EDI payment instructions. Buyer shall make such arrangements for payment as Seller shall from time to time reasonably require and Seller may suspend scheduling, production, shipment or delivery of goods until such arrangements are made. If Seller reasonably believes that Buyer is or may become unable to perform its obligations hereunder, Seller may require that Buyer provide Seller with security for, or other assurance of, performance, in either case acceptable to Seller. In the event that Buyer fails to do so or fails to make payment in full within the time period set forth on the invoice or expressly agreed upon in writing by the parties, such failure will constitute a material breach of contract by Buyer permitting Seller to suspend scheduling, production, shipment or delivery of goods under this contract or any other contract between Buyer and Seller. Buyer shall pay to Seller interest on any unpaid amount at the maximum rate permitted by law or the Prime Rate in effect by JPMorgan Chase Bank, N.A. (or any successor institution) on the first day of the month such amounts first become past due plus 3.5%, whichever is less. Seller shall have, in addition, all other remedies permitted to Seller by law, equity or this contract. If Seller takes legal action to collect any amount due hereunder, Buyer shall pay all dispute resolution costs, including court costs plus reasonable legal fees incurred by Seller in bringing such legal action. Seller shall have the right to set off against any monies due Seller hereunder any obligations of Seller or its affiliates to Buyer.

2. Taxes: To the extent legally permissible, all present and future taxes imposed by any federal, state or local authority of any country which Seller may be required to pay or collect, upon or with reference to the sale, purchase, transportation, delivery, storage, use or consumption of the goods or services, including taxes upon or measured by the receipts therefrom (except net income and equity franchise taxes) shall be for the account of Buyer. The purchase is subject to state or local use tax, unless it is specifically exempt from taxation. The purchase is not exempt merely because the Seller was not required to collect sales tax or made by remote means. Buyer assumes responsibility for correctly assessing and remitting any use tax due to the proper jurisdiction(s).

3. Risk of Loss; Incidental Transportation and Storage Charges; Title: Risk of loss shall pass to Buyer upon tender of delivery at the delivery point specified in this contract. Any charges at the delivery point for spotting, switching, handling, storage and other accessorial services, and demurrage, shall be for Buyer's account. Seller shall have the right to assess a storage and handling charge for goods left in Seller's possession after notification to Buyer that the goods are available to ship. Title to the goods shall pass to Buyer upon Seller's receipt of full payment for the goods.

4. Time of Shipment and Shipping: Except with respect to payment of amounts due by Buyer to Seller hereunder, time is not of the essence hereunder. Each shipment is a separate sale. Seller reserves the right to ship all or any part of the goods from any shipping point other than the shipping point or points specified herein. Shipment in installments is permitted. Buyer shall furnish shipping instructions to enable Seller to perform the contract in accordance with its terms. Failure by Buyer to do so shall entitle Seller, in addition to all other rights, to cancel such portion of the contract that has not been performed, or to make shipment in such manner as Seller may elect. Seller will use reasonable efforts to comply with Buyer's requests regarding transportation, but Seller reserves the right to make alternate transportation arrangements, even if at a higher cost to Buyer, if the transportation specified by Buyer is deemed by Seller to be unavailable or unsatisfactory. Seller shall notify Buyer of any such change within a reasonable time.

5. Specification Variations: Except in the particulars specified by Buyer and expressly agreed to in a writing signed by Seller, the goods furnished hereunder shall be produced in accordance with Seller's standard practices. All goods, however, including those produced to meet an exact specification, shall be subject to Seller's mill tolerances and variations consistent with good mill practice in respect to: (a) dimension, weight, straightness, section, composition and mechanical and/or physical properties; (b) normal variations in surface and internal conditions and in quality; (c) deviations from tolerances and variations consistent with practical testing and inspection methods; and (d) regular mill practice on over and under shipment.

6. Inspection: Where mill inspection is made by Buyer, Buyer's inspector shall be deemed the agent of Buyer with authority to waive specified tests and details of test procedure and to accept goods as conforming to this contract with respect to all characteristics of such goods for which such inspection is made. In all cases Buyer shall conduct a timely inspection of the goods upon receipt or within a commercially reasonable time and manner not to exceed fifteen (15) days from such receipt. Buyer's use of the goods in its production operations shall be deemed an acceptance of the goods involved as conforming to this contract unless Buyer provides Seller written notice of rejection or of a non-conformity respecting such goods prior to or concurrent with Buyer's use thereof. Buyer's inspection or failure to inspect shall not delay payment.

7. Force Majeure, Allocation of Production: In the event either party's performance hereunder is delayed or made impossible or commercially impracticable due to causes including fire, explosion, war, terrorism, strike or other differences with workers, shortage of energy sources, facility, material or labor, delay in or lack of transportation, temporary or permanent plant shutdown, breakdown or accident, compliance with or other action taken to carry out the intent or purpose of any law, regulation, or other requirement of any governmental authority, or any cause beyond that party's reasonable control (each, a "force majeure" event), that party shall have such additional time in which to perform this contract as may be reasonably necessary under the circumstances. However, the obligation of Buyer to pay for goods delivered is never suspended or delayed. In addition, if due to a force majeure event or any other cause, Seller is unable to produce sufficient goods to meet all demands from customers and internal uses, Seller shall have the right to allocate production among its customers and plants in any manner which Seller may determine, acting reasonably. This Section 7 is to be applied in conjunction with UCC Section 2-615, Excuse by Failure of Presupposed Conditions, in the case of domestic U.S. sales; provided, however, that in the event of a conflict, this Section 7 shall govern.

1 of 5

Annex 3 - Hot-rolled strip products price list (Source: TATA Steel Europe)

TATA STEEL

TATA

Hot-rolled strip products

Price extras in Euros

Effective 1 April 2015

General

This document shows price extras only.
The invoiced price comprises these extras plus basis price, distribution and tax.
Material is charged on gross weight. Lengths and widths should be specified in whole millimetres.
Unless otherwise agreed with Tata Steel, sales are FCA Tata Steel IJmuiden loading quay (ship), FCA Tata Steel IJmuiden loading dock (truck) or FCA Tata Steel IJmuiden railway yard (rail).
All prices in this list are in EUR/tonne and do not include value-added tax or any other tax relating to the sale and delivery of the goods. If delivery is within the European Union, the purchaser will bear all taxes and will reimburse Tata Steel for any taxes charged to Tata Steel in respect of the sale or delivery of the goods.
All transactions are subject to Tata Steel IJmuiden BV General Conditions of Sale.
Specifications are subject to mill acceptance and not all combinations of extras are necessarily available. For specific information about products and their availability, please check www.tatasteeleurope.com or consult Tata Steel.

1. Quality

1.1 Steel for drawing and cold forming	Tata Steel	EN 10111 : 2008	€/tonne
		DD11	0
		DD12	8
		DD13	15
		DD14	25
	DD14+		30

1.2 High-strength low-alloy steel	Tata Steel - Ympress®	EN 10149-2 : 1996*	€/tonne
	Ympress S315MC	S315MC	35
	Ympress S355MC	S355MC	45
	Ympress S420MC	S420MC	65
	Ympress S460MC	S460MC	75
	Ympress S500MC	S500MC	85
	Ympress S550MC	S550MC	98
		S650MC	160
	Ympress E690TM		165
	Ympress S700MC	S700MC	185
	Tata Steel - Ympress® Laser**		
	Ympress E250C Laser		35
	Ympress S355MC Laser		65
	Ympress S420MC Laser		85

Notes:
* 3.1 certificate required
** Only sold by approved channels

1

Hot-rolled strip products price extras in EUR
Effective 1 April 2015

1.3 Carbon-manganese steel	Tata Steel		€/tonne
	CMN250		45

1.4 Structural steel	Tata Steel	EN 10025-2 : 2004	€/tonne
	n.a.	S185	5
		S235JR	10
		S235JR+N	15
		S235J0	15
		S235J0+N	20
		S235J2	20
		S235J2+N	25
		S275JR	20
		S275JR+N	25
		S275J0	30
		S275J0+N	35
		S275J2	35
		S275J2+N	40
		S355JR	40
		S355JR+N	45
		S355J0	45
		S355J0+N	50
		S355J2	50
		S355J2+N	55
		S355K2	55
		S355K2+N	60

Notes:
Suitability for cold forming (option C): supplementary extra of €20/t.

1.5 Advanced high-strength steel	Tata Steel	prEN 10338:2009	€/tonne
	Dual phase		
	DP600	HDT580X	85
	Ferrite-bainite		
	FB590	HDT590F	115
	Boron steel		
	HQ1500HR		100

1.6 Case hardening steel	Tata Steel	EN 10084 : 2008	€/tonne
	n.a.	C15E	30

1.7 High carbon steel	Tata Steel	EN 10132-4 : 2000	€/ton
	n.a.	C55S	58
		C60S	65
	n.a.	C67S	70
		C75S	75

1.8 Steel for simple pressure vessels	Tata Steel	EN 10207 : 2005	€/tonne
	n.a.	P235S	45
		P265S	55

1.9 Steel for pressure vessels	Tata Steel	EN 10028-2 : 2009	€/tonne
	n.a.	P235GH	50
		P265GH	60

1.10 Steel for gas cylinders	Tata Steel	EN 10120 : 2008*	€/tonne
	n.a.	P245NB	27
		P265NB	35

* 3.1 certificate required

1.11 Ship plate (with testing by and certificate from)

Tata Steel	Lloyds Register of Shipping	Germanischer Lloyds	€/tonne
n.a.	Grade A	Grade A	20
	Grade B		40

1.12 Steel for tube/line pipes

Tata Steel	EN 10208-2 : 2009	API 5L	€/tonne
n.a.		A	15
	L245MB/NB	B	30
	L290MB/NB	X42	40
		X46	50
	L360MB	X52	60
		X56	75
	L415MB	X60	75
	L450MB	X65	80
	L485MB	X70	90

2. Floor Plate

2.1 Durbar®

	€/tonne
Durbar pattern	35
Thickness ≤ 4mm	10
Width <1250mm	7

Notes:
1 The price of Durbar is composed of the basis price, the extra for grade and dimension and the extra shown in this table, plus any appropriate extras that follow.
2 Durbar meets the requirements for mechanical properties specified by EN 10025-2 : 2004.

3. Dimensions

3.1 Thickness and width: coils

Thickness (mm)		Width (mm)					
		≥900 <1000	≥1000 <1100	≥1100 <1300	≥1300 ≤1550	>1550 ≤1830	>1830 ≤2070
≥	<	€/tonne					
1,40	1,50	45	42	40		-	-
1,50	1,75	40	37	35	35	-	-
1,75	1,85	35	32	28	28	28	-
1,85	2,00	35	32	28	28	28	-
2,00	2,50	33	30	20	20	23	30
2,50	3,00	30	27	18	18	20	30
3,00	4,00	28	25	15	15	20	25
4,00	7,00	25	22	13	13	18	25
7,00	10,00	30	27	18	18	20	25
10,00	12,00	33	30	20	20	23	25
12,00	15,00	33	30	23	23	25	27
15,00	≤20,00	40	37	25	25	25	27

Notes:
1 Where dimensions are specified as a range, a maximum (with all tolerances under) or a minimum (with all tolerances over), the extras applicable are those for the mean of the range as specified or implied.
2 Other dimensions available on request.

4. Pickling and oiling

4.1 Thickness and width: coils

Thickness (mm)		Width (mm)			
			≥1000	>1550	>1830
		<1000	≤1550	≤1830	≤2070
≥	<	€/tonne			
1,50	1,75	45	43	43	43
1,75	2,00	45	40	40	40
2,00	5,00	35	30	30	30
5,00	≤6,35	35	30	30	30

4.2 Supplementary price extra

	€/tonne
For tensile strength ≥ 470 Mpa (≥S420MC ; ≥S355J/K ; ≥L415MB)	8
Unoiled pickled	10

5 Dimensional tolerances

5.1 Thickness tolerances

EN 10051 : 2010	€/tonne
Normal	0
3/4 normal	0
2/3 normal	4
1/2 normal	5
Other	15

5.2 Width tolerances & side trimming (pickled coil only)

EN 10051 : 2010	€/tonne
Normal (Mill Edge)	0
Special / outside EN 10051 : 2010 (Side Trimmed Last)	10

5.3 Low crown

	Re≤360MPa	Re>360MPa
	€/tonne	
No crown specified	0	0
≤50µm	10	20
≤30µm	15	on request

Notes:
Crown values at C40 measurement position.

6 Quantity

6.1 Coil weights

Max. coil weigth		Width (mm)		
		≥ 900	≥ 1100	≥ 1500
		< 1100	< 1500	
≥	<	€/tonne		
5	10	30	30	35
10		0	0	0

Notes:
1. Coil weight price extras apply unless the specified coil weight is the result of technical limitations at Tata Steel.
2. The minimum specifiable coil weight is 5 tonnes.
3. Specified coil weights must be in balance with the ordered quantity.

6.2 Order quantity per order item

Quantity (tonnes)		Tata Steel tolerance	€/tonne
≥	<		
100		±10%	0
40	100	±20%	0
20	40	±20%	10

Notes:
1. An order item is a quantity of material specified in one order of which the specification (grade, dimension, etc) delivery time and destination is the same.
2. The minimum order quantity is 20 tonnes.
3. Material should be ordered in quantities that are multiples of whole coils.
4. Tata Steel will seek to supply the nearest number of whole coils to meet the ordered quantity or a quantity that is within the tolerances shown.
5. Where quantity is specified as a range, a maximum (with all tolerances under) or a minimum (with all tolerances over), the extras applicable are those for the mean of the range as specified or implied.

6.3 Welds

	€/tonne
If recoiling welds are not accepted	3

7 Testing and inspection

7.1 Test certificates

	€/tonne
to EN 10204 : 2004	
Declaration of compliance with order - type 2.1	0
Test report (cast analysis only) - type 2.2	0
Test report (cast + mechanical properties) - type 2.2	3
Inspection certificate (cast analysis and mechanical properties based on specific testing) - type 3.1	5
Inspection certificate (signed by an authorised representative of a test agency, appointed by the purchaser) - type 3.2*	10
Other, non-mandatory tests	**on request**

* Personal inspection costs will be invoiced to the purchaser or his customer by the inspection agency and must be paid direct to the inspection agency.

Notes:
At purchaser's choice only one certificate to EN 10204 will be issued, to be agreed on ordering.

8 Other extras

8.1

	€/tonne
Special heat analyses (low S-content)	
Max 0,015%	16
Max 0,008%	21
Max 0,005%	25
Skin passed	
Reduction under 3% (at customer request)	23
Fit for specific application	
Surface critical applications (exposed)	15
Safety critical parts (safety parts)	15

9 Packaging

9.1

	€/tonne
Steel strapping	0
Paper/film and steel strapping	3
Steel/board box, paper/film and steel strapping	5

Notes:
1. For weighing and invoicing gross equals net.
2. The wood if used in packing is included in the weight.
3. Packaging materials are to be regarded as non-returnable.

www.tatasteeleurope.com

Tata Steel
PO Box 10.000
1970 CA IJmuiden
The Netherlands
T: +31 (0) 251 496126
E: strip.enquiries@tatasteel.com

IS:04/2015

Ympress® and Durbar® are trademarks of Tata Steel.

Care has been taken to ensure that this information is accurate, but Tata Steel, including its subsidiaries, does not accept responsibility or liability for errors or information which is found to be misleading.

Tata Steel reserves the right to change this information at any time without prior notice. The online version will take precedence over the printed version at any moment in time.

Copyright 2015
Tata Steel Europe Limited

Annex 4 - Top 50 Steelmakers in the World in 2013 (Source: World Steel Association)

(million tonnes crude steel production)

COMPANY	HQ	Tonnage 2013	Tonnage 2012	Rank in 2013	Rank in 2012	Rank Δ 2013/2012
ArcelorMittal (*)	Luxembourg	96.1	93.6	1	1	=
Nippon Steel & Sumitomo Metal Corporation (*)	Japan	50.1	47.9	2	2	=
Hebei Steel Group (**)	China	45.8	42.8	3	3	=
Baosteel Group (*)	China	43.9	42.7	4	4	=
Wuhan Steel Group (*)	China	39.3	36.4	5	6	↑
POSCO (*)	South Korea	38.4	39.9	6	5	↓
Shagang Group	China	35.1	32.3	7	7	=
Ansteel Group (*)	China	33.7	30.2	8	10	↑
Shougang Group (*)	China	31.5	31.4	9	8	↓
JFE (*)	Japan	31.2	30.4	10	9	↓
Tata Steel Group (*)	India	25.3	23.0	11	11	=
Shandong Steel Group	China	22.8	23.0	12	11	↓
US Steel Corporation (*)	USA	20.4	21.4	13	12	↓
Nucor Corporation (*)	USA	20.2	20.1	14	13	↓
Tianjin Bohai Steel (1)	China	19.3		15		
Gerdau (*)	Brazil	19.0	19.8	16	14	↓
Maanshan Steel	China	18.8	17.3	17	15	↓
Hyundai Steel (*)	South Korea	17.2	17.1	18	16	↓
Benxi Steel	China	16.8	15.1	19	19	=
Evraz Group (*)	Russia	16.1	15.9	20	18	↓
ThyssenKrupp (*)	Germany	15.9	15.1	21	19	↓
Severstal (*)	Russia	15.7	15.1	22	19	↓
NLMK (*)	Russia	15.5	14.9	23	20	↓
Valin Group	China	15.0	14.1	24	21	↓
Metinvest (*)	Ukraine	14.3	12.5	25	28	↑
Jianlong Group	China	14.3	13.8	25	22	↓
IMIDRO (*)	Iran	14.3	13.6	25	23	↓
China Steel Corporation (*)	Taiwan, China	14.3	12.7	25	27	↑
SAIL (*)	India	13.5	13.5	26	24	↓
Fangda Steel (2)	China	13.2	3.3	27	59	↑
Rizhao Steel	China	12.7	13.2	28	25	↓
MMK (*)	Russia	11.9	13.0	29	26	↓
JSW Steel Limited (*)	India	11.8	8.5	30	33	↑
Jiuquan Steel	China	11.2	10.1	31	30	↓
Baotou Steel	China	10.7	10.2	32	29	↓
Anyang Steel	China	10.3	7.7	33	36	↑
Zongheng Steel	China	10.2	9.1	34	31	↓
Taiyuan Steel	China	10.0	10.1	35	30	↓
Jingye Steel	China	9.7	7.3	36	39	↑
Techint Group (*)	Argentina	9.0	8.7	37	32	↓
Jinxi Steel	China	8.7	9.1	38	31	↓
Xinyu Steel	China	8.5	8.7	39	32	↓
Zenith Steel	China	8.5	7.6	39	37	↓
Erdemir Group (*)	Turkey	8.3	7.9	40	35	↓
Sanming Steel	China	8.2	6.9	41	42	↑
Guofeng Steel	China	8.1	8.0	42	34	↓
Shaanxi Steel	China	8.0	6.7	43	43	=
voestalpine Group (*)	Austria	8.0	7.5		38	↓
ISD Corporation	Ukraine	7.9	8.5	44	40	↓
Citic Pacific	China	7.7	6.6	45	44	↓
Riva Forni Elettrici SpA (*) (3)	Italy	7.6	7.8	46		
Kobe Steel Ltd. (*)	Japan	7.5	7.4	47	41	↓
CELSA Group (*)	Spain	7.0	7.6	48	37	↓
Usiminas (*)	Brazil	6.9	7.2	49	40	↓
Essar Steel (*)	India	6.1	6.7	50	43	↓
Nanjing Steel	China	6.1	7.2		40	↓

* worldsteel Members

** Handan which is part of Hebei Group is a member of worldsteel

(1) Some Chinese companies consolidated to form Tianjin Bohai Steel in 2013

(2) Pingxiang and Jiujiang were merged with Fangda Steel at the end of 2012

(3) RIVA Fire Group was split into ILVA SpA and Riva Forni Electtrici SpA in June 2013

Notes on company ownershp and tonnage calculations:

For worldsteel members, the data was sourced from the official tonnage declaration.

For Chinese companies, the official CISA tonnage publication was used.

In cases of more than 50% ownership, 100% of the subsidiary's tonnage is included. In cases of 30%-50% ownership, pro-rata tonnage is included. Unless otherwise specified, less than 30% ownership is considered a minority interest and therefore not included.

Available online: http://www.worldsteel.org/dms/internetDocumentList/downloads/statistics/2012-2013-Top-50-steel-producing-companies-and-rank/document/2012-2013%20Top%2050%20steel-producing%20companies%20and%20rank.pdf

Annex 5 – Script for the interviews in the first stage of the research

Guião das entrevistas - TÓPICOS	
Conceito de risco	Do ponto de vista do SCM, o que é o risco para a empresa?
Fontes e tipos de risco	Principais fontes de risco
Percepção/contemplação do risco	Principais tipos de riscos a que a empresa está exposta
	Exposição as diferentes tipos de riscos do ponto de vista do grau de probabilidade de ocorrência
	Do ponto de vista do impacto nos resultados da empresa
Relações com fornecedores	Estão identificados e são "monitorizados" indicadores de risco dos fornecedores
	Análise dos riscos da cadeia de abastecimento em conjunto com os fornecedores
	Variação do número médio de fornecedores em função do tipo de produto (estratégico/ bottleneck, etc)
	Variação do número médio de fornecedores em função do tipo de relação
	Variação do grau de exposição ao risco com o tipo de relação com o fornecedor
	Proximidade/Dependência/Poder negocial
	Papel SLAs na partilha/transferência do risco
Diferentes estratégias	Estratégias de mitigação do riscos utilizadas
Gestão do Risco / Desempenho	A eficiência na gestão do risco da SC na avaliação do desempenho
Incoterms utilizados	Incoterms habitualmente utilizados
Escolha	Decisão do Fornecedor/da Empresa/Negociados
Critérios de decisão	Critérios de selecção
	Relevância do controlo sobre a operação
	Relevância da escala, do poder negocial

Annex 6 – Script for the interviews in the second stage of the research

	Fase	Conteúdo	Assunto	Aspectos a focar
Aspectos relativos à gestão da cadei ade abastecimento	Abertura	Apresentação	**Apresentação (MP)**	
			Objecto do estudo e objectivo visado	
			Confidencialidade e permissão para gravação	
			Apresentação do entrevistado (breve resumo curricular)	
	Empresa	Caracterização do sector e do mercado		Característas genéricas do mercado do aço
				Características da empresa
		Estrutura da empresa		Enquadramento da função compras na organização
	Compras	Planeamento das compras	**Articulação funcional área financeira, comercial, logística, compras**	Articulação funcional
			Spend analysis e sourcing	Peso relativo do aço
				Grau de criticidade do aço
				Posição da empresa no mercado do aço (A quem compra; tipo de fornecedor; descrição da relação com fornecedores)
	Risco SCM do Aço	Identificação do risco	**Fontes e tipos de risco - Aço**	Principais fontes de risco na gestão da cadeia de abastecimeto do aço
				Principais tipos de riscos a que a empresa está exposta no caso do aço
			Graduação dos riscos - Aço	Percepção do grau de probabilidade de ocorrência dos diferentes riscos mais importantes
				Percepçao do impacto nos resultados da empresa
			Percepção/contemplação do risco	Identificaçao e monitorizaçao de indicadores de risco
				Analise de risco conjunta
	Mitigação dos Riscos	Estratégias de mitigação dos riscos	**Relações com fornecedores**	Numero de fornecedores de aço
				Principais critérios de selecção/avaliação dos fornecedores
				Relaçao de média/longa duração ou compra (se não estiver já referido)
			Diferentes estratégias	Descrever estratégias uitlizadas na gestao dos riscos identificados
			Graduação das estratégias	Planos de contingência no caso do Aço
			Eventuais planos de contingência	Gestão do risco da SC vs. avaliação do desempenho
			Gestão do Risco e avaliação do desempenho	Relaçao eficiência na gestão do risco da SC vs KPIs da funçao Compra de Aço
Aspectos relativos à contratação, pagamento, transporte, seguros	Contratação	Incoterms - Prática implementada	**Incoterms utilizados**	Incoterms habitualmente utilizados
			Escolha	Processo de adopção
			Titularidade da decisão	Decisão interna de adequação
				Critérios de selecção (relevo do risco)
			Articulação Compras/Logística/ Dep. Financeiro na decisão	Existe articulação entre diferentes departamentos na decisão de adopção do Incoterm?
		Pagamentos	**Formas de pagamento**	Formas utilizadas e articulação com diferentes aspectos...
		Seguros		(Se relevante)
Check-list verificação riscos				Check-list final (base: lista de risk events de Manuj and Mentzer, 2008b)
				Verificação da relevância do Commodity Price Risk