Supply Chain Risk Management Game

- the design, construction, testing and evaluation of a serious game that facilitates learning about Supply Chain Risk Management -

M.Sc. Thesis

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我听见 我忘记; 我看见 我记住; 我做 我了解。

I hear and I forget...
I see and I remember…
I act and I understand...

Confucius. *Chinese Social Philosopher.* (551 B.C. – 479 B.C.)

We are much more likely to act our way into new ways of thinking than to think our way into new ways of acting.

Karl Weick. *Psychologist*.

We can certainly distinguish between play and the attitude of the player.
For the player play is not serious: that is why he plays.
Play itself contains its own, even scared, seriousness.
Play fulfils its purpose only if the player loses himself in play.
Only seriousness in playing makes the play wholly play.
One who doesn't take the game seriously is a spoilsport.
The players are not the subjects of play; instead play merely reaches presentation through the players.
The most original sense of playing is the medial one.
All playing is a being-played.
The attraction of a game, the fascination it exerts, consists precisely in the fact that the game tends to master the players.

Hans-Georg Gadamer in 'Truth and method' (1989). *Philosopher*. (†13-3-2002)

Deloitte.

Enterprise Risk Services

The Enterprise Risk Services (ERS, or Risk Consulting) practices at Deloitte member firms worldwide help clients manage risk and uncertainty, from the boardroom to the network. Through these member firms, Deloitte professionals provide a broad array of services that allow clients around the globe to better measure, manage and control risk to enhance the reliability of systems and processes throughout the enterprise.

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Preface

Risks in large and complex infrastructures, such as global supply chains, have transformed our world during the last decade(s). The focus in this thesis is on the design of a serious game to educate (future) managers about Supply Chain Risks and subsequent Managerial issues. The main challenge has been to identify a number of complex issues, dynamics and trade-offs that occur in real-life supply networks, and, to incorporate these topics in a Serious Game. This report contains many considerations I had during the actual game design process. The final result is the Supply Chain Risk Management Game, which is a playable game.

This thesis is the result of my Master Thesis Project for the master Systems Engineering, Policy and Management. The project has been conducted between September and April 2009 at Deloitte Enterprise Risk Services. Conducting this project at Deloitte has been fun, interesting and motivating.

Several people contributed to the project and the final result. I would like to thank everybody for their help and time allocated to my project. First of all I would like to thank all members of the graduation committee: Prof. Dr. G.P. van Wee, Ir. M.W. Ludema, Dr. Ir. S.A. Meijer, Drs. P. Weel and Ir. D. Janmaat. They have helped getting and keeping me on the right track. I hope your enthusiasm and constructive comments are reflected in this report.

Furthermore, I would like to thank the TPM students that participated in a game session and the colleagues at Deloitte for their help, ideas and the time allocated for the interviews. I want to thank M. van Zwam *(partner Deloitte)* for providing the green light for my internship and introducing me to the Energy, Utilities and Infrastructures team.

Finally, I would like to thank my friends and family for their support throughout my study.

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Rob Kuijpers

Alkmaar, 26 June 2009.

All remaining errors are my own.

Summary

Risks in large and complex infrastructures, such as (global) supply chains, have transformed our world during the last decade(s). The focus of this thesis is on the design of a serious game to educate (future) managers about Supply Chain Risks and subsequent managerial issues. The main challenge has been to identify a number of complex issues, dynamics and trade-offs that occur in real-life supply networks, and, to incorporate these topics in a Serious Game.

There are four main reasons to pursue this project; 1) the observation of increased risk exposure in today's complex supply chains due to trends such as globalization, integration, sourcing from and outsourcing to Low Cost Countries and an increased focus on cost-reduction, 2) managers indicating that their organization pays too little attention to risk management 3) a further understanding of risk in the supply chain, will enable (future) managers to control risks effectively and efficiently, and -*partly based on the first three reasons*- 4) the Client of the game, Deloitte, has identified several distinct activities to which the game session could 'add value'. For instance, a game session can be an easy accessible way to introduce organisations, departments or teams to Supply Chain and/or Risk Management practices. Furthermore, internal and external training opportunities exist.

This thesis describes the design process of a serious game that facilitates learning about the key concepts of Supply Chain Risk Management (SCRM). The game design process consists of several activities, such as 'design', 'construction', 'testing' and 'evaluation' (Duke 1981). The key concepts include both the theoretical background as well as practical issues managers face when dealing with risks. The game is titled 'Supply Chain Risk Management Game' (SCRMG).

The central research question addressed in this thesis is: '*How well can key concepts of Supply Chain Risk Management be learned through participating in the game session?*'

The research question was answered after having designed, constructed, tested and evaluated the SCRMG. The final design consists of an introduction, actual game-play, and a debriefing. A serious game, such as the SCRMG, is played during a game session. The game session is an event that has three major inputs, the design of the SCRMG, the 'load' (value of parameters), and the 'situation' (i.e. location, number of participants). During the game session participants gain experience.

It is obvious there is a 'make-problem'; the creation of a serious game that did not exist before. To answer the research question the main design objective is formulated as; '*Design and develop a serious game that facilitates learning about the key concepts of Supply Chain Risk Management'.*

The SCRMG includes the following six topics important topics of Supply Chain Risk Management (SCRM);

1) the theoretical background of SCRM,
2) different types of risk (internal, supply, demand & external risks) ,
3) the risk management approach,
4) risk management strategies,
5) the need for collaboration and coordination in supply chains, and
6) the need to manage risk *pro-actively* (instead of *passively*).

Six learning goals of the new educational tool are derived from these six topics. The end result of reaching these learning goals is that participants develop a holistic perspective on Supply Chain Risks and subsequent management issues. The result may be interpreted alternatively as an 'increase in risk

awareness'. Within Supply Chain Risk Management literature, it is believed that an increase in risk awareness enables people and organizations to manage risk more efficient and effective.

A serious game is the learning tool of choice because 'reciprocal interdependency' that exists in real-life supply chains or networks can be simulated through interactive play between players. Furthermore, serious gaming can provide a valuable educational experience, especially to 'Generation Y'. This generation prefers a 'trial and error approach' for learning and expects to be entertained during the learning exercise.

Several actors are included in the SCRMG to simulate a supply network. The participants of the game session take on the role of a farm, processing company or a supermarket. The context of the SCRMG is the European meat sector. The goal and challenge of these actors is to maximize profits while (and through) minimizing risk exposure for the benefit of the whole supply chain. The participants have multiple options to manage risk.

The focus of the game is on 'risk arising from disruptions to normal activities'. For that purpose, the author has defined Supply Chain Disruption Risk Management as: '*the process of systematically identifying, analyzing and dealing with disruption risks to supply chains, through coordination or collaboration among the supply chain partners, to decrease supply chain vulnerability and increase supply chain resilience, so as to ensure profitability and continuity for the whole supply chain.*

In order to answer the research question, an instrument has been developed to test and measure the performance of the game session. This performance reflects the educational value of the game session.

The research methods used to fulfil the main design objective and to subsequently answer the central research question are desk research in the form of a literature review, six interviews and test activities to improve the design.

The SCRMG has been designed using the game design method of Duke (1981). This method consists of four phases: the 'initiation', 'design', 'construction' and 'use' phase. In the initiation phase, the domain of Supply Chain Risk Management has been studied and interviews have been conducted to identify design requirements. Furthermore, existing Supply Chain Management Games have been evaluated to gain inspiration for the design phase and to ensure the to-be-designed game is unique.

The 'theoretical viewpoints' used to conduct the study (and to construct the game) are insights gained from Normal Accident Theory, High Reliability Theory, Transaction Cost Analysis, Supply Chain Management, Risk Management, Supply Chain Risk Management and Network Management.

In the 'design phase' a conceptual design of the game has been created based upon the design requirements. After extensive discussions about the conceptual design, the construction phase began.

The 'construction phase' consisted of an iterative and creative process of construction, testing and evaluation. During this process, the conceptual design of the game has been worked out into a final design. The final design of the Supply Chain Risk Management Game is a combination of a role-playing and a board game. In the game, players have to pro-actively manage risk and collaborate with supply chain partners in order to sustain profits for their companies.

The final design of the game has been evaluated during a two-hour game session with nine Bachelor-level students. A questionnaire based on –*inter alia*- the six learning goals has been developed to measure 'self-reported' learning effects. The questionnaire was completed by the participants (N=9).

Results indicate that 14 out of 15 propositions are rated on the 'positive side' of the 7-point ordered response (*Likert*) scale. Further, qualitative data gathered in a game session report indicates that there is much interaction between players in the game and there are few *structural* flaws in the design of the SCRMG.

Based on both quantitative and qualitative data gathered in one 'official' game session and several other test activities, the answer to the central research question is:

There are strong indications that the key concepts of SCRM can be learned through participating in the game session. More game sessions –with different audiences- can be beneficial in order to further improve the design, and to gather more qualitative and quantitative data to support our indications.

A limitation of this research effort is that the effectiveness –in terms of learning- of the designed artefact cannot be *proven*; as participants themselves are part of the learning experience and the concept of learning is 'immeasurable' and 'intangible'.

Several recommendations for future use of the SCRMG by Deloitte have been formulated. The SCRMG should be customized to meet the demand of different target audiences, such as students (for recruitment activities) or (young) professionals for internal or external training purposes. The SCRMG is designed for 'adaptability' and is suited for flexible use in terms of the duration, number of participants and the type and variety of Supply Chain Risks.

The final design is a playable game but can be used to construct new games in which another sector can be simulated. Several criteria to transfer the SCRMG to other sectors have been identified. It is possible to transfer the SCRMG to other sectors. Finally, two suggestions for future research concerning the development of more comprehensive models to analyze Risk in Supply Chains are formulated.

Contents

1. A serious game to facilitate learning about Supply Chain Risk Management

1.1 Introduction

"Managing today's multi-actor systems, such as supply chains [...] is becoming an increasingly challenging task given the developments in the markets, most prominently globalization [...] (van Houten 2007, p. 1)". "*The greater the uncertainties in supply and demand, globalisation of the market, shorter and shorter product and technology life cycles, and the increased use of manufacturing, distribution and logistics partners resulting in complex international supply network relationships, have led to higher exposure to risks in the supply chain* (Christopher & Lee 2004, p. 1)."

Today's supply chain managers are faced with an increasing challenging task of managing risk in their supply chains. As Hammant and Braithwaith (2004, p. 1) put it: "With supply chain networks becoming ever more global and complex, risk and contingency planning is not simple." "Supply chain Risk Management (SCRM) is the process of systematically identifying, analyzing and dealing with risks to supply chains (Waters 2008, p. 76)". A supply chain or supply network is a multi-actor system, recognized in the following definition of the supply chain (Christopher 1998):
"*The supply chain is the network of organisations that are linked through upstream and downstream relationships in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer.*"

"Multiple tools exist to support managers in gaining more insight into these kind of systems, such as simulation models or case-studies (van Houten 2007, p. 1)." Serious games are another tool that can be used to support learning about complex systems, such as supply chains, or other types of infrastructures (Mayer & Veeneman 2002). Geurts, Duke and Vermeulen (2007, p. 544) report that: "Games are effective at conveying the totality of a model and the dynamics of a system."

To educate (future) managers on the key concepts[1] of Supply Chain Risk Management – an interactive learning method is to be preferred above a traditional learning method, like textbooks, case studies and traditional lectures (Qualters *et al*. 2006, p. 2). This can be considered a knowledge gap, a gap exist between traditional learning methods and desired ones.

Serious games[2] are able to learn people about logistic networks, and are especially suited to Generation Y[3] / Millennial Generation (Mehring 2000; Qualters *et al*. 2006), because they prefer 'a trial and error approach' for learning. As Hofstede (2006, p. 544) states about 'simulated netchains'; "*Although such simulation games are necessarily simplifications, their crucial message usually comes*

[1] The term *key concepts* is taken over from Hobbs (1996, p. 17). The author uses this term to describe "ideas that underpin a scientific research area". In the same way we will use the term 'key concepts' throughout this thesis to describe the ideas that underpin Supply Chain Risk Management. In addition to this, for several reasons, we will include the practical management issues also in this term. Practical issues are for example 'limited time' and 'limited budgets'.

[2] Also used terms in literature: 'gaming simulation', 'professional games', 'management games', 'business games', 'business simulation game', 'simulated netchains', 'management flight simulator' and 'simulation games'. In this thesis we will be using the term 'serious game' to describe type of game to be designed.

[3] People born between 1978 and 1995. Generation Y is the generation after Generation X (1964-1978) (Pham *et al.* 2008; Van Dam 2007). Sometimes referred to as the 'Google Generation'.

across well. This message is that 'the netchain as a whole is potentially a viable level at which to think of organizing'".

Within Deloitte –a global (risk) consulting Enterprise- there is considerable activity in serious gaming. Several games have been designed and are currently used to introduce students, employees and clients to specific areas of expertise (Deloitte 2008a; 2008b). For the emerging area of Supply Chain Risk Management, a serious game does not exist and needs to be developed to fill the knowledge gap and to expand Deloitte's 'risk awareness training' Service Offerings. Similarly, Summers (2004) reports that new business practices increase the demand for new business games.

In this thesis we will argue to our challenge is to design, construct, test and evaluate a serious game to educate (future) managers about Supply Chain Risk Management (SCRM). As will become apparent throughout this thesis, we support the idea that the challenge is to get the complexity, dynamics and trade-offs concerning supply chain risks and subsequent management issues into the minds of (future) managers using a serious game.

In the next paragraphs the problem is further described by discussing several aspects relating to Supply Chain Management, Risk Management and Serious Gaming.

We discuss the academic and business relevance of Supply Chain Risk Management in §1.2. We then will introduce several issues that 'add to complexity' when managing risk in a supply chain context in §1.3. Theoretical viewpoints on Supply Chain Risk Management are the topic of §1.4. We then discuss high-level strategies to manage risk in §1.5. The need for 'risk awareness' is discussed in §1.6. Knowledge exchange is treated in §1.7. §1.8 builds upon all previous paragraphs and introduces the goal of this project. Then the learning goals of the game are formulated in §1.9. The in- and outputs of a game session are presented in §1.10. The key reasons to pursue the project are summarized in §1.11.

We conclude this chapter with an overview of the thesis structure.

1.2 Relevance of Supply Chain Risk Management

Managers state that their organization has too little attention for risk management and lack formal procedures about the topic, while at the same time studies show managers think that their supply chain is becoming more vulnerable to risks in the future, than it was in the past (Aberdeen Group 2008, McKinsey 2006). Almost two third (65%) of the 3000 executives surveyed stated that the risk to supply their customers with goods cost-effectively has increased during the 2001-2006 period (McKinsey 2006). Next to the business relevance of Supply Chain Risk Management, universities around the world increase their attention to risk-related research.

"*At an academic level there has emerged a growing body of research into risk from a number of different perspectives, for example: economics, finance, strategic management and international management* (Jüttner 2005, p. 121)." Peck (2006 p. 127) reports: "[...] *this once obscure area has attracted considerable attention from academics and consultants around the world*". As Jüttner (2005) puts it: "*Although awareness is increasing among practitioners, the concepts of supply chain vulnerability and its managerial counterpart Supply Chain Risk Management are still in their infancy*"

While the ability to manage risk effectively is critical to ensure a smooth flow of product through the supply chain, this area has only recently received attention in supply chain research (Jüttner *et al*. 2003 (as cited by Blackhurst *et al*. 2008, p. 144)). Zsidisin (2003, p. 217) reports that "*there is little understanding of what risk means within a supply management context, although a few scholars have begun to address the issue*".

Increased Risk Exposure
Drivers of the increased 'risk exposure' are the trend of globalization, outsourcing to, and sourcing from Low Cost Countries, the adoption of Just in Time (JIT) practices (less safety stock), more information sharing and 'single sourcing' strategies (Waters 2008). These strategies focus upon decreasing Total Costs, but they simultaneously increase risk exposure (Peck 2005, p. 217; Waters 2008; Jüttner 2005). "*Well-tried responses are holding safety stock to avoid risks to material flow, using multiple sourcing to overcome risks from suppliers, having spare capacity to avoid risks to operations, using long lead times to overcome variable demand, and so on* (Waters 2008, p. 16)" (also: Blackhurst *et al.* 2008; Christopher & Lee 2004, p. 1). But the difficulty -*from a business perspective*- is that, "these methods of avoiding risks often increase costs and reduce efficiency (Waters 2008, p. 16)". Furthermore, such measures are less attractive, with an increased focus on agility and responsiveness (Zsidisin *et al.* 2005).

Next to the above mentioned fundamental trade-off between costs and risk exposure, other problems from the field of Supply Chain Risk Management are mentioned in scientific literature. The main problem follows from the fact that traditional risk management focuses on internal control, whereas Supply Chain Risk Management should involve all actors in order to be effective. "Traditional risk management approaches derived from a single company perspective are not ideally suited to accommodate the requirements in a supply chain context (Jüttner 2005)." This implies several issues which are further described in the next paragraphs.

SCRM is not a fully developed scientific research field, but can be characterized as an emerging 'body of knowledge'. It is often described by researchers by an overview of best practices, 'common themes' (Handfield *et al.* 2006), to-do lists or 'general principles' (Kleindorfer & Saad 2005). The quantitative definition of risk is: risk = chance * impact (*for instance* Knemeyer *et al.* 2008). Risk Management can thus focus on reducing the chance of risk or reducing the impact of risk.

1.3 Issues that 'add to complexity'

One of the most important general principles is the trade-off between costs and risk exposure (Peck 2005, p. 217; Waters 2008; Jüttner 2005). Another important issue that adds to the complexity of multi actor risk management is the 'silo approach'. This means that Risk Management is spread among functional silo's (or spread along organizations in the supply chain), and each actor/silo optimizes their own risk management process. The result is sub-optimal overall supply chain performance. The frequently suggested solution is coordination and collaboration, in order to achieve optimal performance.

Furthermore, the presence of '*interdependency'* in networks -organizations depend on each other in networks (de Bruijn & ten Heuvelhof 2004, p. 41) - is often mentioned as a complex issue when dealing with risks in a network situation. Lazzarini, Chaddad and Cook (2001, p. 1) introduce the

concept of "netchain analysis": Netchain analysis interprets supply chain and network perspectives on inter-organisational collaboration with particular emphasis on the value creating and coordination mechanism sources. They "*posit that sources of value and coordination mechanisms correspond to particular and distinct types of interdependencies: pooled, sequential, and reciprocal. It is further argued that the recognition and accounting of these simultaneous interdependencies is crucial for a more advanced understanding of complex inter-organisational relations (ibid.).*"

The type of interdependence in supply chains can be characterized –*in our supply chain perspective towards risk*- as 'reciprocal'; "the input-output exchange can move in both directions" (Skipper *et al*. 2008). According to Jüttner (2005), supply chain risks can manifest in two directions along the chain, and can therefore be separated in 'supply-' and 'demand risks'. Supply risks influence the downstream node and demand risks influence the upstream node. In this conceptual perspective, the flows in the network consist of risks. These risks can relate to tangible (products, materials) or intangible flows (information, money) in the network. When dependency between companies increases, they become more exposed to the risks of other companies (Hallikas *et al*. 2004), because risks are shared and transferred. Another complex issue from the field of risk management are problems with quantifying the probability and impact of a risk, due to limited or incomplete information.

1.4 Theoretical viewpoints

Several principles of theories may provide a further understanding about Supply Chain Risk Management. In this paragraph their relevance is explained by the main line of thought.

Normal Accident Theory: "accidents are inevitable in complex, tightly-coupled technological systems (Rijpma 1997)". Therefore, Perrow (1999) calls these accidents 'normal'. In similar lines, Craighead *et al*. (2007, p. 131) argue that: "supply chain disruptions are unavoidable and, as a consequence, that all supply chains are inherently risky." Instead of accepting that accidents are inevitable, **High Reliability Theory** states that organizations can become 'High Reliability Organizations' by organizational learning and the creation of 'collective mindfulness' (Weick *et al.* 2002, p. 8). Amongst other principles, HRO's use redundancy to back up failing parts and persons (Rijpma 1997). Zsidisin *et al.* (2004) state a theoretical foundation for SCRM is '**Agency Theory'**, which studies the principal – agent relation. "In the buyer-supplier relationship, the purchasing organization serves as the principal and the supplier as the agent". Finally, from New Institutional Economics literature, **Transaction Cost Analysis** is mentioned by Hobbs (1996, p. 16) as "one possible approach to understanding and evaluating supply chain management". TCA recognizes four types (or sources) of transaction costs: searching, bargaining, monitoring and enforcing costs (Williamson 1985). These costs are relevant when managing risk in networks. The choice between certain (risk reducing) alternatives, is explained by (expected) **Utility Theory** (Friedman 1948).

These theories can provide more insight into Supply Chain Risk Management. The terminology differs amongst these theories. The terms used are 'unavoidable system accidents', 'failures' and 'risk'. Using the assumptions underlying these theories, it seems to be valid to apply these theories to SCRM, as other researchers did (*for instance* Kleindorfer & Saad 2005; Marley 2006; Peck 2005; Wagner & Bode 2006).

1.5 Risk Management strategies

To handle all sorts of risk, four main strategies are distinguished. The traditional reaction of lots of managers and companies is to *avoid* risk. Risk is perceived to be a bad thing and must be mitigated. This approach can be characterized as: risk averse. Next to avoid, the three other (high-abstraction-level) strategies are *accept*, *share* and *transfer* (Hallikas *et al*. 2004). The strategies of players to mitigate risk in the game can be based on these four main strategies. More strategies can be distinguished on a lower abstraction level.

In this thesis, we will be using the term 'risk' to refer to a variety of phenomena. Ritchie and Brindley (2007, p. 305) have studied numerous definitions of risks and conclude that most definitions of risks have three dimensions in common;

1) *likelihood of occurrence of a particular event or outcome*
2) *consequences of the particular event or outcome occurring; and*
3) *causal pathway leading to the event*

Throughout this thesis we will be using the term 'risk' to refer to a phenomenon that includes these three dimensions. Other terms, such as 'accidents', 'failures', 'loss', 'disruption' and 'uncertainty' can all be characterized as a 'special case of the risk construct (*ibid*.)', if we can distinguish the three dimensions as suggested by Ritchie and Brindley (*ibid.*). *"The terms risk and uncertainty are frequently used interchangeably, as typically risk contexts are often somewhere in the middle of the risk-uncertainty spectrum (i.e. neither pure risk taking nor complete uncertainty) (ibid.)."* In similar lines, Alberts (2006, p. 6) suggest four elements of risk (Figure 1). Although Alberts *(ibid.)* uses different terms as Ritchie and Brindley (2007), the author distinguishes the same dimensions of risk.

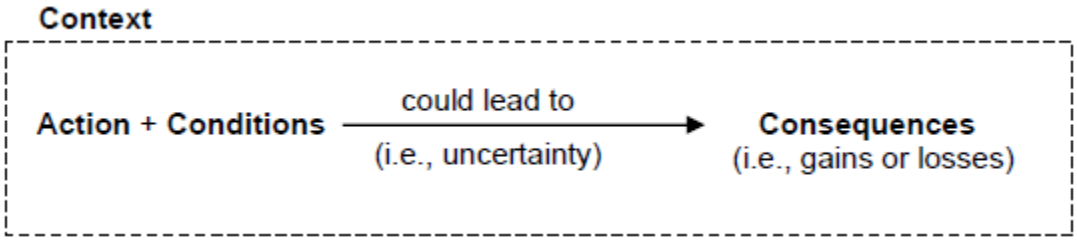


Figure 1: The four elements of risk (Alberts 2006, p. 6)

Alberts (2006) considers the 'context' as an element of risk. For SCRM, the context is a supply chain context. The 'actions and conditions 'could lead to' 'consequences'. A definition of risk is provided by Deloitte (2006): "Risk is the potential for loss or diminished opportunity for gain caused by factors that can adversely affect the achievement of a company's objectives." Alberts (2006) illustrates (Figure 1) that risk is about cause and effect and that the consequences can be 'gains'.

1.6 Need for risk-awareness

Organizations can become successful in managing risk by training their employees, hereby creating 'risk awareness' and a 'risk culture'. The following terms illustrate this; 'The learning organization as manager of risk (Faculty of Technology Policy & Management 2008)', 'Risk intelligent Enterprises (Deloitte 2006)'. Sheffi (2005, p. 244) reports two reasons why some companies manage 'the

unexpected' well, and others not. The first one is a 'superior supply chain design'. The second reason relates to the people working in the chain and the organizational culture, "*The essence of resilience is the containment of disruption and recovery from it. Culture contributes to resilience by endowing employees with a set of principles regarding the proper response when the unexpected does occur, and when the formal organization's policy does not cover the situation at hand or is too slow to react.*" According to the 'Risk Intelligence Framework' (Deloitte 2008c, see Appendix A: Risk Intelligence Framework), risk management is based on four pillars: 'process, technology, governance and/or **people**'.

In order manage risk, employees need to be risk aware, which makes them react proactively towards risk, instead of a traditional, reactive approach towards risk. A reactive approach can be explained by the fact that managers take decisions "on the basis of normal conditions" and "risky events are, by definition, rare" (Waters 2008, p. 15). Training employees (by means of a serious game) is a 'bottom-up' risk management strategy.

1.7 Serious Games for Learning

Players learn from a serious game through 'experiential learning (Kolb 1984)'; learn by observation, active experimentation and conceptualization. "*This approach is well suited to study supply chains since it has been used successfully to develop a systems view, develop problem solving skills, and to practice integrating and synthesizing concepts. The instructor is a guide, who provides context, poses problems, suggests analyses, scores solutions, and summarizes lessons* (Mehring 2000, p. 1)." The complexity of supply chains can be understood by experiential / experimental learning (Hofstede 2006; Mehring 2000). Mayer and Veeneman (2002, p. 2) report: "*In all simulation-games it is assumed that the management and design of these infrastructures goes far beyond mono-disciplinary approaches".* Geurts, Duke and Vermeulen (2007, p. 544) report that: "Games are effective at conveying the totality of a model and the dynamics of a system". Games are good educational tools to develop a holistic/'systems thinking' perspective. van Houten (2007) reports that business games can be used to 'raise awareness'. A game is a "simplification and condensation of the real system (Mayer & Veeneman 2002, p. 3)".

To our knowledge, a serious game specifically aimed at risk management in supply chains does not exist.

1.8 Goal of the project

Based on the above mentioned *key concepts*, consultation of relevant literature and interviews with Deloitte employees (see Appendix G: Interview outline and interview reports), the goal of the project is formulated;

> ***The goal of this project is to design, construct, test and evaluate a serious game that facilitates learning about the key concepts of Supply Chain Risk Management***

Based on the goal of the project, the artefact that is designed and developed is titled: **Supply Chain Risk Management Game**. This title reflects the topic and the final outcome of the design and development process: a serious game in that belongs to a family of Supply Chain Management

Games, specifically aimed at risk management (Risk Management is regarded as a special topic of Supply Chain Management).

The three elements of the Supply Chain Risk Management Game (SCRMG) – are: (1) an introduction, (2) actually playing a game, and (3) a debriefing (see Figure 2).

Figure 2: Elements of the Supply Chain Risk Management Game

The 'introduction', 'playing game' and the 'debriefing' each consist of different elements that need to be designed, constructed, tested and evaluated. In the introduction, the participants are introduced to the task at hand. In the 'playing game' element of the SCRMG are actively using game materials and are playing the game. In the 'debriefing' element participants reflect on their experiences.

1.9 Learning goals of the Supply Chain Risk Management Game

Based on the insights gained in this first chapter, the SCRMG must incorporate six topics that will be included in the game session. The learning goals will be adjusted, if insights gained throughout this project require so. The final learning goals are based on six general topics and are specified as; "Participants of the game session reach (a further) understanding about…

1) the theoretical background of SCRM;
2) different types of risk;
3) the risk management approach in a network situation;
4) risk management strategies;
5) the need for collaboration and coordination in supply networks;
6) the need to manage risk pro-active (instead of passive).

The result of reaching these six learning goals is that people develop a holistic perspective on Supply Chain Risks and the subsequent management issues. The end result can be alternatively interpreted as a 'raise of risk awareness'. The learning goals have implications for the design and construction of the Supply Chain Risk Management Game. For example, players should achieve better results if they manage risk *pro-active* instead of *passive*.

1.10 In- and output of a Game Session

A serious game, such as the Supply Chain Risk Management Game, is played in a 'game session'. A game session is an event that has two important inputs: (1) the Supply Chain Risk Management Game, and (2) Participants (without experience). During the game session, participants[4] are

[4] Throughout this thesis, the people that attend a game session are referred to as 'participants'. Only in the second element of the SCRMG, they are actually playing and could be referred to as 'players'.

introduced to the task at hand, play the game and reflect on the outcomes. They thus develop 'experience'. The output of the game session is 'participants with experience'. The in- and output of the game session are visualized below in Figure 3.

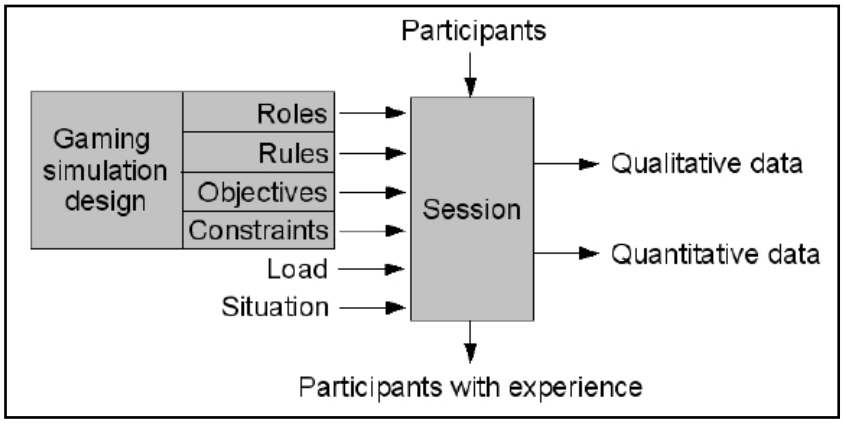


Figure 3: In- and output of a game session (Meijer 2009, p. 27)

The 'gaming simulation design' (of the SCRMG) consists of the roles, rules, objectives and constraints. Other input to a game session is the 'load' and 'situation'. A game session yield both qualitative and quantitative data. The data can be used to test and evaluate the gaming simulation design. These topics will be extensively addressed in all remaining Chapters of this thesis.

1.11 Key reasons to pursue the project

In all previous paragraphs, reasons to pursue this project have been formulated. To conclude this Chapter, these (and other) reasons are listed.

- Serious games have considerable success in the field of logistics, since 1960 (Sterman (1989).
- A serious game about Supply Chain Risk Management is better suited to Generation Y than traditional learning methods.
- The complexity of supply chains can be understood by experiential / experimental learning (Hofstede 2006; Mehring 2000).
- To our knowledge, a serious game with the explicit purpose to facilitate learning about the key concepts of Supply Chain Risk Management does not exist.
- Supply Chain Risk Management is a multi-disciplinary body of knowledge and integrates knowledge from the field of risk management, supply chain management, statistics and decisions sciences.
- It is believed that a further understanding of risk in the supply chain will enable (future) managers to control risks effectively and efficiently.
- SCRM is emerging and is its importance is recognized by both academics and practitioners
- According to Deloitte (2008c), 'People' are one of the four pillars of risk management (see Appendix A: Risk Intelligence Framework).
- "Supply chain disruption announcements are associated with an abnormal decrease in shareholder value of 10.28% (Hendricks & Singhal 2008)".
- *"A game can serve as an opportunity to share knowledge within a group of representatives from different organizations and Deloitte professionals. It is an opportunity to show expertise. The game should start discussion." Interviewee #5, see Appendix G.*

Now the reasons to pursue this project have been summarized, the structure of this thesis will be presented in the next paragraph.

1.12 Thesis structure

In this paragraph the structure of the thesis with a brief description of the content of the Chapters is presented.

In this Chapter the problem has been introduced, explored and delineated through the formulation of the goal of this project and learning goals of the SCRMG. In Chapter 2, the design objectives and research question are introduced. The research methods and data sources are discussed. Chapter 2 concludes with the design approach. A literature review on the domain of Supply Chain Risk Management and Serious gaming will be presented in Chapter 3.

In Chapter 4, the design method and the design process will be further elaborated upon. We will evaluate the Supply Chain Risk Management Game in Chapter 5.

Concluding, in Chapter 6 the conclusions from this research and design effort are presented. Then, the main limitations are discussed and recommendations are formulated (§6.3). Concluding this thesis, we will critically reflect upon the result and we will provide recommendations. The structure of this thesis is presented in Figure 4.

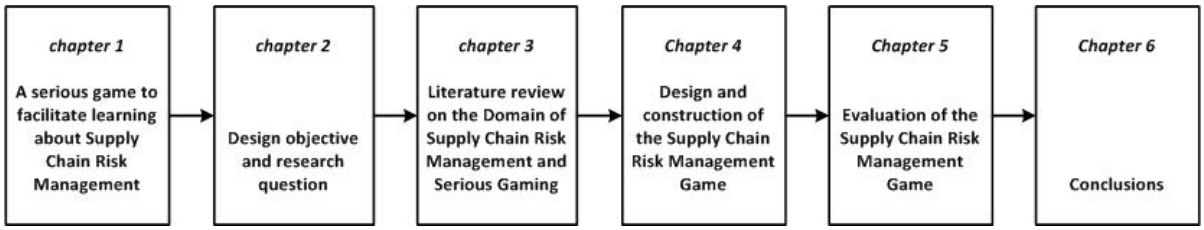


Figure 4: Thesis structure

Throughout this thesis, the focus on research and design are intertwined (see Figure 4). We will conduct the research from a 'design perspective'. In contrary, we will design the SCRMG from a 'research perspective'. Especially in Chapter 3, the research and design part are intertwined. In chapter 3, the input for the design requirements is formulated based upon the insights gained in the literature review. Both the research and design part contribute to the 'design, construction, testing and evaluation' of the Supply Chain Risk Management Game.

In this Chapter the problem has been introduced and several aspects of Supply Chain Risk Management and Serious Gaming have been addressed. The goal of the project has been formulated and the learning goals for the SCRMG have been determined. The design objectives and research questions are the topic of the next Chapter.

2. Design objective and research question

In Chapter 1 the goal of this project has been specified as: 'The goal of this project is to design, construct, test and evaluate a serious game that facilitates learning about the key concepts of Supply Chain Risk Management'.

Chapter 1 has provided an overview of the issues in the area of Supply Chain Risk Management. The research has been focused on the exploration of the key concepts of SCRM and specifically the trade-off between costs and risk exposure. Based on the goal of the research project, formulated in the introduction, the design objectives and research questions are formulated. In this Chapter the design objective (§2.1), the research questions and research methods (§2.2), and the design approach (§2.3) will be discussed.

2.1 Design Objective

From the above formulated goal of the project, it is obvious there is a 'make-problem'. The design task that lies ahead is the creation of a serious game that did not exist before. Therefore, a main design objective is formulated for the 'artefact' that will be created. The design sub-objectives sprout out from the main design objective. Research sub-questions are formulated for all the things we need to know to understand the design problem and necessary activities.

Main design objective:

> **'*Design and develop a serious game, that facilitates learning about the key concepts of Supply Chain Risk Management*'**

A serious game needs an introduction and a debriefing. The introduction to the game is necessary to introduce people to the game they are going to play, the tasks they should perform and the problems they will face. The debriefing is the evaluation-phase, then the link between game-play and reality should be made, in order to meet the learning goals. This improves the 'educational value' of the game. Evaluation is an important method to train professionals. Finally, an instrument must be developed in order to measure the performance of the game; this enables us to answer the research question.

From the above follows the necessity to translate the main design objective into design sub-objectives.

Design sub-objectives (in sequential order):

1. Develop a list of requirements for the SCRMG
2. Develop a serious game that 'facilitates learning about the key concepts of SCRM'
2.1. Develop a player manual
2.2. Develop an introduction to the SCRMG
2.3. Develop a debriefing for the SCRMG
2.4 Develop a facilitator guide
3. Develop an instrument to measure the performance of the SCRMG

The research question can be answered, after developing, testing and evaluating the SCRMG. The following research question follows logically from the main design objective:

> ***How well can key concepts of Supply Chain Risk Management be learned through participating in the game session?***

To answer the research question, several research sub-questions are formulated. The research sub-questions relate to design sub-objectives. **The research sub-questions are:**

1. *What should be included in the introduction to the Supply Chain Risk Management Game?*
2. *What are the key concepts of Supply Chain Risk Management, and how can these concepts be included in the game?*

2.1 What is the theoretical background of Supply Chain Risk Management?

2.2 What are the key concepts of Supply Chain Disruption Risk Management?

2.3 How can the theoretical background and key concepts of Supply Chain Risk Management be included in the Supply Chain Risk Management Game?

2.4 In what way are risks incorporated in (a selection of) Supply Chain Management games?

3. *What should be included in the debriefing of the Supply Chain Risk Management Game?*
4. *How to measure the performance of the SCRMG?*

   4.1 What instrument can be developed to measure the performance of the Supply Chain Risk Management Game?

   4.2 Which performance measures should be included in this instrument?

The final answer to the research sub-questions and the research question will be presented in Chapter 6: Conclusions.

2.2 Research methods & data sources

Research sub-question 1: What should be included in the introduction to the Supply Chain Risk Management Game?

Desk research and interviews are the appropriate research methods to answer research sub-question 1. **Research sub-question 1 must be answered to fulfil design sub-objective 2.2.**

Relevant scientific publications are consulted to describe the theoretical foundations for Supply Chain Management and Risk Management (§3.1 of this thesis). A summary of the theoretical foundations can be included in the introduction to the game. In addition to this, the theories that form the theoretical foundation for SCRM can be included on a conceptual level in the game. For example, NAT states that accidents are inevitable (Perrow 1999). In the game this could be incorporated in the way that accidents will always occur, at some point in time. Transaction Costs Analysis (TCA) could be incorporated with the payment of negotiation expenses by the players. Further, the role of the players and their challenges are part of the introduction. Lastly, the reason why the participants are participating in the SCRMG must be explained. These reasons are likely to vary among different groups, and should be pointed out in each game session.

To ask specific questions about practical issues concerning Risk Management training, interviews with Supply Chain and Risk Management consultants will be conducted.

The main data sources are scientific publications regarding the theoretical constructs. Please note that the introduction cannot be completed before the playable part of the SCRMG is completed. Therefore, one can consider the game itself as an important data source for the introduction to the SCRMG. Kriz and Hense (2006, p. 278-279) define a "list of quality criteria of simulation games [...] based on gaming simulation research", that consists of fifty general quality criteria. These criteria can be used to ensure a certain level of quality of the introduction, before or after the actual design of the introduction.

Research sub-question 2: What are the key concepts of Supply Chain Risk Management, and how can these key concepts be included in the Supply Chain Risk Management Game?
Desk research and interviews are the appropriate research methods to answer research sub-question 2. **Research sub-question 2 must be answered to fulfil design sub-objective 2.**

The key concepts of SCRM can be included in one or more elements of the SCRMG (introduction, game and/or debriefing). Desk research (scientific publications) consisting of the evaluation of existing logistic and risk management games are used to 'translate' the theoretical background (§3.1 of this thesis) and key concepts of SCRM (see §3.2 & §3.3) to the list of requirements (related to design sub-objective 3, see Chapter 4 of this thesis) and finally to the actual construction of the game (reported in Chapter 4). The design steps are illustrated in the left side of 'Figure 5'. Furthermore, some characteristics of serious games make one game better than another (i.e. game flow, simplicity, interaction, goals, competition) and can be derived from literature and evaluation of existing games through evaluating the games (see §3.4). The key concepts are described in Chapter 3. Subsequently, these issues can be incorporated in the game.

Data sources
A limitation of this research method is the availability of the consultants for interviews. Especially during 'audit season' (closing of the financial year), consultants are busy and possibly limited available for interviews. Therefore, interviews will be planned in time and the total number of interviews should be kept low during 'audit season'.

The main data sources for the literature review of risk and supply chain management will be publications from the following authors; Christopher, Peck, Jüttner, Waters, Kleindorfer and Sheffi. These 'guru's' are members of The International Supply Chain Risk Management Network (ISCRIM). The practical management issues are derived from the book Supply Chain Risk Management (Waters 2008), in which the author illustrates a variety of managerial problems by several case studies. Examples from literature are used to describe the practical issues managers face.

Research sub-question 2.4: In what way are risks incorporated in (a selection of) Supply Chain Management games?
A selection of existing Supply Chain Management games will be evaluated (see paragraph 3.4) to answer research sub-question 2.4. **Research sub-question 2.4 must be answered to fulfil design sub-objective 1 and 2**. Actually playing these games is often impossible, because these games are available only in The United States (Shortfall, see Qualters *et al*. 2006), are relatively old (Siemens Brief Case Game Supply Chain simulator, see Mehring 2000) or are not played anytime soon (Ketensynchronisatie, Deloitte 2008a). In that case, published assessments or evaluation reports of

these games are useful information sources. In addition to this -in some cases- the game manual and instructions are published, this can be valuable data sources.

From the results of paragraph 3.4 a number of practical game options and ideas will be derived. A certain context/case for the game is derived from the requirements. The context must be chosen in such a way, that the game will be able to transfer the key concepts about SCRM and will reach the learning goals. Based on desk research, the following games (or publications on these games) seem interesting to evaluate; Shortfall (Qualters 2006), Siemens brief case game supply chain simulator (Mehring 2000), Ketensynchronisatie (Deloitte 2008a), Risk en Control game (Deloitte 2008b), Shampoo-Game[5] (Ludema 2008), Mango Chain Game (Zúñiga-Arias *et al*. 2007) and the role game CODEPRO (Korhonen *et al*. 2007).

As previously explained, the game design process of Duke (1981) will be used to design the game. The model distinguishes four phases during the design process, the initiation, design, construction, and use phase. The activities in these phases are not sequential; design is an iterative, creative and episodic process. The game design process is shown on the left side of 'Figure 5' (phases and activities). In Figure 5 the alignment of the game design process, thesis structure and research questions is presented. Duke (1981) did not include any feedback loops and the arrows have one direction. We could add several feedback loops to illustrate the (non-linear) character of the game design process. The feedback loops are left out of Figure 5 for readability purposes.

Research sub-question 3: What should be included in the debriefing of the Supply Chain Risk Management Game?

Research sub-question 3 must be answered to fulfil design sub-objective 2.3.
The debriefing of the SCRMG should be an interactive discussion between the participants and the facilitator(s). Some useful tips and tricks can be found in literature on gaming simulation (see §3.3). The actual debriefing after game sessions is partly based on the game session observations and the experiences, problems and lessons learned during the game play. Therefore, the debriefing shall be different in each game session, because different participants will participate. Each participant has a different educational and/or professional background and knowledge-level about Supply Chain Risk Management.

The main information source for the debriefing is the introduction and the game. In the debriefing phase, players are asked in what way they experienced the various key concepts of the game, which have been introduced to them during the introduction phase and in the game itself.

Furthermore, in the debriefing phase, discussion should be started, especially when the participants of the game session work in risk management or logistics. This discussion can be based the recognition of concepts from the game which are also experienced in the participants' day-to-day work situation.

The main data sources are the introduction, the game and literature on successful serious games. Please note that the debriefing cannot be completed before the game itself is completed. Therefore, one can consider the game itself as an important data source for the debriefing of the SCRMG. Kriz and Hense (2006, p. 278-279) define a "list of quality criteria of simulation games [...] based on

[5] Facilitated 13-11-2008 in Delft at Faculty TPM in course MOT 1600.

gaming simulation research", that consists of fifty general quality criteria. These criteria can be used to ensure a certain level of quality of the debriefing.

Research sub-question 4: How to measure the performance of the game session?

This question can be answered after reviewing current game evaluation methods, thus desk research is the appropriate research method. **Research sub-question 1 must be answered to fulfil design sub-objective 3.**

Inspiration for an instrument which measures performance of the game can be found in literature on the assessments of serious games. For this purpose, research sub-question 4.1 is formulated. It is possible to measure the educational value of a game session with a pre- and after knowledge questionnaire. This instrument has the benefit of the possibility of statistical analysis (Qualters *et al.* 2006). The educational value of the game is then expressed as some measure of the difference between the pre- and after knowledge on the subject. The key concepts and learning lessons should be incorporated in the performance measurement instrument in some way. For this purpose, research sub-question 4.2 is formulated.

Ideally, one wants to evaluate the 'learning' effects of the SCRMG. It is difficult (if not impossible!) to scientifically prove that participants actually have learned by participating in the game session, because participants themselves are part of the learning experience. Maybe 'perceived learning' or 'self-reported learning' is a better performance measure. Further, the change of behaviour of participants is difficult to measure. The behaviour depends on the intention and the beliefs, according the 'theory of reasoned action' (Ajzen & Madden 1986).

Kriz and Hense (2006) extensively address the main problems regarding the evaluation of serious games. They also propose solutions to address these issues, they suggest a 'theory based evaluation method'. They further propose a 'general list of quality criteria for the quality of a simulation game'. Kriz and Hense (2006, p. 269) report that two elements should be incorporated in the assessment: "it is essential that the artefact assessment takes the evaluation of a simulation game as a product into account, as well as its effect on the process of change". In the evaluation, both these issues will be addressed. The evaluation of the game will be described in Chapter 5 of this thesis.

2.3 Design approach

The design approach can be explained by the alignment of the game design process, the thesis structure and the research questions. The design process, thesis structure and research questions are aligned and visualized in 'Figure 5'.

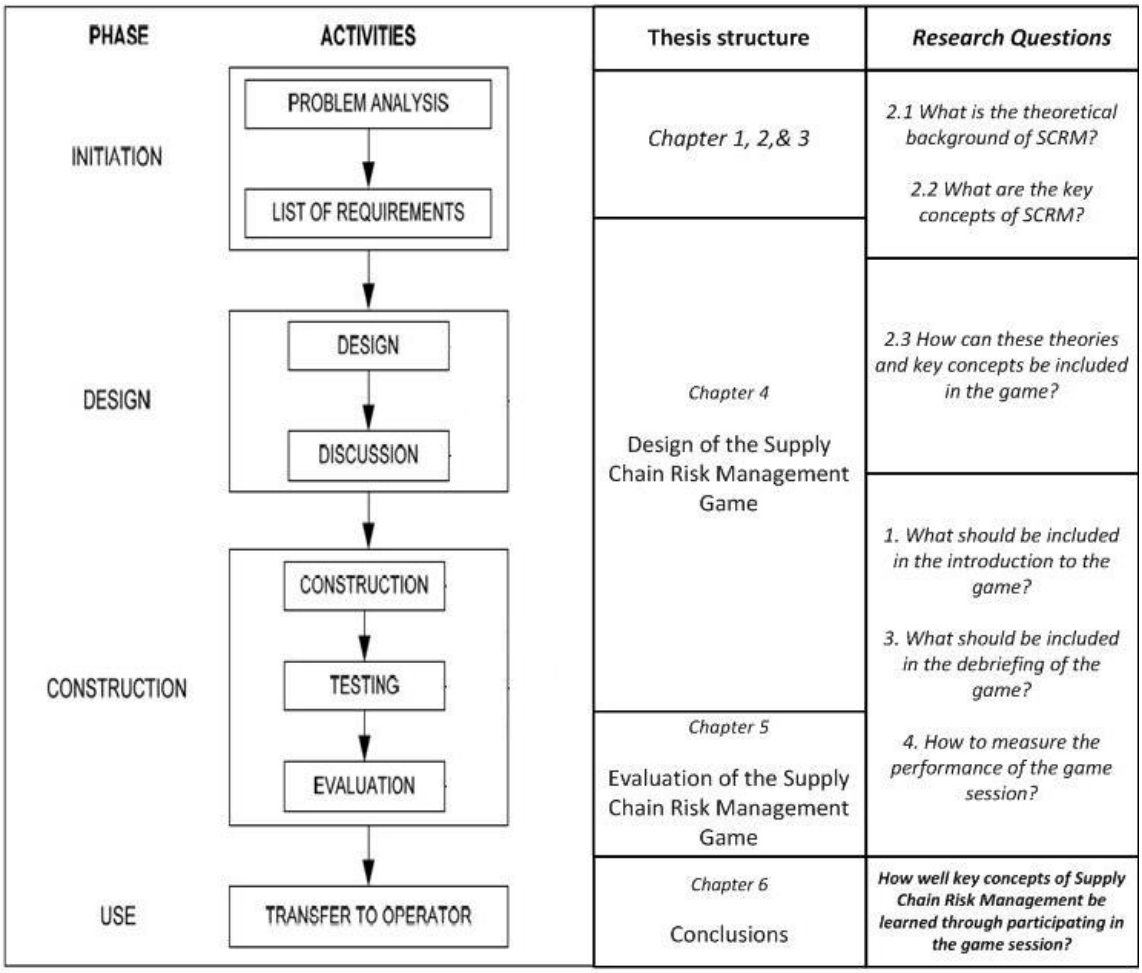


Figure 5: Duke's (1981) Game design process in alignment with the thesis structure and research questions

The game design process with the 'phases and activities' (Duke 1981) is indicated on the left side of Figure 5. The activities from the game design process are documented in the corresponding Chapter of the thesis. The research questions are located on the right side of Figure 5. The research (sub) questions are aligned with the activities in the game design process.

First, research sub-question 2.1 and 2.2 will be answered in the 'initiation phase'. Then research sub-question 2.3 will be answered and a preliminary game design (prototype) will be created. The introduction and debriefing will be created when the prototype is constructed.

Finally, during the 'testing phase' (Figure 5), an instrument will be developed to measure the performance of the game session. At the end of the game design process (Figure 5), the research question can be answered and the main design objective is fulfilled.

This thesis is for a large part structured like the Duke's (1981) game design process. All phases of the game design process (see Figure 5) are documented in the thesis in the following manner. The **initiation phase** consists of Chapter 1, 2 and 3 (activity: problem analysis) and 4 (activity: design requirements. The **design and construction phase** are documented in Chapter 4. The **construction phase** (activity: evaluation) will be described in Chapter 5. The **use phase** will be described in Chapter 6 (activity: transfer to operator (*Deloitte*)). The overview between the links of the design process and the research (sub) question is provided in Figure 5.

It is useful to adopt and adapt an (general) game design process because it provides some structure to the design process before the actual design process starts. However, 'design' is an iterative, creative and episodic process (as explained in TPM course SPM 4110).

To fulfil the main design objective, first the game itself will be designed and developed. Then, all other elements needed to conduct the game session (for instance the facilitator guide) will be created.

The game design method of Duke (1981) is used to structure the design process. Duke's (1981) approach lacks detailed explanation on the exact steps that have to be taken to move from activity A to activity B. For instance, how the list of requirements results in a design is unclear.

This stipulates the need to –at some points- deviate from this approach. Techniques learned at several courses in the SEPAM-Master programme are used to fulfil the main design objective.

The final game design process is visualised in a number of models. In sequential order, these are:
Figure 23: Supply network structure of the Supply Chain Risk Management Game;
Figure 24: Cause-effect model;
Figure 25: Seven phases during the construction phase;
Figure 26: Evaluation approach.

In this Chapter the design objective has been decomposed into design sub-objectives. Based upon the main design objective, a research question has been formulated. This research question has been decomposed into research sub-questions. The research methods and data sources have been discussed. Finally, the design approach has been clarified.

In the next Chapter a literature review will be conducted on the domain of Supply Chain Risk Management and on the domain of Serious Gaming. This is the topic of the next chapter, Chapter 3: Literature review on the Domain of Supply Chain Risk Management and Serious Gaming.

3. Literature review on the Domain of Supply Chain Risk Management and Serious Gaming

In Chapter 1 a short overview has been provided of the key concepts and practical management issues of the field of SCRM. In Chapter 2 the design objectives and research questions have been formulated. We have adopted the game design process of Duke (1981) to illustrate and to describe the design approach. The goal of this project is to 'design, construct, test and evaluate a serious game that facilitates learning about the key concepts of Supply Chain Risk Management' (see §1.8).

To identify the 'input for the requirements' for the Supply Chain Risk Management Game, it is necessary to further explore the theoretical background of SCRM, more practical matters relating to SCRM and serious gaming as a learning method. Finally, existing serious games are evaluated to gain inspiration and to generate ideas for the design and construction of the SCRMG. In this Chapter the theoretical background of SCRM is further elaborated upon (§3.1). Practical matters in Supply Chain Risk Management are described (§3.2). Next, serious gaming as a learning method is discussed (§3.3). Concluding this Chapter, a selection of serious games in the field of supply chain management / logistics will be evaluated (§3.4).

Most subparagraphs -in §3.1 and §3.2- end with the formulation of sub-conclusions. Based on these conclusions, input for the design requirements of the SCRMG is formulated. Only if the subparagraph is relatively short (1 page), the design requirements are formulated directly after the body text. All insights are used to design, construct, test and evaluate the Supply Chain Risk Management Game.

Data and Information Sources
The main research method used in this Chapter is desk research. The selection of scientific papers is based on the number of Scopus-references. The theoretical background is discussed using publications from the developers of theories, as well as other which have applied the theories to the field of supply chain and/or risk management.

As clarified in Chapter 1, SCRM is a fairly new research field; most papers dedicated to SCRM are published from the year 2003. Most papers used in paragraph 3.2 are from the 'guru's' in the field, such as Peck, Christopher and Jüttner from Crandfield University (UK) and Sheffi from the Massachutes Institute of Technology (USA). Other authors relate to other universities. Further, most publications used are from members of the International Supply Chain Risk Network (ISCRIM). Some publications used are the doctoral theses on a topic relating to SCRM.

Because most authors refer to each other and co-author papers, a coherent view on SCRM can be provided. However, some authors write that many difficulties regarding research and developing a coherent body of knowledge remain, such as the lack of empirical research and validation. Further, the terms used to describe SCRM widely vary between authors. SCRM is not an exact science, but is described by researchers with different backgrounds using different theories and terms. Supply Chain Risk Management is a multi-disciplinary body of knowledge. We will undertake a fairly broad literature review for seven reasons:

- Supply Chain Risk Management is a multi-disciplinary body of knowledge;

- To gather information about the reference system;
- To enable us to separate the 'need to haves' from the 'nice to haves';
- To enable us to make the right key design choices for the SCRMG;
- To enable us to create an introduction and debriefing that includes the key concepts;
- To enable us to create additional information that participants may study before or after the game session;
- Relevant theories can be applied to any complex system, such as supply chains.

3.1 Theoretical Background

To create a game that includes the 'key concepts', it is necessary to include the theoretical constructs that underpin the emerging 'body of knowledge' of Supply Chain Risk Management. The learning goals of the game session have been specified in paragraph 1.9. One of the six learning goals is; '*participants of the game session reach (a further) understanding about the theoretical background of SCRM'*. For this purpose, in this paragraph, research sub-question 2.1 is explored: **"What is the theoretical background of Supply Chain Risk Management?"**

Approach
To answer this research sub-question, the theoretical background of supply chain risk and subsequent management issues is investigated through using multiple theoretical viewpoints. One reason for this approach is that "supply networks are undoubtedly becoming significantly more messy units of analysis to deal with (Harland *et al.* 2003)". Therefore, some 'conceptual slack' is adopted.

Structure
The theoretical background is further explored, through a description of Normal Accident Theory (§3.1.1), High Reliability Theory (§3.1.2) and Economic Theories (§3.1.3). Then, other explanatory theories are discussed (§3.1.4). Lastly, a summarizing conceptual model of the theoretical background is presented in the summary (§3.1.5). These insights are used to design and develop the Supply Chain Risk Management Game.

3.1.1 Normal Accident Theory

Normal Accident Theory provides the rationale for the occurrence of accidents in complex socio-technical systems, such as (global) supply chains.

"What kind of systems are most prone to system accidents? (Perrow 1999, p. 72)" Normal Accident Theory (NAT) provides an answer to this question. The main line of thought of Normal Accident Theory is explained by Rijpma (1997, p. 15) as: "accidents are inevitable in complex, tightly-coupled technological systems". Therefore, Perrow (1999) calls these accidents 'normal'. In similar lines, Craighead *et al*. (2007, p. 131) argue that: "supply chain disruptions are unavoidable and, as a consequence, that all supply chains are inherently risky."

Marley (2006, p. 3) puts it more specific as; "The basic notion of NAT is that accidents are inevitable under conditions of tight coupling and a high degree of interactive complexity". Marley continues; "*Tight coupling refers to the level of slack or buffer within the system and interactive complexity*

refers to the way that parts within a system are connected and interact. To reduce catastrophic potential, NAT researchers suggest that firms either add slack to their system or reduce complexity".

Perrow proposed NAT from a socio-technological perspective (Wagner & Bode 2006) and his view can be characterized as pessimistic. As mentioned above, Perrow (1999, p. 72) uses two concepts to describe systems that are most prone to system accidents; "interactiveness, which could confuse operators, and tight coupling, which could prevent speedy recovery from an incident". The concept of interactiveness can best be explained by this quote of Perrow (1999, p. 76);

> *As systems grow in size and in the number of diverse functions they serve, and are built to function in ever more hostile environments, increasing their ties to other systems, they experience more and more incomprehensible or unexpected interactions. They become more vulnerable to unavoidable system accidents.*

The notions in this quote should be related to driving forces surrounding supply chains in today's world in order for NAT and the concept of interactiveness to be relevant. See 'Table 1: Interactiveness and driving forces' for the relation between the concepts of interactiveness and driving forces in current supply chains.

Interactiveness	Driving forces
Grow in size	Globalization, outsourcing to and sourcing from Low Cost Countries, mergers and acquisitions
More hostile environments	Outsourcing to and sourcing from Low Cost Countries, globalization, "increased competition, high customer expectations, reduced cycle time (Weick & Sutcliffe 2001, p. 8)"
Increasing their ties to other systems	Leanness, less inventory

Table 1: Interactiveness and driving forces

The second concept related to the occurrence of accidents is 'tight coupling'. Perrow (1999) explains the concept of tight coupling as;

> *Tight coupling is a mechanical term meaning there is no slack or buffer or give between two items. What happens in one, directly affects what happens in another. High tight coupling implies that there is little slack or buffer within the system or it is not possible to delay processing, while low tight coupling refers to excess slack, buffers or time*

The notions in this quote should be related to driving forces surrounding supply chains in today's world in order for the concept of 'tight coupling' to be relevant to supply chains, see 'Table 2: Interactiveness and driving forces'. Managers have to balance the 'level of coupling': the amount of slack, buffers or time.

Tight coupling	Driving forces
No slack or buffer	An increased focus on cost-reduction, JIT-practices, leanness, less inventory, less safety stock, reduced cycle time.
What happens in one, directly affects what happens in another	Increased dependency on suppliers (single sourcing), globalization, reputation risks

Table 2: Interactiveness and driving forces

Relating to supply chains, Craighead *et al.* (2007, p. 131) argue that: "supply chain disruptions are unavoidable and, as a consequence, that all supply chains are inherently risky." Wagner and Bode (2006, p. 302) apply NAT to supply chain management and state: "Drawing from this theory, one

could assume that the more complex the interactions and the tighter coupled the supply chain, the more prone the supply chain is to unexpected, untoward events."

Kleindorfer and Saad (2005, p. 55-56) state in their list of 10 guiding principles for effective management of supply chain disruptions, that (principle 5), "Extreme leanness and efficiency may result in increasing the level of vulnerability, at both the individual firm level and across the supply chain." This fifth principle implies that in order to minimize risk, and ultimately loss from supply chain disruptions, attention must be given to the trade-off between 'robustness' of the supply chain to disruptions and the overall efficiency of the supply chain under normal operations.

Kleindorfer and Saad's 6th principle is a result from the observation of the trade-off between robustness and efficiency: "As a corollary to principle 5, establishing back-up systems, contingency plans, and maintaining reasonable slack, can increase the level of readiness in managing risk." He notes (2005, p. 56) that this slack can be in a physical or virtual form (or both). Perrow (1999) earlier proposed similar ideas about managing disruptions in complex technological systems. He also stipulates the need for slack and redundancy. He argues that 'coupling' does not has to be physical. In current 'lean' supply chains, JIT-practices make complex systems 'tightly coupled' on a time-basis, rather than a physical coupling. The result can be characterized as increased 'sequential interdependency' in terms of 'Interdependence Theory' (Thompson 1967).

In Figure 6, the characteristics of lean supply chains with their ideal level, the strategy and motivation is presented.

Characteristic	Ideal Level	Strategy	Motivation
Coupling	Tight	Reduce inventory levels	Reduces costs Reduces leadtime Eliminates waste
Interactive Complexity	Linear	Simplify processes	Makes problems more visible Reduces time to complete work Eliminates feedback loops

Figure 6: Consistencies between NAT dimensions and lean management (Marley 2006, p. 44)

Concluding, Normal Accident Theory (Perrow 1999) provides a useful scientific foundation for understanding the increased risk exposure of complex socio-technical systems using the concepts of 'interactiveness' and 'tight coupling'. Lean supply chains are more vulnerable to disruptions because of the ideal level of the characteristic 'tight coupling'. The driving forces in current supply chains have resulted in an increased level of 'Interactiveness', because the last decades companies and their supply chains 'grew in size', 'function in more hostile environments' and their 'ties to other systems increased'. These trends are referred to as *globalization* (Coyle, Bardi and Langley 2003).

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG incorporates Normal Accident Theory

- SCRMG is about a global supply chain

3.1.2 High Reliability Theory

High Reliability Theory provides the rationale for methods on how the reliability of organizations can increase, through 'organizational learning'. Organizations that successfully manage complex technical systems through the adoption of 'organizational learning principles' are termed 'High Reliability Organizations (HRO's)' (Weick & Sutcliffe 2002).

High Reliability Theory (HRT) argues that organizations facing the conditions of tight complexity and interactiveness may be vulnerable to accidents but can manage these conditions through application of countermeasures (Marley 2006, p. 4). Instead of accepting that accidents are inevitable, High Reliability Theory states that organizations can become 'High Reliability Organizations' by organizational learning and the creation of 'collective mindfulness' (Weick & Sutcliffe 2002, p .8).

Risk awareness

In the domain of systems engineering and management, the concept of 'risk awareness' is often mentioned in relevant literature (Thissen & Herder 2003, p. 293). The lack of risk awareness is considered to be a source of failure. Some authors speak about unaware people; others refer to organizational unawareness (Hammant & Braithwaith 2007, p. 6). The Centre for Logistics and Supply Chain Management (2003, p. 42) stresses the importance of the risk awareness in the following way:

"Dealing with supply chain vulnerability requires a change management approach. Such an approach recognizes that the 'right' philosophy for tackling supply chain vulnerability depends on culture, structure and business drivers dominant in an industry sector. Against these criteria we have identified four issues that foster success in supply chain continuity management:

1) Risk awareness among top managers
2) Risk awareness as an integrated part of supply chain management
3) Understanding by each employee of their role in risk awareness
4) Understanding that changes in business strategy change supply chain risk profiles."

The (philosophical) concepts of 'mindfulness' and 'risk awareness' share two characteristics; they are intangible and are related to the people working in organizations. Therefore it is assumed that these concepts have the same meaning. Jüttner (2005, p. 136) puts the concept of risk awareness in a broader context and states that; "*in a supply chain context, risk-related beliefs determine the risk awareness, which in turn influences how the organisations respond to the need to manage risk and plan continuity*" (Figure 7).

Figure 7: Risk: beliefs -> awareness -> response

This conceptual model shows that organizational responses are influenced by risk related beliefs -via the intervening variable 'risk awareness'-. According to this causal relationship, the SCRMG can be used as a learning method to improve organisational responses, if it influences the participants 'risk related beliefs'. The 'theory of reasoned action' provides a similar rationale: "*At the most basic level*

of explanation, the theory postulates that behavior is a function of salient information, or beliefs, relevant to the behavior (Ajzen & Madden 1986, p. 454)."

Amongst other principles, HRO's use redundancy to back up failing parts and persons (Rijpma 1997). So, redundancy is mentioned by both NAT and HRT, it is a general design principle in the domain of systems engineering. Redundancy increases system reliability. Further, NAT and HRT propose the same management approach to reduce disruptions, "*According to NAT and HRT, the likelihood of disruptions can be reduced by making structural changes to reduce interactive complexity, reduce tight coupling, or attack both simultaneously* (Marley 2006, p. 3)."

"*The effectiveness of high-reliability organizations, stems from the ability to respond to fluctuating conditions. Collective mindfulness, which can be developed in any organization, consists of;*
1) viewing any failure as a systemic problem to be examined and learned from;
2) reluctance to simplify interpretations;
3) integrated sensitivity to and communication about operations throughout the organization;
4) commitment to resilience and
5) fluidity of decision making structures (Weick & Sutcliffe 2002, p. 7)."

These five principles are theoretical, but are relevant for all sorts of management disciplines, when 'managing the unexpected'. Examples of HRO's are aircraft carriers, air traffic controllers and nuclear power plants. What distinguishes these organizations from other organizations is that accidents could have happened thousands of times, but, surprisingly few accidents did actually occur.

Using the aircraft carrier as an example, Weick and Sutcliffe (2001, p. 26) stress the importance and relevance of HRT for every organization with the following question: "Can you think of a better group than a carrier to use as a benchmark for your own efforts to be more alert, mindful, resilient?". They continue with: "What is surprising is the extent to which the qualities of a well-functioning carrier generalize to other organizations (2001, p. 28)". They further illustrate the relevance of HRT to other management disciplines by comparing the operations and tasks of people on an aircraft carrier with the operations and tasks of people in a production facility:

> *The basic task of people on a carrier is to move aircraft off the pointed end of the ship and back onto the blunt end of the ship. Your basic task is to move products or services out the front door and raw materials in the back door.*

The implicit premise one holds when applying the ideas of HRT's to Supply Chain Risk Management, is that the people working in the organization are –*at least to some extent*- not mindful, not resilient, not alert and/or not aware. In the perspective of HRT, this lack of mindfulness, resilience, alertness and awareness is the cause of decreased system reliability and results in system failure. Applied to the systems as analysed in SCRM, these failures are called (supply chain) *disruptions*! Zsidisin (2005, p. 3403) writes in his article about 'business continuity planning (BCP) that: "lack of awareness of all the events that might occur and cause a supply disruption".

It is important to mention that –*in the perspective of organizational behaviour theorists*- the management of supply chain risks is a philosophical and psychological issue, focused on human behaviour, training, communication, states of mind (alertness, mindfulness) and thinking patterns, rather than a (purely) mathematical issue (as used to be in operations management). 'People' are

one of the four pillars of risk management (Deloitte 2008c, see Appendix A: Risk Intelligence Framework). The importance of mindfulness is also mentioned by Christopher and Towill (2000, p. 206), they recognize 'mindsets' as a part of agility: "Agility is a business-wide capability that embraces organizational structures, information systems, logistics processes and, in particular, mindsets."

Concluding, High Reliability Theory (Weick & Sutcliffe 2002) provides a useful scientific foundation for understanding how the increased risk exposure of supply chains can be managed. According to High Reliability Theory, organizational and human assets as 'mindfulness' and 'awareness' provide the capability of achieving high reliability. Ideally, the game session should contribute to the development of these important intangible human or organizational assets through increasing risk related beliefs and risk awareness (see Figure 7). High Reliability Theory (HRT) argues that organizations facing the conditions of tight complexity and interactiveness may be vulnerable to accidents but can manage these conditions through application of countermeasures, such as decreasing the level of coupling and/or decreasing the level of complexity.

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG influences risk related beliefs
- SCRMG increases risk awareness
- SCRMG incorporates High Reliability Theory

3.1.3 Transaction Cost Analysis

Economic theories are relevant for managing disruptions in supply chains. Transaction Cost Analysis (TCA) is mentioned by Hobbs (1996, p. 15) as "*one possible approach to understanding and evaluating supply chain management and has the potential to be combined in an interdisciplinary setting with the insights provided by the marketing, logistics and organizational behaviour literatures*" (also: Grover & Malhotra 2003). In this paragraph Transaction Cost Analysis and the relevance for SCRM is reported.

Transaction Cost Analysis[6] (TCA) has been proposed by Coase (1937), who was awarded the Nobel Prize for economics for his work (Grover & Malhotra 2003). "*The transaction cost approach to the study of economic organization regards the transaction as the basic unit of analysis and holds that an understanding of transaction cost economizing is central to the study of organizations* (Williamson 1981, p. 1)". "In any economic exchange, people have to agree on how to divide costs, benefits and risks (Williamson 1985)".

"*[...] the key characteristics of transactions are: the degree of uncertainty surrounding the transaction, the degree of asset specificity, and the frequency of the transactions* (Hobbs 1996, p. 6)". TCA distinguishes costs related to transactions: 'transaction costs'[7]. More specific, these are: "the costs involved in *coordinating* economic transactions (Groenewegen 2006, p. 1)".

These include:

[6] Also referred to as Transaction Cost Theory or Transaction Cost Economics.

[7] Deloitte Enterprise Risk Services offers several services about the specification, monitoring and enforcement of contracts. As a professional services firm, Deloitte charges their customers for delivering these services: **transaction costs.**

- The costs of discovering what prices should be (Hobbs 1996; or 'search costs' (Groenewegen 2006);
- The costs of negotiating individual contracts for each exchange transaction (Groenewegen 2006; Hobbs 1996);
- The costs of accurately specifying the details of a transaction in a long-term contract (Hobbs 1996)
- Monitoring costs (Groenewegen 2006) and,
- In case of opportunistic behaviour, enforcement costs (Groenewegen 2006).

All these costs are relevant when managing risk in supply chains, because of economic transactions between suppliers and buyers. The assumptions of Transactions Cost Analysis (TCA) are different than the assumptions of the neoclassical paradigm, "but both theories prescribe a specific rule of rational behaviour: actors minimizing transaction costs (Groenewegen 2006, p. 2)". If this rule of behaviour is extended with the management of risk, one can argue that the specific rule of behaviour is: 'to minimize (transaction) costs and risk exposure'. Transaction costs can be generally represented in terms of two major components (Grover & Malhotra 2003, p. 459): 'Transaction costs = coordination costs + transactions risk'. This fits well with our earlier mentioned fundamental trade off between costs and risk (see Chapter 2).

There is a need to keep the transaction costs low according to Meijer (2009, p. 13); "Minimising transaction costs leads to a better performing network. A better performing network delivers more value to the consumer and more profits for the companies in the network." In addition to this, there is a need to keep both production and transaction costs low in order to maintain competitiveness. As Ketchen Jr. and Hult (2007, p. 1) put it: "Rather than competing *firm versus firm*, today's organizations are battling *supply chain versus supply chain*."

TCA uses the concept of 'bounded rationality' (Hobbs 1996, p. 3) to describe the behaviour of rational actors of which the rationality is 'bounded' by incomplete information. Therefore, according to Wilson (2006) managers have "a limited ability to make rational decisions" (as theoretically they cannot obtain 'full information'). "They are limited in their ability to receive, store, retrieve, and communicate information without error (Grover & Malhotra 2003, p. 458)". Furthermore, TCA implies managers' "propensity to pursue actions that support self-interest by behaving opportunistically" (*ibid.*). As Hobbs (1996, p. 3) reports: "*it recognizes that businesses and individuals will sometimes seek to exploit a situation to their own advantage. This does not imply that all those involved in transactions act opportunistically all of the time, rather, it recognizes that the risk of opportunism is often present*."

Concluding, Transaction Cost Analysis incorporates the two important concepts of 'bounded rationality' and 'opportunistic behaviour'. These concepts "create an environment of uncertainty and complexity, such that the cost of transacting under these conditions involves additional risk and expense (Wilson 2006, p. 19)." By incorporating these concepts, TCA recognizes 'human nature as we know it' (Williamson 1981). TCA takes the transaction itself as the unit of analysis and recognizes that there are a variety of costs related to transactions. There are two major components that build transaction costs: *coordination costs* and *transaction risk*.

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG incorporates Transaction Cost Analysis
- SCRMG incorporates coordination costs
- SCRMG incorporates transaction risk
- SCRMG incorporates competition

3.1.4 Other explanatory theories

As we have seen, several theories -which each take a different unit of analysis-, contribute to a theoretical foundation for SCRM. In this paragraph other theories mentioned in relevant literature are briefly discussed.

Utility Theory

From the field of Neoclassical theories, Utility Theory describes a theoretical perspective on the choice between (risk reducing) alternatives. "A fundamental theoretical framework for modelling risk-sensitive decision makers is expected utility theory (Kouvelis *et al*. 2006)". According to Nobel Prize recipient Friedman (1948, p. 26), "*the behavior of consumer units in choosing among alternatives open to them is provided by the hypothesis that a consumer unit behaves as if they have a consistent set of preferences which can be completely described by attaching a numerical value to alternatives each of which is regarded as certain*[8]." This consumer unit is a 'full-informed rational actor' and will choose "among alternatives involving risk that one for which the expected utility is largest (Friedman 1948)".

Agency Theory

Agency Theory is proposed by Eisenhardt (1989) and takes the metaphor of a contract between the buyer and supplier as the unit of analysis. Zsidisin *et al*. (2004, p. 399) explain the relevance of Agency Theory in the following way; "*Several principles of agency theory can provide a theoretical foundation for understanding how and why organizations conduct supply risk assessments. Agency theory applies to the study of problems arising when one party, the principal, delegates work to another party, the agent. In the buyer-supplier relationship, the purchasing organization serves as the principal and the supplier as the agent."* Zdisidin *et al.* (2004) distinguish six variables (derived from Agency Theory) that influence the 'contract'/relationship between buyer and supplier. These variables result in the need to conduct a supply risk assessment. The variables are 1) information systems that monitor supplier performance, 2) outcome uncertainty, 3) goal conflict, 4) relationship length, 5) adverse selection and 6) moral hazard.

Portfolio Theory

The main premise of Portfolio Theory is "diversification reduces risk" (Kleindorfer & Saad 2005, p. 55). The question whether to have one or multiple suppliers for one product or component is relevant in the light of Portfolio Theory. Intuitively, having multiple suppliers for a certain product or (sub) component is a risk reducing strategy. Single sourcing is a risky strategy; it increases dependency on one supplier. The strategy is riskier because the potential impact of a disruption increases, compared to 'dual sourcing'.

Concluding, Utility Theory, Agency Theory and Portfolio theory are mentioned in scientific research about SCRM and provide understanding for the issues concerned in this research field.

[8] Each alternative is regarded as *certain* because the neoclassical theory assumes 'perfect information'.

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG incorporates Utility Theory
- SCRMG incorporates Agency Theory
- SCRMG incorporates Portfolio Theory

3.1.5 Summary

To summarize the findings of the exploration of the theoretical background, two conceptual models are presented in this summary. In the first conceptual model, the most frequent mentioned theories in Supply Chain (Risk) Management literature are presented (Figure 8).

Each theory takes a different perspective on Supply Chains and has a different 'unit of analysis'. In other words: each theory answers a different (but relevant) question. Therefore, in the conceptual model, each theory with the unit of analysis (on the arrow) and its main question (in the box) is presented. Each theory can be used to understand different aspects of the supply chain.

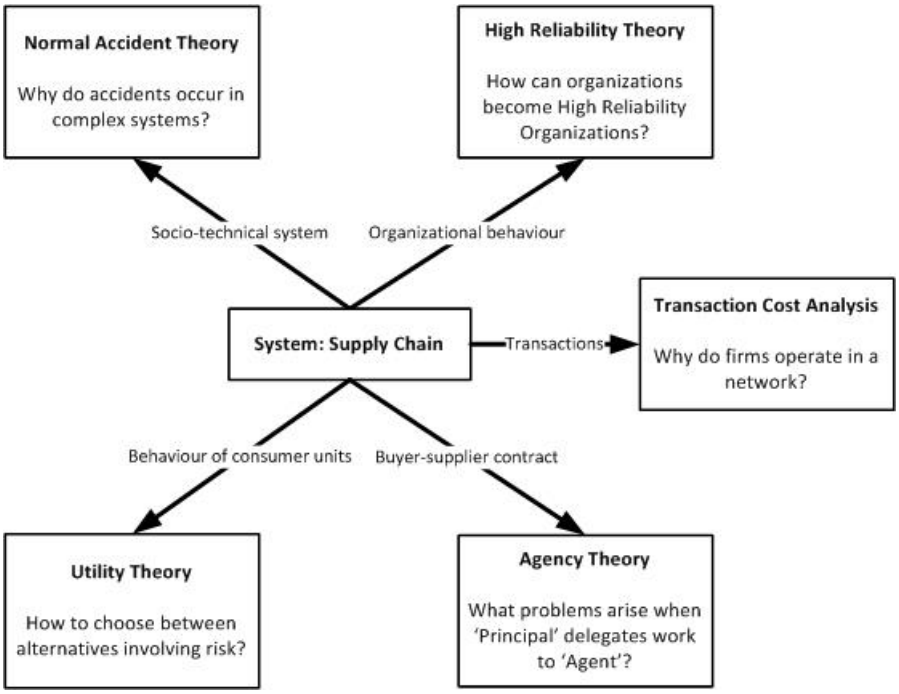


Figure 8: Several Theories provide a scientific foundation of Supply Chain Risk Management

The complexity of the system can be described by the number of actors/decision making units and the number of relations between them. NAT, HRT and TCA have no limit regarding the number of actors and relations. Agency theory analyses the relation between two actors; the 'principal' and the 'agent'. Utility theory has a single actor perspective. Each theory has a different unit of analysis, combined with the insights gained throughout this paragraph; these theories can be positioned in a unique location in a conceptual representation of a supply chain. Five scientific theories (Portfolio Theory is excluded) that have been discussed are positioned a supply chain, that exist of conceptual supply chain with a 'tier 1 supplier', the 'focal company' and a 'tier 1 customer' (Figure 9). The product flows from 'supplier' to 'costumer'.

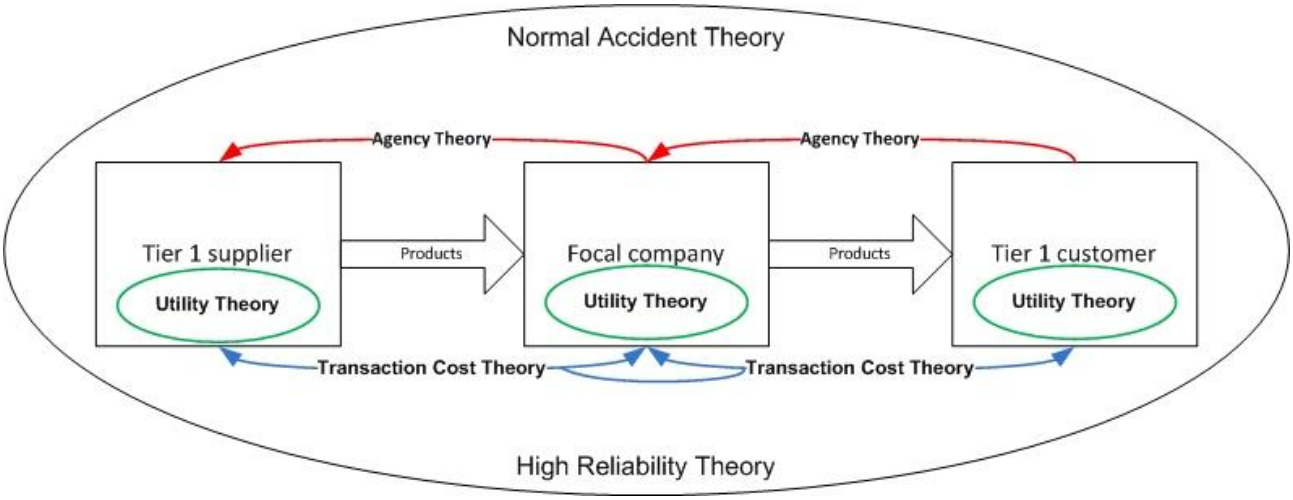


Figure 9: Theories positioned in a conceptual supply chain

3.2 Supply Chain Risk Management

In the previous paragraph, the theoretical background of Supply Chain Risk Management is discussed. This paragraph will focus on more practical matters, such as the steps that have to be taken when managing risk in supply networks. In this paragraph research sub-question 2.2 is explored: **"What are the key concepts of Supply Chain Disruption Risk Management?"**

First, definitions of Supply Chain Risk Management are discussed (§3.2.1). The remainder of this paragraph is structured according to the 'supply network risk tool' (Harland *et al*. 2003, p. 56), this is a tool 'for helping to identify, asses and manage risk' (Figure 10)[9].

The supply chain risk sources are addressed (§3.2.2 –**step 1** & **2**). Next, the risk assessment process is treated (§3.2.3 – **step 3**). Then, the management part of the Supply Chain Risk Analysis and Management (SCRAM) model is discussed (§3.2.4 – **step 4**). The paragraph ends with an elaboration on the risk strategy and the strategic cost-risk trade-off (§3.2.5 – **step 5**). These insights are used to design and construct the Supply Chain Risk Management Game (SCRMG).

[9] "*The risk tool has been developed iteratively and is tested in a pilot and four case studies conducted in a focal firm in the electronics sector* (Harland *et al.* 2003, p. 56)". A similar framework of Deloitte (2007) is presented in Appendix A. In similar lines, Kleindorfer and Saad (2005) offer a conceptual framework for managing disruption risks in supply chains, they distinguish three steps: Specify, Asses, Mitigate (SAM).

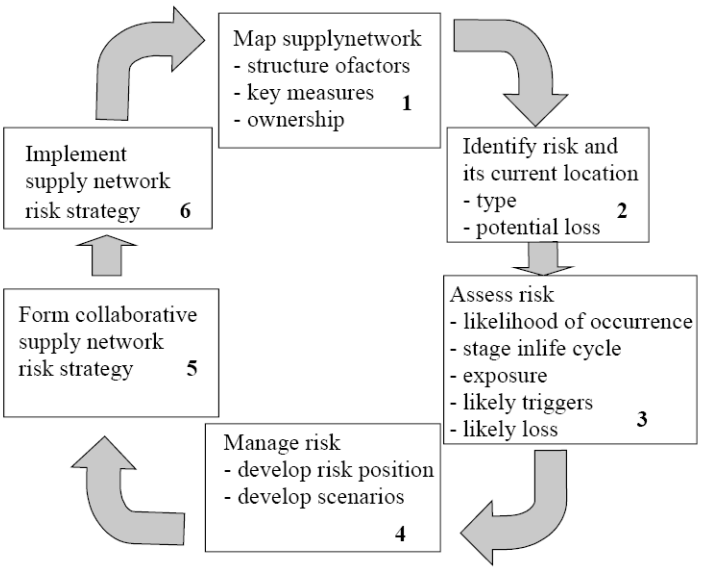


Figure 10: Supply network risk tool (Harland *et al.* 2003, p. 56)

3.2.1 Defining Supply Chain Risk Management

Waters (2008, p. 76) defines SCRM as; "*Supply chain risk management is the process of systematically identifying, analyzing and dealing with risks to supply chains*". The second part of this definition is further specified by Tang (2006, p. 2), Tang incorporates the goal and methods of SCRM into his definition and defines SCRM as: "*The management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity*." According to this definition, collaboration and coordination are the tools that the supply chain partners have to use in order to 'deal' with supply chain risks. Finally, Jüttner (2005, p. 123) incorporates the goal of SCRM, when he defines SCRM as a managerial 'remit' as; "*the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole*." After an evaluation of existing Supply Chain Management Games – which will be reported in paragraph 3.4, the focus of the to-be-designed game is on 'risk arising from disruptions to normal activities'. This choice to delineate the design and research activities is based on Kleindorfer and Saad (2005, p. 1): "*There are two broad categories of risk affecting supply chain design and management: 1) risks arising from the problems of coordinating supply and demand, and (2) risk arising from disruptions to normal activities*".

These three definitions do not 'bite'; they complement each other, because Waters (2008), Tang (2006) and Jüttner (2005) incorporate different aspects and (subtle) differences of shared aspects into their definitions. If these three definitions and the focus on 'disruptions' are combined, Supply Chain Disruption Risk Management (SCDRM) can be defined as;

> ***Supply chain disruption risk management is the process of systematically identifying, analyzing and dealing with disruption risks to supply chains (=WHAT), through coordination or collaboration (=HOW) among the supply chain partners (=WHO), to decrease supply chain vulnerability and increase supply chain resilience, so as to ensure profitability and continuity for the whole supply chain (=WHY).***

This definition answers the 'what, how, who and why question'. From now on, this definition is used in this thesis. Recall that the goal of this project is *'[...] to design, construct, test and evaluate a*

serious game that facilitates learning about the key concepts of Supply Chain Risk Management'. The above stated definition of SCRM is regarded as a 'key concept' which is necessary in order to achieve the goal of this project. The definition can be incorporated in one of the game elements (Figure 2). Please note that the reason to turn to SCRM practices is to 'ensure profitability and continuity' – this implicates that an *economic* perspective on the subject is adopted[10].

The basis constructs of SCRM are visualized in Figure 11 (Jüttner, Peck & Christopher 2003, p. 121). 'Risk sources' lead to 'supply chain risk consequences'. The consequences of the 'risk sources' are influenced by (1) the supply chain and the (2) 'supply chain risk mitigating strategies'. This conceptual diagram is used to construct the game. An important notion is that the consequences of the risk sources can be reduced by Supply Chain Risk Mitigating Strategies.

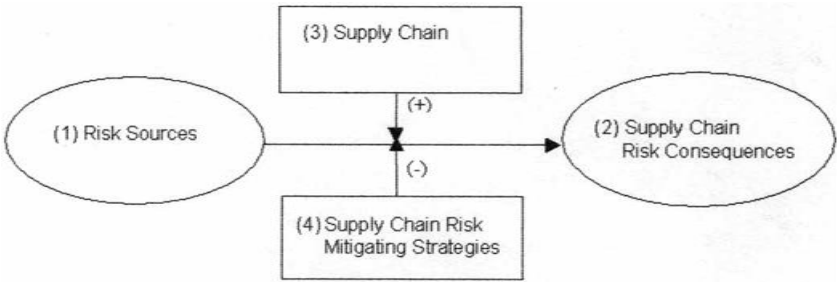


Figure 11: Basic constructs of SCRM (Jüttner, Peck & Christopher 2003, p. 121)

In Chapter 1, several types of risk have been briefly addressed. The next subparagraph elaborates on different 'supply chain risk sources', that are useful in order to categorize identified supply chain risks.

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- Risk sources have Supply Chain Risk consequences, but can be mitigated by Supply Chain Risk Mitigating Strategies
- SCRMG incorporates a definition of Supply Chain Risk Management

3.2.2 Mapping and identifying risk: supply chain risk sources

The first step in the risk assessment process (Figure 16) is the 'identification stage'. In order to properly identify a phenomenon, one needs a classification / structuring model. In this paragraph two models are discussed that provide a framework which can support the structuring of identified risks.

Several categories of risk are mentioned in literature, as briefly pointed out in Chapter 1. There are basically two kinds of risk to a supply chain; internal risks and external risks (Waters 2008, p. 8; Christopher 2003, p. 14). "Internal risks are [...] more widespread in their effects. These are the risk to operations that managers can control – such as delays and breakdowns – and there are traditional ways of dealing with them." External risks however, are uncontrollable. "External risks come from outside the supply chain, such as earthquakes, hurricanes, industrial action, wars, terrorist attacks,

[10] To meet the day-to-day business reality of Deloitte Clients: managing the effects of the global financial crisis. During the interviews (see Appendix G) it became apparent that companies prioritize financial risks over –for instance- *'sustainability risks'*.

outbreaks of disease, price rises, shortage of raw materials etc." Please note that the risk can be internal to the supply chain as a whole, but external to an individual company in that chain.

When further specifying risks, Waters (2008, p. 177) distinguishes another type of risk, 'supply chain risk'. "Each member of a supply chain is vulnerable to its own risk (internal risk), risks to other members of the supply chain (supply chain risks) and risks that arise from interaction between the supply chain and its environment (external risks)." These different categories of risk are termed 'supply chain risk sources'. As defined by Jüttner (2005, p. 122) "Supply chain risk sources are any variables which cannot be predicted with certainty and from which disruptions can emerge". The supply chain risk sources of a supply network are visualized in Figure 12.

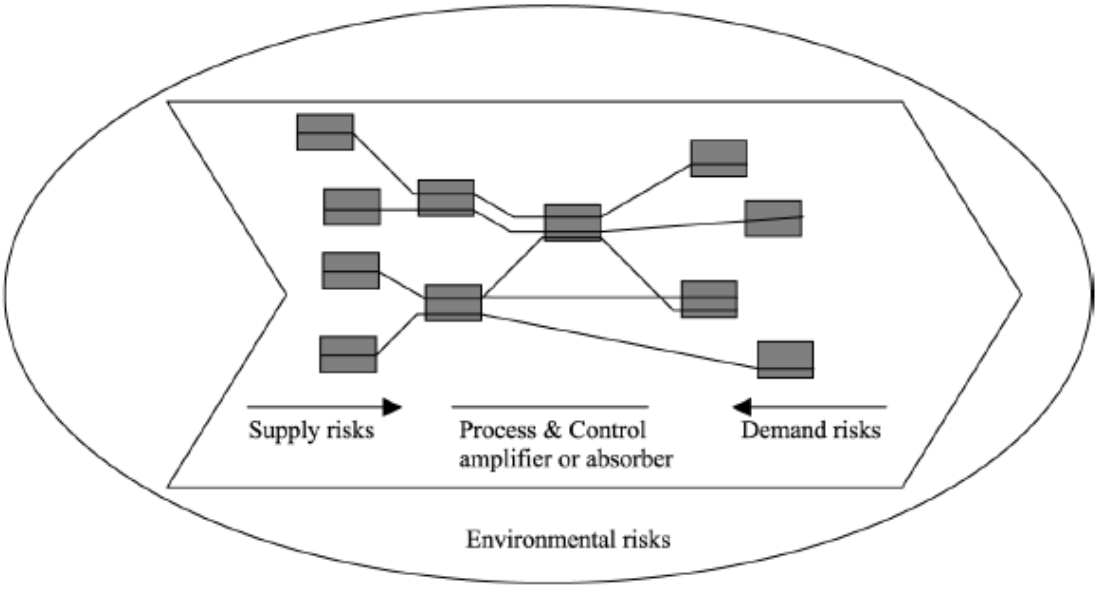


Figure 12: Supply Chain Risk Sources (Jüttner 2005, p. 123)

As visualized in Figure 12, Jüttner (2005) separates the internal risks into two categories, 'process' and 'control' risks and states that the internal risks either work as an '*amplifier'* or as an '*absorber'*, referring to either sufficient or insufficient management of these risks. Christopher and Lee (2004, p. 3) also refer to this (amplification / absorption) effect; they termed it 'chaos risks'. "*The complexity and uncertainty within a supply chain can also increase the 'chaos' risks within the supply chain. These chaos effects result from overreactions, unnecessary interventions, second guessing, mistrust, and distorted information throughout a supply chain (ibid.)*".

If proper control mechanisms are put in place by a supply chain partner, then the impact of a supply risk is reduced. If insufficient control mechanisms are put in place, then a supply risk is amplified and can have a severe impact on the companies' and supply chain performance. Following our definition of SCDRM as stated above, the performance is specified as '*profitability and continuity for the whole supply chain*'.

In Table 3, the supply chain risk sources (supply, process, control, demand and environmental risks) are defined (also: Figure 12). The definitions are taken over from Jüttner (2005), who investigated and compared the different supply risk sources and their categories based on consultation of relevant scientific literature and extensive empirical research. Jüttner (2005) adopts a "supply chain

orientation" and notes that the pathway of supply and demand risks is not limited between two members of the supply chain; "*Supply and demand risks describe the direction of potential disruptive effects (from supplier of raw materials to the end consumer or vice versa) and are not restricted to dyadic relationships between two directly related vendor and customer organizations.*"

Supply Chain Risk Source	Definition (Jüttner 2005)
Supply Risk	Supply risk is the uncertainty associated with supplier activities and in general supplier relationships
Demand Risk	Demand risk is any risk associated with the outbound logistics flows and product demand
Process Risk	Processes can either amplify or absorb the effect of risks in the supply chain and refer to the design and implementation of processes within and between the entities in the supply chain
Control Risk	Supply chain control mechanisms like decision rules and policies regarding order quantities, batch sizes and safety stocks can either amplify or absorb risk effects
Environmental Risk	Environmental risk sources comprise any external uncertainties arising from the supply chain

Table 3: Supply Chain Risk Sources Defined

A different model of SCRM is proposed by Peck (2005, p. 218), it distinguishes risks manifesting at four different levels (Figure 13). The model has similarities with the model of Jüttner (Figure 12), both models can be used to 'design and develop the serious game' (in the introduction, game or debriefing). Furthermore, these two models/schematics can each have their benefits for 'facilitating learning' about different types of risk and are therefore both discussed in this paragraph.

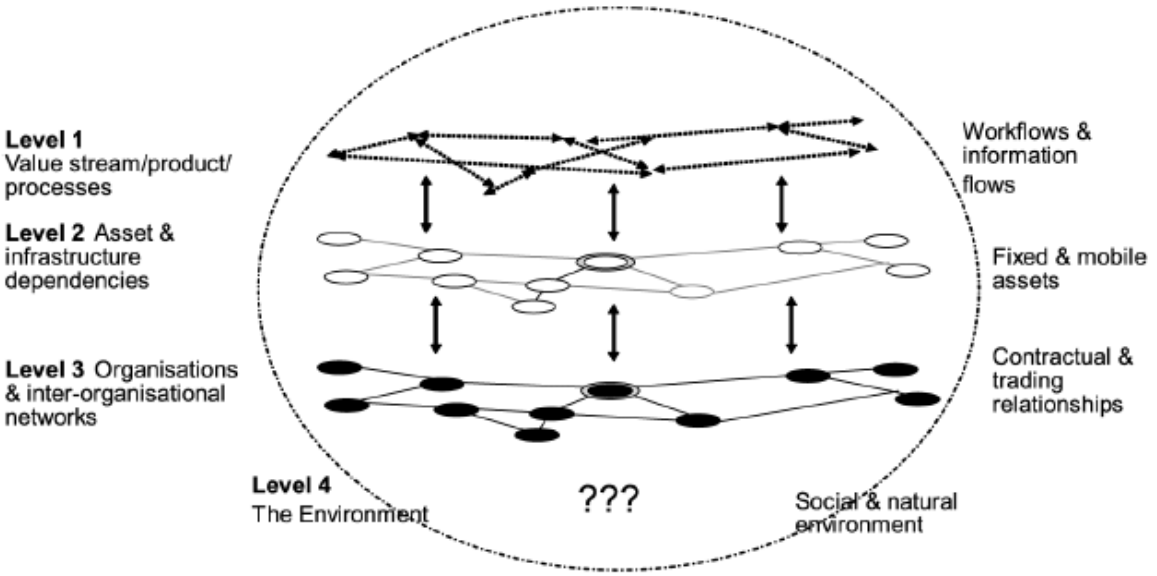


Figure 13: An integrative model of a supply chain as an adaptive system (Peck 2005, p. 218)

The difference in these two models is that Jüttner (2005) takes a *horizontal* view on risks (Figure 12) and distinguishes five types of supply chain risk sources, where Peck (2005) distinguishes four *vertical* layers of risk (Figure 13). Jüttner (2005) basically takes the actors as the unit of analysis in his conceptual model when classifying risk. Peck (2005) takes the technical system as the unit of analysis. Both approaches have their benefits and are presumably chosen by the authors to support the specific research project undertaken and presented in their papers. Recognizing that supply

chains have become complex socio-technical systems, these views can have unique benefits; both different layers and types of risk can be incorporated in the SCRMG.

Lazzarini *et al.* (2001) introduces the concept of 'netchain analysis' (NA) and states that the *horizontal* view refers to Network Analysis (NA) and the *vertical* view refers to Supply Chain Analysis (SCA). "A netchain is a set of networks comprised of horizontal ties between firms within a particular industry or group, which are sequentially arranged based on vertical ties between firms in different layers.

Lazzarini *et al*. (2001) combine horizontal and vertical interdependencies: "supply chain analysis suggests vertical interdependencies". "Unlike SCA, NA is not particularly concerned with vertically organized ties, but rather with horizontal relationships between firms belonging to a particular industry or group". The relevance of concept of 'netchains' is a reason to incorporate both elements from Jüttner (2005) and Peck (2005) in the Supply Chain Risk Management Game.

The supply chain risk sources overlap, an *external* (environmental) risk can result into a supply or demand risk, which then becomes *internal* to the supply chain. In the model of Peck (2005), an environmental risk at level 4 can result in a risk at level 3, 2 and/or 1. Hence, the time dimension influences risks. What is perceived to be an environmental risk can become a supply or demand risk in the future.

The relation between uncertainty and time is illustrated in Figure 14. According to Rosenhead (1989), uncertainty (nonlinearly) increases over time, what implies that the risk management process must a continuous effort in the chain. The pace of this continuous risk management process is then determined by the dynamics of the supply chain; the 'industry dynamics' (Ritchie & Brindley 2007). In this view risk management is a 'snapshot' with limited validity.

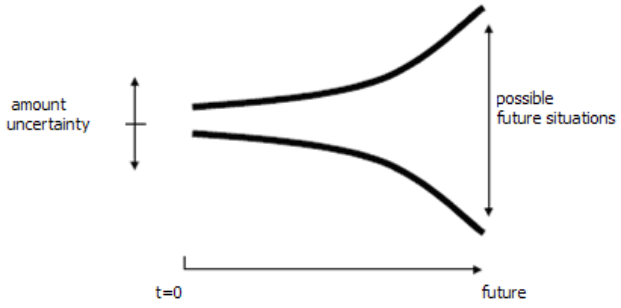


Figure 14: Uncertainty increases over time (Rosenhead 1989)

The supply chain risk sources and two different models are treated, which can be used to map, indentify, and categorize risk. The next paragraph will further elaborate on the risk assessment process, which is the next step in the in 'supply network risk tool' (Figure 10 – **step 3**).

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG incorporates supply, demand, process, control and environmental risk
- SCRMG incorporates risk at different levels
- In the SCRMG, risk management is a continuous effort

3.2.3 Asses risk

After mapping and identifying risk, the next step is to 'asses risk'. The "*process of risk assessment is usually broken down into three stages*", namely 1) risk identification, 2) risk estimation and 3) risk evaluation (White 1995, p. 36; Blackhurst 2008, p. 145). Some authors include 'risk monitoring' as an activity in the risk assessment process (Hallikas *et al*. 2004)[11]. A conceptual model with the three stages of risk assessment process is presented in Figure 15.

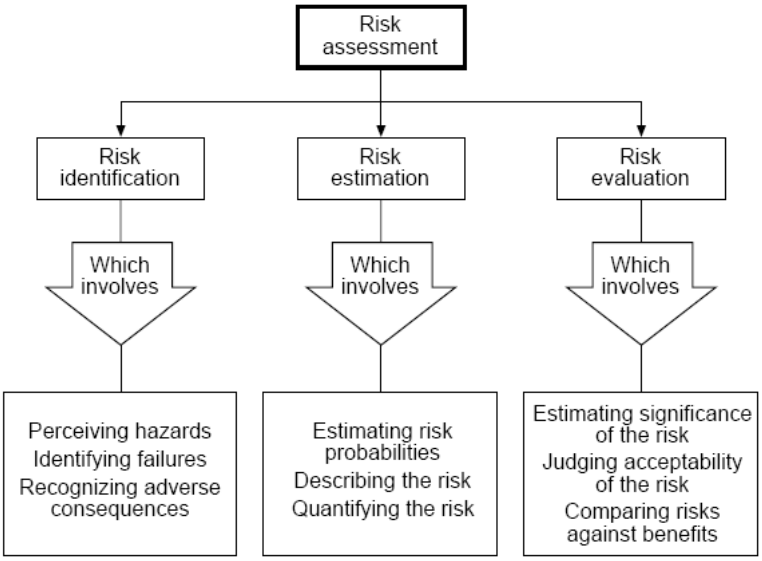


Figure 15: The process of risk assessment (White 1995, p. 37)

The risk identification stage involves 'perceiving hazards', 'identifying failures' and 'recognizing adverse consequences'.

One method to do this is called Failure Mode and effects analysis (FMEA), which "*essentially is a systematic brainstorming session aimed at finding out what could go wrong with a system or process* (White 1995, p. 36)". The need to brainstorm with supply chain partners is also pointed out by Harland (2003) "*The specific risks that will be considered for the particular problem/product should be identified, through brainstorming with other actors in the supply network*." Waters (2008, p. 142) explains the use of FMEA; "*it starts by listing every activity in the supply chain and systematically identifying the ways in which each element can fail – effectively using a process analysis to produce a risk register. A 'risk priority number' is calculated through assigning a subjective score (between 1 and 10) to three factors; 1) the probability, 2) severity and 3) likelihood that remedial action can be taken before the failure becomes critical*". These numbers are multiplied and "show where managers should start looking for remedial action".

The models of Peck (2005) and Jüttner (2005) can be used in order to map and categorize 'what could go wrong', for instance in a 'systematic brainstorming session', that requires "expertise and sound prior knowledge of the system under analysis (White 1995)". In such a brainstorming session, the models of Peck (2005) and Jüttner (2005) provide a starting point to discuss different 'failure

[11] One can argue that the 'risk monitoring' process is essentially again the risk identification stage. The risk assessment cycle starts over.

modes'. These 'failure modes' can be classified *vertically* (in different levels (see Figure 13)) and/or *horizontally* (in different supply chain risk sources (see Figure 12)).

In the problem exploration (2.2) some problems with quantifying risk were briefly addressed, when it was mentioned that an 'important issue from the field of risk management are problems with quantifying the probability and impact of a risk, due to limited or incomplete information'. These issues relate to the 'risk estimation stage'.

The risk estimation stage involves 'estimating risk probabilities', 'describing the risk' and 'quantifying risk' (Figure 15). "*Once risks are identified, their impact and probability must be assessed* (Blackhurst *et al.* 2008)". The risk diagram is a tool to conduct a 'risk likelihood/impact analysis' and "can be helpful in this respect" (Hallikas *et al.* 2004), it is a tool to support supply chain risk analysis (Jüttner 2005).

If the risks are identified, either with brainstorming techniques or more formal methods, the identified risks can be visualized in the risk diagram according their impact and probability. The quantitative definition of supply chain risks is then expressed as Supply Chain Risk = Probability (of an event) * Business Impact (or severity) of the event (Knemeyer *et al.* 2008; Zsidisin *et al.* 2004; Harland *et al.* 2003). Harland *et al.* (2003, p. 53) report that managers tend to focus more on the magnitude of the loss than on the probability it will be realized.

The risk diagram is presented in Figure 16.

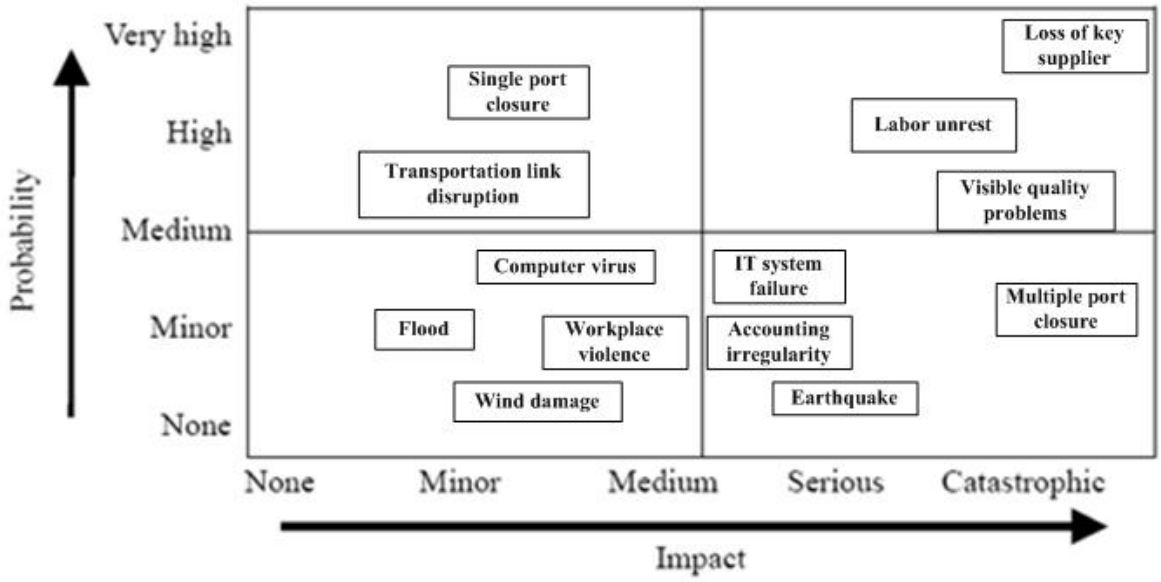


Figure 16: Risk Diagram (Blackhurst *et al.* 2008, p. 53; also: Hallikas *et al*. 2004; examples from Sheffi (2005, p. 32)

In the risk diagram the impact ranges from 'none' till 'catastrophic impact' and the probability ranges from 'none' till 'very high'. Basically, two important questions are answered in the risk diagram; the first question is: How likely is it that an event will occur? "The likelihood of an event occurring depends partly on the extent of the *exposure*[12] to risk and partly on the likelihood of a trigger that will *realise* the risk (Harland *et al*. 2003)". In similar lines, Hammant and Braithwaite

[12] = vulnerability (synonym).

(2007, p. 98) mention that identifying and addressing risk is a "huge and complex problem", that starts with "*intrinsic vulnerability of the supply chain (its exposure to risks) and its resilience to the various risks that it may encounter (ability to ride the shocks)*".

Resilience is defined by Peck (2005, p. 211) as "the ability of a system to return to its original [or desired] state after being disturbed". Vulnerability is defined by Peck (2006): "exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain". The reliability of the supply chain can then by described as a function of vulnerability and resilience.

The second question addressed by the risk diagram is; 'What is the significance of the consequences and losses (impact)?' There are multiple dimensions of loss; "financial, performance, physical, psychological, social and time loss (Harland *et al*. 2003, p. 52-53)". In the context of this thesis, the significance of losses is defined in terms of 'profitability and continuity for the whole supply chain', following our earlier stated definition of SCRM.

Several problems arise when the risks are addressed in the "semi-quantitative assessment (Hallikas *et al*. 2004, p. 53)" when dealing with *supply chain disruptions to normal activities*[13]. Two main problems are 1) data about the probability of occurrence is required and 2) data about the impact is required[14]. Especially in a network (multi-actor) situation, both probability and impact are difficult to address. In a network situation multiple actors are dependent on each other, and the concept of visibility limits their understanding of the risks up-or downstream the chain. Visibility is treated beneath. In the supply chain context actors are 'reciprocal' dependent on each other, in the endeavour to ensure 'profitability and continuity'. This dependency and (possibly) "*goal incongruence* (Jüttner 2005)" require a soft approach to asses risk. In an (extreme) soft view, risk is seen as a social construct (de Bruijn & ten Heuvelhof 2004).

The extension of the risk assessment process (from a single actor to a multi actor situation) can be supported by the risk diagram. The risk diagram is a tool for risk estimation and can be used after the brainstorming sessions in the identification phase. The risk diagram can be used to communicate about risks within a single organization or between supply chain partners.

Limited visibility

The concept of 'limited visibility' is important throughout the risk assessment process (Figure 15) and also limits the ability for organizations to map all risks –from a supply chain orientation / systems perspective- (as shown in Figure 12 and Figure 13). According to Christopher and Lee (2004, p. 6) a "lack of visibility leads to a "lack of confidence" a "build-up of buffers" and "long pipelines". They constructed the 'risk spiral' that "*exists everywhere*", see Figure 17.

[13] The problem has been delineated in §3.2 when the distinction was made between 1) risk arising from problems with coordination supply and demand and 2) supply chain 'disruptions to normal activities', following Kleindorfer's (2005, p. 1) distinct categories of risk in supply chains.

[14] These problems are similar to the critique on Utility Theory (see 3.1.4 Other explanatory theories). The critique on Utility Theory is basically that it –falsely- assumes 'the full-informed rational actor'.

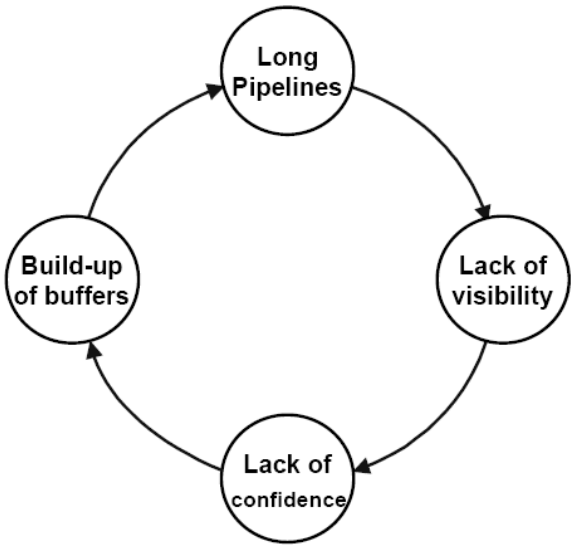


Figure 17: Risk Spiral (Christopher & Lee 2004, p. 6)

The lack of visibility results in sub-optimal supply chain performance (long pipelines). The lack of visibility in the supply chain is a result of what is referred to by de Bruijn & Ten Heuvelhof (2004) as the 'closedness' of actors in a network situation: actors benefit from behaving opportunistically by not sharing all information about the risks they are exposed to, due to 'goal incongruence' (Jüttner 2005). The lack of visibility is confirmed by research of Jüttner (2005, p. 132), a large part of the surveyed managers (44%) stated organizations are "never/hardly never encouraged to share information on their exposure to specific risks". The solution to 'break out the spiral' is to improve visibility and improve confidence.

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG incorporates risk identification
- SCRMG incorporates risk estimation
- SCRMG incorporates risk evaluation
- SCRMG incorporates 'vulnerability'
- SCRMG incorporates 'resilience'
- Players experience limited visibility
- Players can behave opportunistically

3.2.4 Manage risk: SCRAM-model

The fourth step in 'Figure 10: Supply network risk tool (Harland *et al.* 2003, p. 56)' is to 'manage risk'. Numerous approaches are mentioned by managers. The approach is to design and develop the SCRMG is use an existing framework. The Supply Chain Risk Analysis and Management model is developed by Deloitte Consulting (Treur 2008). The model incorporates 13 strategies to reduce risk on 9 categories of risk. These 9 categories include a total of 67 risk factors. These categories are based on the multilayer model of Peck (2005, see Figure 13) which is discussed in paragraph 4.2.2. The value stream/product or process (Peck 2005, level 1) is incorporated through the Supply Chain Operations Reference (SCOR) model *version 8.0* (Supply Chain Council 2006). In Table 4, the strategies, the risk factor categories and their reference are listed.

As of spring 2009, the new SCOR-model (version 9.0) incorporates 'risk' in the four main processes of supply chain management: source, make, plan and deliver. The SCOR-model version 9.0 "enables to manage supply chain risk process (Supply Chain Council 2009)". The new model incorporates 'source risk', 'make risk', 'plan risk' and 'deliver risk'. "*While much of the underlying content of the Model has been used by practitioners for many years, the SCOR-model provides a unique framework that links business process, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities* (Supply Chain Council 2009)."

Reference to risk factor category	SCOR-model Level 1: Peck (2005)				Level 2: Peck (2005)	Level 2: Peck (2005)	Level 2: Peck (2005)	Level 3: Peck (2005)	Level 3: Peck (2005)
Risk factor category									
Strategy	**Plan**	**Source**	**Make**	**Deliver**	**Transport**	**IT & Comm.**	**Sites & Facilities**	**Suppliers & Third parties**	**Customer**
1. Capacity			x				x		
2. Inventory		x		x					
3. Improve forecasting accuracy	x								
4. Raise shipment visibility	x	x			x				
5. Raise internal visibility	x		x	x					
6. Prepare continuity plans and/or back up arrangements					x	x	x		
7. Network modelling					x		x		
8. Reinforce contracts								x	
9. Localize sourcing		x						x	x
10. Alternative logistics		x		x	x				
11. Acquire multiple suppliers, or align the strategy with one supplier		x						x	
12. Standardize products and/or processes	x		x				x	x	
13. Postponement of production	x								x

Table 4: Link between strategy and risk factor of the SCRAM model (after Treur 2008)

The 'x' marks which risk factor categories are *reduced* by the risk strategy. An important limitation of the model is that it does not include Peck's level 4 risks: external risks.

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- SCRMG incorporates different risk management strategies
- SCRMG incorporates different levels of risk
- SCRMG incorporates different risk factors

3.2.5 Risk strategy

After mapping, identifying, assessing and managing risk, the last steps to be taken (Figure 10) is to form and implement a risk strategy[15]. "An effective disruption-management strategy is a necessary component of a firm's overall supply chain strategy (Tomlin 2006, p. 655)". There is a need to integrate risk management along the supply chain. As Christopher and Peck (2004) put it; *"Risk management requires a new focus on managing and mitigating risk which extends beyond the four walls of a plant".*

Integration

Waters (2008, p. 86) suggests five levels of integration for Supply Chain Risk Management, based on the following rationale; "*a risk might appear within an individual organization, but the links between organizations automatically transmit its effects to other members of the chain[16] […] the reliability of the whole supply chain depends on its weakest link […] so, all members of a chain should work together for their mutual benefit, reducing the overall vulnerability*". Improving visibility is a "strategic move to a fully integrated risk management approach (Waters 2008, p. 197)". According to Kouvelis *et al*. (2006, p. 37), "integration is the essential theme of supply chain management". The five levels of integration are (Waters 2008);

- Level 1. No significant risk management is done anywhere in the supply chain
- Level 2. Some basic risk management is done within the separate activities of logistics within some organizations
- Level 3. Risk management is done for the broad logistics function, but is contained within separate organizations
- Level 4. Risk management is extended and coordinated along the supply chain to include first-tier suppliers and customers
- Level 5. Risk management is extended to the broader supply chain

The move from low to higher levels is by Deloitte (2006) referred to as a development towards 'risk maturity / risk intelligence'. Waters (and others) state that most companies still operate at level 2 or 3. Few companies seem to have reached higher levels (which are High Reliability Organizations, see §4.2.1). According to Jüttner (2005, p. 139), "the concept of SCRM is still in its infancy, and understanding of SCRM is patchy, both in terms of its key issues and its implementation". Therefore, it is not surprising that companies are still at lower levels of integration, which is confirmed by research of McKinsey (2006) and Aberdeen Group (2008).

General risk management strategies

'Risk management systems and actions' is identified by Paulsson (2007, p. 344) as "of special significance from a *disruption risk point of view*". Next to reducing risk –the strategy used in the SCRAM-model-, four other high level strategies can be used to manage the risk. These include: transferring risk, reducing (mitigating / eliminating) risk, taking (accept) risk and subdividing risk into individual levels for further analysis (Hallikas *et al*. 2004). According to Jüttner, Peck and Christopher (2003), the reducing strategy can be subdivided into avoidance, control, cooperation and flexibility

[15] This sequence can be debated. The model of Harland *et al.* 2003 is used because it incorporates all necessary steps.

[16] Waters (2008) mentiones the existence of a knock-off (domino) effect.

strategies. Adopting the view of Jüttner, Peck and Christopher (2003) -that cooperation is indeed a risk reducing strategy- the following risk management decision tree is constructed (Figure 18).

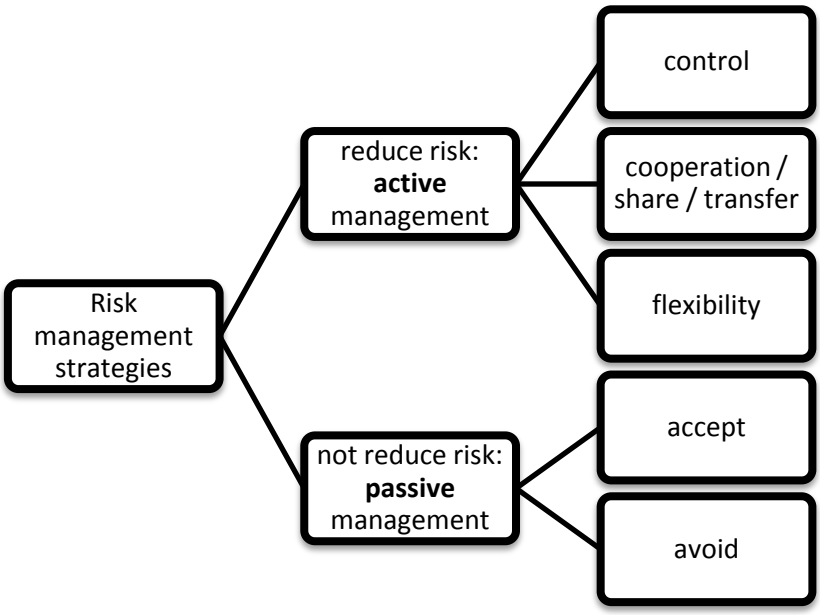


Figure 18: Risk management decision tree

The decision illustrated in the tree is the decision to *actively* or to *passively* manage risk[17]. Another categorization is 'preventive' (ex-ante) or 'interceptive' (ex-post) management (Gaonkar & Viswanadham, 2007). However, from a management perspective, the two categories of **active** and **passive** management seem of better use -in this specific project-. As Kriz & Hense (2006, p. 278) take into account in their 'list of quality criteria for a simulation game' (criterion #32): "the simulation encourages a variety of perspectives and change of perspectives". The participants should learn that they need to manage risk (pro-) *actively* instead of *passively* (also: Waters 2008).

Risk transferring

Transferring risk in a network is as follows explained (Hallikas *et al*. 2004): *"The network relationships often include transferring risks from one company to another. This may reduce the total risk if the company taking the risk can cope with it better than the company transferring it."* In contrary, sometimes risks are transferred to actors that are in worse positions to cope with risks. Following our definition of SCRM, this stipulates the need for 'collaboration and coordination', so as to ensure the right **allocation of risks**: "benefit and risk sharing (Harland *et al.* 2003, p. 60)". "In any economic exchange, people have to agree on how to divide costs, benefits and risks (Williamson 1985)". The concept of risk allocation is very important if a supply chain wide orientation is adopted. The economically best possible manner to manage risks is by the actor for which the costs of mitigation are the lowest. The costs of disruptions increase when risks 'fire' further down the supply

[17] In this view, avoiding risk is a *passive* risk management strategy. Further, 'cooperating', 'sharing' and 'transferring' risks are placed in the same box, because of the characteristic that these strategies require multiple actors.

chain. In addition to this, the 'focal company' is often blamed for the behaviour of their direct and indirect suppliers, the so-called 'reputation risks'[18].

Both the financial importance of reputation risks and fact that costs tend to increase when disruptions occur lower in the chain (thus closer to the end market), requires appropriate 'management of the interfaces', which is essentially based on the proposition that the individual companies, actors or systems are difficult to manage, because of the complexity and the specialist knowledge one needs. Therefore, one could focus on the management of the interface between these companies, actors or systems. For SCRM, this means, the coordination of outbound and inbound logistics, transportation and communication between the chain members and all other processes. Furthermore, -*from a supply chain wide orientation*- risk should be managed as quickly as possible, because of the increasing marginal costs of disruptions. From a single actor perspective, it can be beneficial to transfer risks to the downstream partner.

Eliminating risk can be achieved by stopping with the business activity; however, this is not always a reasonable option, especially if logistics/supply chain activities are an integral part of the business activities. To take (accept) a risk is not a 'good decision' according to Tomlin (2006); "Firms that passively accept the risk of disruptions leave themselves open to the danger of severe financial and market-share loss" (as proven by Hendricks and Singhal 2008). Recall that no supply chain is totally risk free; there is always 'inherent risk', which is discussed in paragraph '3.1.1 Normal Accident Theory'. In other words -*contrary to desires*- "there is no such thing as zero-risk (Harland *et al*. 2003, p. 54)."

Economic perspective

The economic trade-off between taking (accepting) and reducing (proactively managing) risk is visualized in a model of Husdal (2007). A rational decision maker will reduce (mitigate) risks till the costs of disruptions are lower than the costs of mitigation, this point is the intersection in Figure 19. Companies which are on the left side of the intersection should turn to SCRM practices. Husdal (2007) further explains the economic rationale of the figure: "*it could be said that the marginal cost of disruptions initially will fall sharply while the marginal cost of countermeasures will only rise slightly. The more countermeasures that are put in place, the less extra benefit is achieved for each marginal investment in reliability. This is in line with the traditional way of thinking in contingency planning, that it often only takes small changes or investments to make a considerable impact. Full and 100% reliability however is very costly, due to the unpredictable manner of the potential disruptions*." In this thesis it is argued that 100% reliability is not possible, because accidents are 'normal' in complex socio-technical systems (see 3.1.1 Normal Accident Theory).

This economic trade-off is visualized in Figure 19.

[18] "*A Fortune 25 chief executive officer is worried that he might see his company's name on the cover of the New York Times because a small unknown fourth tier supplier of trucking services in a low cost country is using child labor at no pay* (Cavinato 2004, p. 383)".

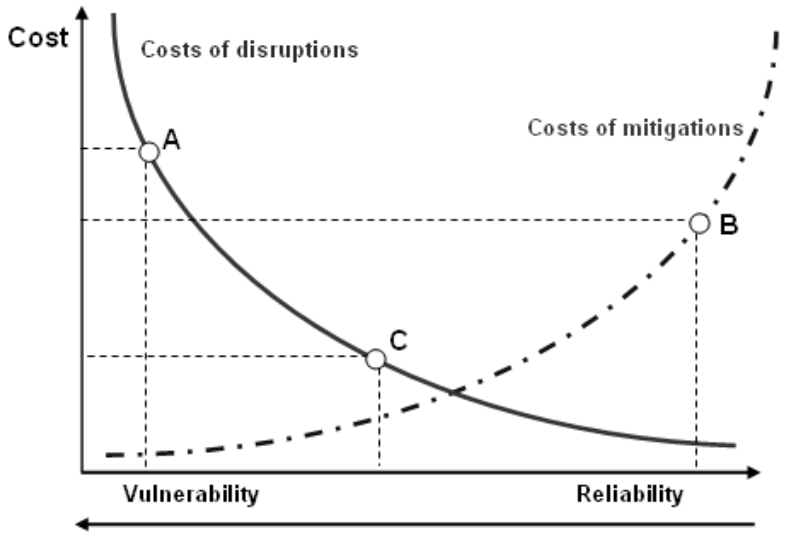


Figure 19: Cost of disruptions vs. cost of mitigations (Husdal 2007)

Next to the development to more integration, SCRM should contribute to resilience, which reduces the impact of an event. According to Sheffi (2005), "the essence of resilience is the containment of disruption and recovery from it." Sheffi (2005) continues by explaining the link between culture and resilience. "*Culture contributes to resilience by endowing employees with a set of principles regarding the proper response when the unexpected does occur, and when the formal organization's policy does not cover the situation at hand or is too slow to react*."

The general steps and strategies for mitigating risk are not directly applicable to each individual company. The risk management process must be tailored to the specific situation of an organizations supply chain, its business goals, products and "risk appetite (COSO 2004)": there is "no one size fits all solution (Kleindorfer & Saad 2005)".

In our perspective towards the management of disruption risk in supply chains, actors choose the appropriate risk management strategy on the basis of three important factors: costs and exposure covered and 'risk appetite'. The 'risk appetite' of organizations reflects the organizational perspective and culture towards risk taking. As Harland *et al.* (2003, p. 54) report: *"businesses and individuals trade-off risks and benefits every day, performing some form of balancing of risk and reward. The way that they make these trade-offs depends on what are deemed to be acceptable levels of risk, the size of the benefit and the attitude of the organisation to risk taking".*

The following input for the design requirements of the SCRMG has been identified in this paragraph:

- Players can integrate risk management in the supply chain
- SCRMG incorporates '*vulnerability*'
- SCRMG incorporates '*resilience*'
- SCRMG incorporates risk management strategies that can be implemented by a single actor
- SCRMG incorporates risk management strategies that can be implemented by multiple actors
- SCRMG incorporates cost of disruptions
- SCRMG incorporates costs of mitigations

- Players must trade-off the costs of disruptions versus the costs of mitigations

3.3 Serious gaming as a learning method

The theoretical background (§3.1 Theoretical Background) and the steps to be taken in proactive management of Supply Chain Risks (§3.2 Supply Chain Risk Management) have been discussed. In the introduction (Chapter 1) the arguments to use serious gaming as a learning method about SCRM were briefly mentioned. *The goal of this project is to design, construct, test and evaluate a serious game that facilitates learning about the key concepts of Supply Chain Risk Management.*

In this paragraph the arguments to use serious gaming as a learning method are discussed. First, in §3.3.1 the arguments to use serious gaming are recalled and worked out. Next, §3.3.2 clarifies in which way serious gaming '*facilitates learning*'.

3.3.1 Arguments to use serious gaming

Within this thesis a serious game about SCRM is designed and developed. There are four main arguments to use serious gaming as a tool/method to 'facilitate learning' about the key concepts Supply Chain Risk Management. The four arguments now formulated and clarified:

1) serious games simulate an environment that allows players to experiment safely

Van Dam[19] (2007) has written the book titled "25 best practices in learning and talent development" and poses the following question: "How do you craft an engaging classroom learning experience that will increase the retention of knowledge and maximize limited learning dollars?". Van Dam answers this question with: "The key is to create a situation in the classroom that simulates a real-life experience". In similar lines, Mayer and Veeneman (2002, p. 3) state that games "are a simplification and condensation of the real system, allowing participants to experiment safely with (future) decisions [...] and reflect on the outcomes".

2) serious gaming is an interactive learning method

To educate (future) logistic managers on SCRM "an interactive learning method is to be preferred above a traditional learning method, like textbooks, case studies and traditional lectures (Qualters *et al*. 2006, p. 2)". Furthermore, Qualters *et al.* (2006, p. 3) report that "*simulation and gaming are good teaching tools, because the participants are required to be directly involved in the decision making process and thus, allow for learning of interactive decision making*." The learning process is further described in paragraph 3.3.2 with the learning cycle of Kolb (1984).

The interaction is also a reason why games are time-efficient: "Games allow us to develop and test strategies, test alternatives and their impact upon our goals in a much tighter, responsive time frame than the real world (Qualters *et al.* 2006, p. 3".

3) serious gaming is able to learn people about logistic networks

Serious games are able to learn people about logistic networks (Hofstede 2006, p. 544; Mehring 2000). Hofstede (2006) writes that: "to learn about the practice of chains and networks, simulation

[19] Dr. van Dam is the Global Chief Learning Officer for Deloitte Touche Tohmatsu.

gaming is presented a suitable means". In paragraph 4.1 and 4.2 our focus towards a 'supply chain wide orientation' is stressed. This holistic perspective on the topic is also pointed out by Hofstede, (2006, p. 544) Hofstede adopts the term 'simulated netchains[20]' and writes that; "*Although such simulation games are necessarily simplifications, their crucial message usually comes across well. This message is that 'the netchain as a whole is potentially a viable level at which to think of organizing'*"[21].

A more practical reason that serious gaming is able to learn people about logistic networks is based from the fact that numerous games about logistics networks have been successfully used. In 1961, Forrester has created the successful 'Beergame' (as reported by Sterman 1989) probably based on his assumption that the 'bullwhip-effect' could best be learned by a game, and not by traditional lectures. Van Dam (2007) also states that normal types of learning are not the most effective way of learning: "*With the wide acceptance of technology usage over the past 10 to 15 years, many classroom programs have evolved into presentation based PowerPoint ™ slides. Research has indicated that this is not the most effective way to learn, build skills or, more importantly, retain knowledge. Simulating reality provides a context for learners to retain the information and develop skills. A simulation requires the participant to become intrinsically involved in the situation by completing a task or deliverable using data and inputs as they world appear in a real work environment.*"

4) serious gaming is especially suited for the target audience

Serious gaming is especially to the target audience: 'Generation Y' (Mehring 2000; Qualters *et al*. 2006; van Dam 2007). The target audience will largely consist of bachelor or master level students or young professionals. These groups all belong to 'Generation Y'. The people referred to as 'Generation Y' are those born between 1978 and 1995 (Pham *et al.* 2008).
Generation Y is the generation after Generation X (1964-1978) and is sometimes referred to as the 'Google generation', the 'Millennial generation' or the 'Net Generation'. This generation prefers a "communal, active manner using trial and error approaches (Qualters *et al*. 2006, p. 2)" for learning.

3.3.2 Serious gaming facilitates 'learning'

In §1.9, the goal of this project has been defined as: '[...] *to design, construct, test and evaluate a serious game that facilitates learning about the key concepts of Supply Chain Risk Management*'. The way in which serious gaming facilitates learning about SCRM is explained by the concept of 'experiential learning'. As Mehring reports (2000, p. 1);

> *"Experiential learning is well suited to study supply chains since it has been used successfully to develop a systems view, develop problem solving skills, and to practice integrating and synthesizing concepts. The instructor is a guide, who provides context, poses problems, suggests analyses, scores solutions, and summarizes lessons".*

[20] The concept of 'netchain' has been first introduced by Lazzarini *et al*. 2001, as discussed in §3.2.2
[21] The supply chain wide 'level of organizing' is incorporated in our definition of SCRM (see §3.2.1), in the various models discussed (see §3.2.2) and in the strategy for effective Supply Chain Risk Management: 'integration' (see §3.2.3).

The 'systems view' needs to be developed because SCRM requires a focus "beyond the four walls of a plant" (Christopher & Peck 2004). To describe the learning process in experiential learning, the learning cycle of Kolb (1984) is presented (Figure 20), this is the "standard conceptual framework for describing learning processes (Meijer 2009)".

"The learning cycle emphasizes the sequence of experimentation, experience, reflection and conceptualization. Gaming simulations follow the learning cycle once or several times, depending on the design of the gaming simulation (Meijer 2009, p. 57-58)".

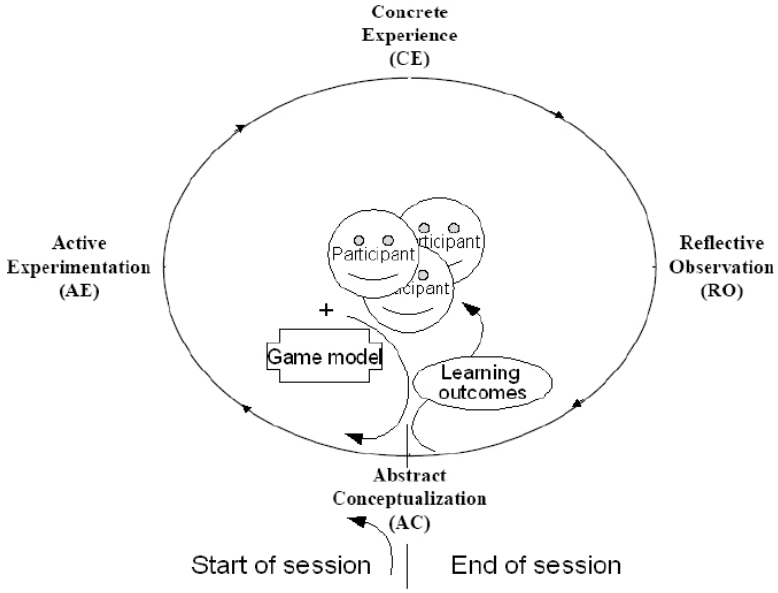


Figure 20: Kolb's learning cycle, (after Kolb 1984), with start and end of session, game model and participants (Meijer 2009, p. 58)

"Before playing, participants are introduced to the gaming simulation design. They conceptualise what their task will be and how to win (AC). Then the session starts and participants experiment actively with the roles, rules and incentives of the gaming simulation (AE). The active experimentation leads to a concrete experience of the gaming simulation session (CE). During the debriefing participants reflect upon the experience (RO) and discuss how to conceptualise this (AC) in the group, moderated by a game leader. Learning outcomes are the spin-off of the debriefing (Meijer 2009)*."*

The Supply Chain Risk Management Game consists of three elements: an introduction, the game and a debriefing (see Figure 2). In terms of Kolb (1984), the introduction is the 'AC phase'. The 'AE' and 'CE' phase is the time participants play the game. The debriefing is the 'RO phase'.

Gaming versus traditional learning methods

According to van Dam (2007): *"gaming can be an excellent preparation for business. Serious gamers are likely to be: more skilled and multi-tasking, agile in making decisions, evaluating risks and managing dilemma's, flexible and persistent in the face of change, and highly skilled in social networking and team activities".* About the implications for learning: *"Gen Yers can learn from facilitated sharing of knowledge in a typical classroom environment. Yet, Gen Yers prefer to learn in networks or teams, using multi-media and expect to be entertained and excited during the learning intervention. Experiential learning is important to them. Therefore, it is the expectation that business*

simulations will become the next wave of games which can help familiarize young people with a business previously unknown to them."

3.4 Evaluation of Supply Chain Management games

In this paragraph a selection of serious games in the field of logistics / supply chain management is evaluated to answer research sub-question 2.4: **"In what way are risks incorporated in (a selection of) Supply Chain Management Games?"**

In this paragraph, first, the reasons to evaluate existing Supply Chain Management Games are discussed. Second, the selection process is reported. Third, the elements included in the evaluation are reported. Fourth, the similarities and differences between the games are discussed. Fifth, conclusions are formulated. Finally, the implications for the design of the SCRMG are discussed. The complete overview of the evaluation of existing SCM games is presented in Appendix B.

3.4.1 Six reasons to evaluate existing Supply Chain Management games

From a 'game designer's perspective', there are six reasons to evaluate existing Supply Chain Management games. The reasons are:

1) To gain **inspiration** for the game design;
2) To **save time** during the game design process by using and adapting (extensively tested) game components;
3) To **bridge (an expected) gap** between the 'list of requirements' and an end product[22];
4) To identify **opportunities**;
5) To **avoid pitfalls**, and;
6) To create a game that is **'unique'**.

Above mentioned reasons stipulate the need to evaluate existing Supply Chain Management games.

3.4.2 Selection process

A selection of existing games in the field of logistics / supply chain management is evaluated in this paragraph. Ten games are identified, based on desk research.

The first selection criterion is the use of computers in the gaming simulation. Fully computer supported games offer limited possibilities for use in a non-computer aided game; a *'paper game'*. In order to reach the specified learning goals, people must discuss and debate with each other to maximize interaction between participants. Further, in the relatively short time available for the initiation, design and construction phase (see Figure 5), a fully computerized game is not doable (and not desirable if negotiation and discussion contributes to the learning goals). These (and other) requirements are listed in Table 20: Complete list of design requirements.

The second selection criterion is that the game should be a 'supply chain' game. This means that in the game, products must be bought and sold in a trade-network.

The third criterion is that multiple players are involved in the game.

The fourth criterion is that data sources must be available.

[22] More on the link between design activities and the iterative character of the game design process in Chapter 4. More specific, the designer expects a 'gap' between the activities in the game design process (Figure 5).

The outcome of the selection process is a selection of ten games, developed by Universities and private companies around the world.

3.4.3 Elements included in the evaluation

In 'Table 17: Evaluation of existing serious games' (see Appendix B) first some general data is presented for administration purposes: the title, institute, reference and URL. Then the game is described by the purpose, audience and use of computers. Because 'supply chain' games are evaluated, the product / components that are traded in the game and the actors in the game are listed. Then, game-elements are listed, such as the main dilemma or trade-off and how players can win the game. Further, the risks, competition and external events are described. In category 'miscellaneous' other findings are noted. Lastly, it is reported if the author has actually played the game or read a publication about it.

3.4.4 Discussion on SCM games

When reading about these games and playing some of them, several observations can be made.

First, the games differ widely in their use of computers, number of actors, number of players, products, competition and the incorporation of risks in the game, see Table 17. Each game is unique, because it is built for a different audience, for different (learning or research) objectives and these games have been built by different people across the globe. Not to mention the differences in game length, design and development resources, success etc. In mathematical terms, one can argue that there are 'unlimited degrees of freedom'.

Second, the learning objectives range from specific objectives (i.e. *importance of information sharing when dealing with demand uncertainty*) to more general objectives (i.e. *to show the importance of the logistics function*). Several games try to explain the importance of management between organizational functions. For instance, Korhonen, Pekkanen and Pirttilä (2007, p. 1) report: "*inherent differences between functions and how they cause problems and potential sub-optimization in a supply chain [...] make improvement more difficult. Because of this, there is a need for different functions to learn about interrelationships in the supply chain and learn to work cross-functionally.*"

Some game elements that seem beneficial for the Supply Chain Risk Game are marked green in Table 17 (presented in Appendix B). The things that are not beneficial for the game are marked red. The choice to mark things green or red is made by the designer, keeping the results of paragraph 4.2 in mind. In that paragraph it is shown that there are multiple types of risk, according to Peck (2005) and Jüttner (2005). Multiple types of risk should be incorporated to provide game session participants with a holistic perspective on Supply Chain Risks and the subsequent management issues.

3.4.5 Conclusions

Ten games are evaluated to answer research sub-question 2.4: **"In what way are risks incorporated in (a selection of) Supply Chain Management Games?"**

In games, uncertainty can be simulated by game components -such as the throw of a dice-. Therefore, to answer research sub-question 2.4, -next to risks-, uncertainties and uncertain events are also taken into account. Next, to answer research sub-question 2.4, games included in the evaluation are discussed.

In the Trust and Tracing Game (Meijer *et al*. 2008; Meijer 2009), players can either *trace* or *trust* their suppliers, and therefore have a risk to trace someone when it is not needed or to mistrust someone. There are financial consequences. In the Risk & Control game (Deloitte 2008b) players get a limited budget to implement 'controls' to reach certain goals. There are financial consequences if players over- or under spend their budget. In the Distribution Game (Supply Chain Consulting Ltd. 2005), risk is related to setting the right amount of production capacity. Too much, too little or no production capacity at all has financial consequences.

In Shortfall, risks are incorporated through 'event cards' that are drawn after each round of the game. These events will "affect game play for the next round", and "affect one or all tiers of your team" (Qualters *et al*. 2006). The goal and challenge of the board game titled Shortfall is; "maximizing profits with an increased awareness of environmental impact (Qualters *et al*. 2006)". In similar lines, the goal and challenge for players of SCRMG can be formulated as; '*maximizing profits while minimizing risk exposure*'. The commonality in both goals is the presence of a trade-off.

The Siemens Brief Case Game Supply Chain Simulator is a toolbox to construct different types of games. Mehring (2000) has constructed a game that is about matching supply and demand. The game CODEPRO (Korhonen *et al*. 2007) is played at the start of a 'supply chain management improvement program'. Players have to deliver products on time and without defects.

The Mango Chain Game (Zúñiga-Arias *et al*. 2007; Meijer 2009) incorporates uncertainties: "Risk allocation refers to three types of uncertainties present in the gaming simulation: (1) variability in the supply from the simulated producers, (2) quality loss with a chance of 1/6 in each transport stage, and (3) uncertainty about the consumer market price." In the Supply Chain Game (Involvation 2009), customer demand is uncertain (determined by the throw of a dice). In the Distributor Game (van Houten 2007), players are able to not pay for delivered products. Further, negotiation about prices implies the risk of paying of much for products. Lastly, the Beergame (Forrester 1961; Sterman 1989) is dedicated to Kleindorfer and Saad's (2005) category 1: 'matching supply and demand'. The Beergame has been played since the 1960ies by thousands of students and professionals.

3.4.6 Implications for the design of the Supply Chain Risk Management Game: focus on disruptions

As Zeng and Johnson (2009, p. 72) report about the Beergame: "the game has been played in different ways, from a board format for a couple of decades to today's on-line version, and modified into several variations (such as the 'Shampoo Game', Ludema 2008)." Chen and Samroengraja (2000) have created a variant of the Beergame. They report: "*We call the new game the stationary beer game, which models the material and information flows in a production-distribution channel serving a stationary market where the customer demands in different periods are independent and identically distributed. Different players, who all know the demand distribution, manage the different stages of the channel. Summarizing the initial experience with the stationary beer game, the paper provides compelling reasons why this game is an effective teaching tool*." Even an adapted version of the Beergame, with stationary demand -known by all players- is regarded as an effective teaching tool.

To construct a game that is ***unique*** and thus contributes to the existing family of SCM games, the design of the Supply Chain Risk Management Game should focus on Kleindorfer and Saad's (2005) category 2: "disruptions to normal activities". The (mis)match between supply and demand

(category 1 – Kleindorfer and Saad (2005)) can be included in the game, but as a result of the disruptions to normal activities.

Hendricks and Singhal (2008) have studied the effects of reported supply chain disruptions on shareholder value. Based on 838 publicly announced reported disruptions in U.S. newspapers, they conclude that "Supply chain disruption announcements are associated with an abnormal decrease in shareholder value of 10.28%".

For Deloitte, this may provide business potential, as their (corporate) clients will not turn to SCRM practices and invest in training their employees about the topic, if it does not affect shareholder value. The active management of Supply Chain Disruptions is not likely to increase shareholder value, but will rather prevent shareholder value to decrease. Hendricks and Singhal (2003; 2008) studied the financial impact of disruptions. They report (Hendricks & Singhal 2008):

> ***"The analysis of the shareholder value loss due to supply chain disruptions is valuable because it provides firms with a sense of the economic impact of poor supply chain performance. The evidence clearly indicates that ignoring the possibility of supply chain disruptions can have severe negative economic consequences. An obvious question for managers is what are the strategies for avoiding disruptions and/or mitigating the negative effect of supply chain disruptions?"***

Concluding, the design of the SCRMG will focus on 'disruptions to normal activities'. For companies operating and competing on a global level, disruptions are '*normal'* and have severe financial consequences. Another reason to focus on disruptions to normal activities is provided by Handfield *et al.* 2006): "*The level of awareness of the potential for disruptions, and the capability to respond, is the single greatest preventive action that organizations can take to prevent the effects of a major disruption from disrupting global operations.*"

Throughout this Chapter, research sub-questions have been explored. In Chapter 2, it has been argued that 'Research sub-questions are formulated for all the things we need to know to understand the design problem and necessary activities'. The author has reached a further understanding about the design problem and necessary activities. At the end of this chapter -in paragraph 3.4.6- several arguments to focus on 'disruptions to normal activities' have been provided.

Enough information is gathered to start with the design of the Supply Chain Risk Management Game. This is the topic of Chapter 4: Design and construction of the Supply Chain Risk Management Game.

4. Design and construction of the Supply Chain Risk Management Game

In Chapter 3 the problem has been analysed through an exploration of research sub-questions. The theoretical background has been explored (§3.1) and Supply Chain Risk Management (§3.2) has been further described. The arguments to use serious gaming have been recalled and worked out (§3.3) and a selection of games has been evaluated (§3.4). In this Chapter the game design will be provided. The game can be positioned in the family of serious games on logistics / Supply Chain Management as evaluated in §3.4 Evaluation of Supply Chain Management games.

In this chapter, first, the game design method will be described (§4.1). Second, the game design process will be described (§4.2). The game design process ends with the presentation of the final design.

4.1 Game design method

In §2.2 and §2.3 the game design method has been described and discussed. An overview of the phases and activities during the game design process (Duke 1981) has been presented in 'Figure 5: Duke's (1981) Game design process in alignment with the thesis structure and research questions'. The guidelines and the details of the design method are described in this paragraph.

To overcome errors that are a "threat to the validity of the game", some guidelines to help the designer while creating a game are suggested by Peters, Vissers and Heijne (1998). These guidelines will be followed. The guidelines and the manner how these are followed are listed in Table 5.

Guidelines	How are the guidelines followed?
Work systematically	- guidelines and game design process (Duke 1981) are followed - general design method is taken over from successful existing games - design choices are clarified in this thesis
Make clear deductions and small steps during the design process	- all design steps are reported. The adjustments after testing are logged (see Appendix C: Testing log). - The construction phase is split into two main parts. First, a simple trade network is constructed. Second, 'risk management' will be incorporated in the game (see Figure 25).
Check the validity explicitly: 'The concept of the game is presented to other persons and their opinion about the correspondence between the game model and the reference system.'	- the game concept is discussed with other game builders and they are asked to judge the game from their expert view: 'peer debriefing'. - the game concept is presented to future players: 'member check'. - NB: external validity is less important, as will be explained in paragraph 4.2.2.
Test the game extensively	- test activities will be conducted and logged (see Appendix C: Testing log)

Table 5: Guidelines to overcome errors that are a threat to the validity of the game (Peters, Vissers & Heijne 1998)

In similar lines, Duke (1995, p. 6) proposed six guidelines, based on lessons learned after designing and construction numerous (100+) serious games. The lessons are:

1) *Have precise and reasonable objectives for the game and stick closely to them;*
2) *Be persistent, do not be deterred by critics;*
3) *Employ teamwork effectively – a successful game requires an amalgamation of talents;*
4) *Remember that games serve well as devices for communication, so it is incumbent on the designers to identify who is trying to communicate with whom and, quite specifically, about what substantive content;*
5) *Remember that games serve poorly for predictive purposes;*
6) *Games are situation specific. If well designed for a specific client, the same game should not be expected to perform well in a different environment.*

Above mentioned lessons will be kept in mind. Further, these lessons stipulate various limitations of serious games regarding their usability and application. During the construction phase, the lessons and guidelines (Table 5) can be supporting. Further, -as explained in 2.3- the game design process (Figure 5) lacks detailed explanation on the step between activities 'formulation of list of requirements' and 'design'. These limitations of the game design method of Duke (1981) can be overcome by using the guidelines and lessons as reported above.

Paragraph outline
In this paragraph the first three phases are discussed. The SCRMG will be evaluated in Chapter 5, this is the 'use-phase' (see Figure 5). The initiation, design and construction phase described below;

Phase 1: Initiation phase
The design requirements of the game will be developed according to the game design method of Duke (1981). In this design process methodology, the development of a list of requirements is a phase in the game design process (Figure 5). In the 'initiation phase', the design requirements are formulated, based on the problem analysis. In the literature review (Chapter 4), the problem has been further analysed, through an exploration of the research sub-questions. The list of requirements is based on the literature review (Chapter 3) and conversations with TU mentors and interviews with Deloitte employees from both the 'Enterprise Risk Services' group and the 'Supply Chain Strategy' group. The interview outline and interview reports are presented in 'Appendix G: Interview '.

Phase 2: Design phase
During the design phase a conceptual design of the game is created. This has been done by going through an iterative, creative and episodic process that consisted of multiple cycles of design and discussion, with both the Deloitte and TU Delft mentors. The conceptual design consists of a description of five game elements: client, purpose, description of the roles and processes, linkages between these roles and the steps of play in each game round. For each element of the SCRMG (see Figure 2: Elements of the Supply Chain Risk Management Game) one or multiple key design choices have been made. The key design choices are presented in **bold**.

Phase 3: Construction phase
The construction phase consists of an iterative, creative and episodic process of constructing, testing and evaluating of the game. The design improves with each testing activity. In the construction phase, the design philosophy of 'rapid prototyping' is used because of the limited time available and because of the 'out-of-the-box' character of the design task. The testing phase will be crucial in order to remove errors and to fine-tune the value of the variables because of the chosen design

philosophy of 'rapid prototyping'. The changes after each test-session or test-activity are documented in the testing log (Appendix C: Testing log).

Two main design steps can be distinguished in the construction phase. First, the game-infrastructure is designed and developed, which is a trade-network in which three actors buy and sell products to make a profit. After testing this trade-network, the second design step begins. The second design step is the incorporation of 'risk management systems and actions' (Paulsson 2007) in the game infrastructure. The second design step contributes to the uniqueness of the game. This second design steps consists of six phases, as further described in paragraph '4.2.3 Construction phase'. In total, seven phases are distinguished which are visualized in 'Figure 25: Seven phases during the construction phase'. The episodic character of the design and construction phase is visualized by a circle in Figure 25.

4.2 Game design process

In this paragraph the game design process will be described. The initiation, design and construction phase are described, according to the sequence displayed in Figure 5.

4.2.1 Initiation phase

The initiation phase of the 'game design process' (see Figure 5) consists of a problem analysis resulting in a list of requirements. The problem has been introduced in Chapter 1, the research sub-questions and the design objective have been formulated in Chapter 2. Research sub-questions have been explored in Chapter 3. The list of requirements is constructed in the following way. In Chapter 3 the 'key concepts' of SCRM have been identified. These key concepts are translated into design requirements. The criteria whether a certain input is regarded as a key concept will be made –partly subjective- by the author.

To summarize the most important elements of the problem analysis, Duke (1981) suggests five game elements: client, purpose, subject matter, intended audience and context of use. These game elements are described next;

Client

Deloitte is the client of the SCRMG. Based on several interviews with Deloitte employees, different design requirements have been identified and taken into account. The initial game design (prototype) will be created based upon the requirements from category 'gaming', 'supply chain risk management' and 'practical'. All design requirements are presented in 'Table 20: Complete list of design requirements'. For Deloitte, some specific requirements are added. The most valuable way to use the game session is to deploy it at clients. In that case, additional steps have to be taken which are listed in the list of requirements (see Table 20: *'Deloitte*). For Deloitte, the SCRMG should be designed for 'adaptability'; it must be able to adapt the SCRMG for different purposes.

Purpose

The primary purpose of the game is to 'facilitate learning about the key concepts of Supply Chain Risk Management'. In §1.9, the following learning goals have been specified. 'Participants of the game session reach (a further) understanding about…

1) the theoretical background of SCRM;
2) different types of risk (internal, supply, demand & external risk);
3) the risk management approach in a network situation;
4) risk management strategies;
5) the need for collaboration and coordination in supply networks;
6) the need to manage risk pro-active instead of passive.

The result of reaching these six learning goals is that people develop a holistic perspective on Supply Chain Risks and the subsequent management issues.

Subject matter
Supply Chain (disruption) Risk Management. For an extensive overview of the topic, the reader is referred to §3.2. In short, the topic has been defined and delineated as (see §3.1);

> ***Supply chain disruption risk management is the process of systematically identifying, analyzing and dealing with risks to supply chains (=WHAT), through coordination or collaboration (=HOW) among the supply chain partners (=WHO), to reduce risk exposure (decrease supply chain vulnerability and increase supply chain resilience), so as to ensure profitability and continuity for the whole supply chain (=WHY).***

Intended audience
The Supply Chain Risk Management Game is intended for ***everyone that is interested in Risk, Supply Chain and/or Supply Chain Risk Management***. The *most likely* audience is Generation Y, which consists of students and young professionals. In the preceding parts of this thesis we have referred to (future) managers. This group of people is likely to benefit the most from participating in a game session, because they can use acquired knowledge about Supply Chain Risk Management in their (future) jobs. In similar lines, van Dam (2007) reports: "...*it is the expectation that business simulations will become the next wave of games which can help familiarize young people with a business previously unknown to them."*

Further, the SCRMG 'facilitates learning about the key concepts of SCRM'. More experienced people may protest to the way in which reality is simulated in the game and are not likely to learn much by participating in a game session if they are already familiar with the 'key concepts of SCRM'. Risk management is more complex than can be simulated in a game.

Concluding, participants should have a low pre-knowledge level (which is also a results from the interviews conducted with Deloitte employees, see Appendix G). However, some pre-knowledge about Supply Chain Management can be beneficial in order to understand what processes take place in the game.

In §3.3 it has been argued that serious gaming is especially suited for Generation Y. For Deloitte, the target audience are students (for recruitment purposes), Deloitte (young) professionals, and clients who want to train their employees.

Context of use
A learning context. The result of reaching the learning goals is that people develop a holistic perspective on Supply Chain Risks and the subsequent management issues. Based on the literature

review (Chapter 3) and interviews with Deloitte employees, the list of requirements has been formulated (see Table 20). Suggestions for embedding the SCRMG in a wider learning context (after Kriz & Hense 2006) are presented in the 'facilitator guide' (see Appendix H).

For Deloitte, specific requirements are listed. Especially in case of game session conducted at a specific organization, the game session needs to be (to some extend) customized to their specific issues and problems in order to maximize client value.

The most important elements of the SCRMG have been described. The remainder of this sub-paragraph is described the design requirements. The method to generate requirements is clarified, the categories and the data sources are explained, and finally a hierarchy is added to clarify the relative importance of the design requirements.

Method to generate design requirements
The design requirements are derived from parts of the literature review (Chapter 3), as formulated at the end of sub paragraphs in §3.1 and §3.2. The practical requirements are the design constraints and are formulated by the designer in cooperation with Deloitte professionals. The gaming requirements are derived from the evaluation of existing supply chain games (see 3.4) and the review of literature. Next, the design requirements are explained for each category;

- *Supply Chain Risk Management*
These requirements are derived from the analysis in §3.1 and §3.2, both the theoretical background as well as the more practical issues are taken into account. Some elements have been identified that separate Supply Chain Risk management from 'normal' risk management (i.e. risk transferring, collaboration, coordination).

-Gaming
The requirements in this category are derived from interviews with Deloitte management, the evaluation of existing games (see §3.4) and some more general design requirements (like balancing luck and strategy). For an overview of 50 general quality criteria for the design and evaluation of serious games, the reader is referred to Kriz and Hense (2006).

-Practical
Practical requirements may be regarded as design constraints. Two practical design requirements are derived from interviews with Deloitte employees. The game session can be attended by 4-10 people and the total duration of a game session should not exceed 4 hours. The designer added three more practical design constraints.

-Deloitte
If Deloitte uses the SCRMG for internal or external training purposes, additional requirements must be fulfilled. These requirements are based on several interviews with Deloitte management. The most important thing is to adapt and prepare the game according to customer demands. The game must be adapted to their specific risks, product/market combination, etc. Further, the situation and the pre-knowledge level of participants are important. Lastly, the introduction and debriefing must be customized and the exact requirements depend on the 'context of use', see above.

The quotes from the interviewees of Deloitte have resulted in the formulation of several need-to-haves. We will explain the link between the summaries of the interview reports (Appendix G:

Interview outline and interview reports) and subsequent formulation of need-to-haves (listed in 'Table 6') by several selected quotes and questions and answers.

Selected Quotes from six interviewees

In this section several selected quotes from six interviewees are presented. The quotes provide 'input' for the design choices, construction and final use of SCRMG – from the client's perspective. Each interview report is coded with a number, presented between brackets. This number corresponds with the number of the interview report as presented in Appendix G.

"Games can convey a message better than traditional learning methods. It is tangible, and you learn from games because you make mistakes. A simple game can have more educational value than a complex game. You have to convey the essential points." (#4)

"Companies think they are unique, and that the risks for companies are also unique. In reality this is not true. The problems they have to deal with are for many companies the same. Because the risks are similar and because you want to convey a certain message, a game on a generic level is the right option. A game based on a specific type of risk is less interesting for people that do not have affinity with that chain". (#4)

"Globalization and its risk are major issues for our clients." (#5)

Question: 'If the goal of the game is training / educating on the subject of risk awareness, how much time and how many players should I focus on?

Answer (#4): "5 to 6 players. The maximum duration is one part-time".
Answer (#5): "4 to 10 people. In a workshop setting, the duration may be half a day"

About the learning opportunities for or a professional services firm: ***"for example senior consultants, to see across the organizational matrix". For companies: "accounting, sourcing, marketing.....different functions have different perspectives on Supply Chain Management" (#6).***

"Use a classic production chain. People are familiarized. (#6)"

"The goals of the game session should have to be determined together with the client" (#1).

"Key words are: 'risk allocation', management of interfaces, dependencies, collaboration and coordination'. Supply Chain Risk Management enables to address and manage these topics." (#2)

About an existing game: Risk & Control Game (evaluated in paragraph 3.4).
The game has been used on a business course for students and at a learning course at the 'foundations training' in Prague (#3).

Need to haves (partly) based on the quotes from interviewees

Several important design requirements (which are called 'need-to-haves') are based on the results from six interviews with Deloitte employees. In some cases, the quotes from interviewees overlap with the results from the study on the domain of Supply Chain Risk Management. The following need-to-haves are based on the quotes from interviewees.

- The game session can be attended by 4-10 people
- Total duration of a game session should not exceed 4 hours
- The game session should be tailored to specific issues and needs, therefore the game must be customizable and adaptable to the requirements of a specific target group
- The game session must have a powerful message (through simplicity)
- SCRMG increases risk awareness

-Hierarchy in the list of requirements

Not all input for the design requirements –as identified in paragraph 3.1 and 3.2- is equally important. A hierarchy in the list of requirements is added to illustrate the relative importance of the identified input for the design requirements. Further, doubles are combined to shorten the list of final design requirements.

Each design requirement is labelled as a 'need to have', a 'nice to have' or as an 'add-on'. The study of relevant scientific literature, six interviews with Deloitte employees, the evaluation of existing SCM games and conversations with both the TU Delft and Deloitte mentors has enabled the designer to separate 'need to haves' from 'nice to haves'. The 'add-ons' are that requirements that can be added for a specific target audience. In the evaluation of the SCRMG (Chapter 5), a verification process is conducted to find out if the 'need to haves' are included in the final design of the SCRMG.

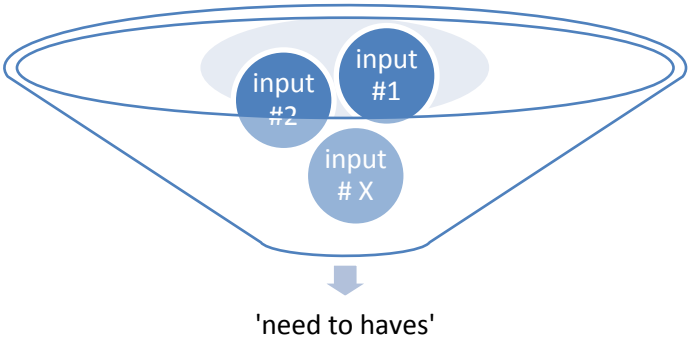


Figure 21: From input to 'need to haves'

The selection process is visualized in Figure 21. The process is subjective. Similarly, van Houten (2007, p. 15) postulates:

> **"the development and usage of business games is a subjective human creation, e.g. due to the influence of game developers, facilitators, players and organizational settings on the analysis, design, implementation, and usage of business games."**

The complete list of design requirements is presented in Appendix J: Complete List of Design Requirements. This list includes the 'need-to-haves', the 'nice-to-haves' and the 'add-ons'. For readability purposes, the need-to-haves for each of the four categories are presented below in Table 6. For the full list of requirements with the data sources, the reader is referred to Appendix J.

Supply Chain Risk Management
• **SCRMG incorporates Normal Accident Theory** • **SCRMG influences risk related beliefs** • **SCRMG increases risk awareness** • **SCRMG incorporates High Reliability Theory** • **SCRMG incorporates Transaction Cost Analysis: 1) coordination costs & 2) transaction risk** • **SCRMG incorporates competition** • **Risk sources have Supply Chain Risk consequences, but can be mitigated by Supply Chain Risk Mitigating Strategies** • **In the SCRMG, risk management is a continuous effort** • **SCRMG incorporates 'vulnerability'** • **SCRMG incorporates 'resilience'** • **Players experience limited visibility** • **Players can behave opportunistically** • **SCRMG incorporates different risk factors** • **SCRMG incorporates risk management strategies that can be implemented by a single actor** • **SCRMG incorporates risk management strategies that can be implemented by multiple actors** • **SCRMG incorporates cost of disruptions** • **SCRMG incorporates costs of mitigations** • **Players must trade-off the costs of disruptions versus the costs of mitigations** • **Players have limited information about probability** • **Players have limited information about impact** • **Players have limited budgets** • **Players have limited time to take decisions**
Gaming (source: interviews and other sources)
• **SCRMG facilitates interaction** • **Participants should know how they can 'win' the game** • **The game session must have a powerful message (through simplicity)** • **Game must be fun** • **Participants of the game have a low pre-knowledge level**
Design Constraints
• **The game session can be attended by 4-10 people** • **Total duration of a game session should not exceed 4 hours**
Deloitte (source: interviews)
• **The game session should be tailored to specific issues and needs, therefore the game must be customizable and adaptable to the requirements of a specific target group**

Table 6: Categorized list of need-to-haves for the design of the Supply Chain Risk Management Game

The thirty 'need to haves' are identified and are the input for the next phase in the game design process: the design phase (see Figure 5).

4.2.2 Design phase

In the design phase, a conceptual design of the game will be created that is based upon the 'need to haves' and the insights gained from in all previous Chapters. Logically, by identifying the 'need to haves', the most important elements to be incorporated in the SCRMG are identified.

The design phase consists of an iterative cycle of design, re-design and discussions meant to improve the design. A conceptual overview of a supply chain is presented below in Figure 22.

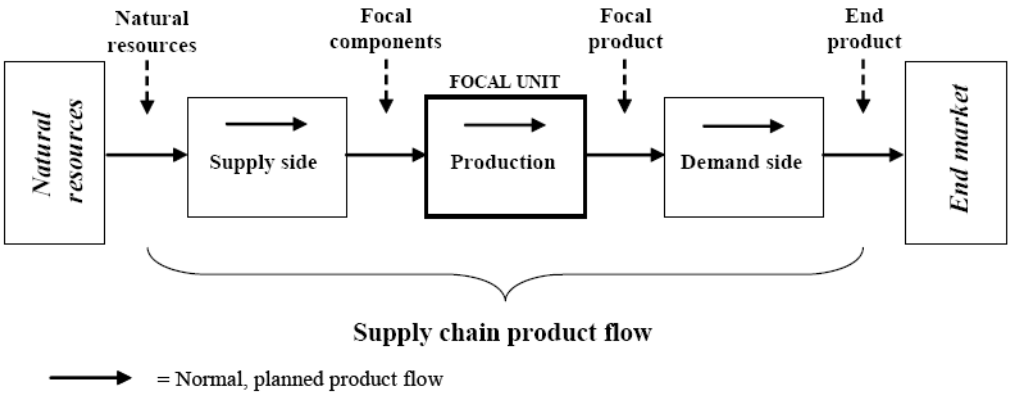


Figure 22: Conceptual overview of a supply chain (Paulsson 2007, p. 344)

The conceptual design of a supply chain is the starting point to create the context for the game, following Mentzer *et al.* (2001 - cited by Jüttner 2005, pp. 3-4), which state that: "*a supply chain at its simplest degree of complexity comprises three entities: a company, a supplier and a customer directly involved in the upstream and downstream flows of products, services, finances and information.*"

The design is created by going through an iterative and creative process that consisted of multiple cycles of design and discussion, with both the Deloitte and TU Delft mentors. The conceptual design consists of a description of five game elements which are derived from Duke (1981) and a representation of these game elements in a conceptual supply chain. An overview of the conceptual design is presented in 'Figure 23'. For each of the game elements one or multiple key design choices have been made.

The conceptual design consists of a description of the scenario of the game, validity and data sources, the general supply network structure, different roles, the processes at these roles, linkages between the roles, the instruments of the players, the game rounds and steps of play, events and performance indicators.

Scenario
A scenario is a description of the plot of the game (Duke 1981). For the scenario, the choice has been made to simulate a part of reality, rather than to use a conceptual, abstract scenario of a fictive world in the game session. In the design phase the conceptual requirements will be combined with information about the meat-supply chain in order to design the game session.

Design Choice 1: The context of the game is the meat supply chain; "from feed to fork[23]"

The seven reasons to use this real-world supply chain as context for the game are:

1) the goal of this project is 'to facilitate learning about SCRM'. After consultation of relevant literature and multiple interviews with Deloitte management, a **recognizable situation** must be presented to the participants. Then they can **identify their selves in their roles**, this stimulates the 'experimental learning process' (see §3.3.2). The roles and processes in the meat supply chain are expected to be well-recognized.

[23] Meuwissen, Van Der Lans & Huirne (2001, p.1).

2) The situation must be **recognizable for participants** (see reason 1), but also 'credible'. Recent developments in the meat supply chain add to the **credibility of the chosen context.** Peters, Vissers & Heijne (1998) refer to this type of validity as 'structural validity'.
3) A number of risks must be incorporated in the game session in order to fulfil the learning objectives. A brief internet-based desk research on the meat supply chain shows that **multiple sources of risk are relevant to chosen context (the meat supply chain)**. **Especially 'disruptions to normal activities' are relevant. The meat chain has a fairly stable demand throughout the year.**
4) The game session will be for many participants a new way of learning and –for some- Supply Chain Management and Risk management will be fairly new subjects. Therefore, the chosen context, roles, processes and product should not be too complicated. Too much complexity is likely to distract from the learning goals (§1.9 Learning goals of the Supply Chain Risk Management Game). The context is **easy to understand in a short timeframe.**
5) **The proposed participants are not likely to work in the Dutch meat sector.** The participants should not be directly involved in the meat industry. Then they can protest against the credibility of the chosen context, because they think that the game does not reflect (their) day-to-day reality. According to Peters, Vissers and Heijne (1998), the game does not have to strongly resemblance reality in this case, because the participants will not have to apply the knowledge and skills directly in reality: there is more "latitude (*ibid*.)" for game design.
6) The author has **acquired knowledge** about the meat chain[24].
7) **Information about the meat value chain is available.**

The arguments to choose the context of the game are clarified. Now the validity of game and the data sources are further explained.

Validity and data sources

Peters, Vissers and Heijne (1998, p. 1) stress the importance of validity for gaming simulations: "*One way to deal with complex situations is the simulation approach: build a simplified model of this reality, learn from this simplified model, and, finally, translate the findings or knowledge back to the reality. Gaming is based on this idea. If we want to make inferences about reality based on experiences and knowledge acquired in a game, we have to be sure that the game model is a good, or valid, representation of the real situation.*" Both the roles, linkages between these roles and processes for each actor are described and adapted in such a way that they reflect/resemble reality. Peters, Vissers and Heijne (1998) call this type of validity, 'process validity'. The main information source for the roles and processes is "Value chain analysis: An approach to supply chain improvement in agri-food chains (Taylor 2005)". In table 5, the guidelines of Peters, Vissers and Heijne (1998) were adopted to *embed* 'validity' during the game design process.

Supply network structure

The supply structure incorporates five different actors; the breeding farm, the farming company, the processing company, the supermarket and the consumer market (see Figure 23). So, there are 5 different actors in the game. The breeding farm and the consumer market are played/simulated by the game facilitator. The farming company, the processing company and the supermarket are played by the participants. In the game session, multiple participants can have the same roles and play the

[24] Faculty TPM, course: SPM 9423.

same type of actor. For each type of actor, multiple players can be created (see Figure 23). For instance, six players can play the game if two farming companies, two processing companies, and two supermarkets play the game. Then a 'supply network' is created, instead of a supply chain. Then, players can order their products at one or two suppliers, and competition is simulated. A bank is included in the game to accept payments. This is not an active role: the bank cannot take decisions and is not a player. The five types of roles and their processes are now explained. The roles and linkages between the roles are presented in Figure 23.

Design choice 2: five roles are incorporated in the Supply Chain Risk Management Game

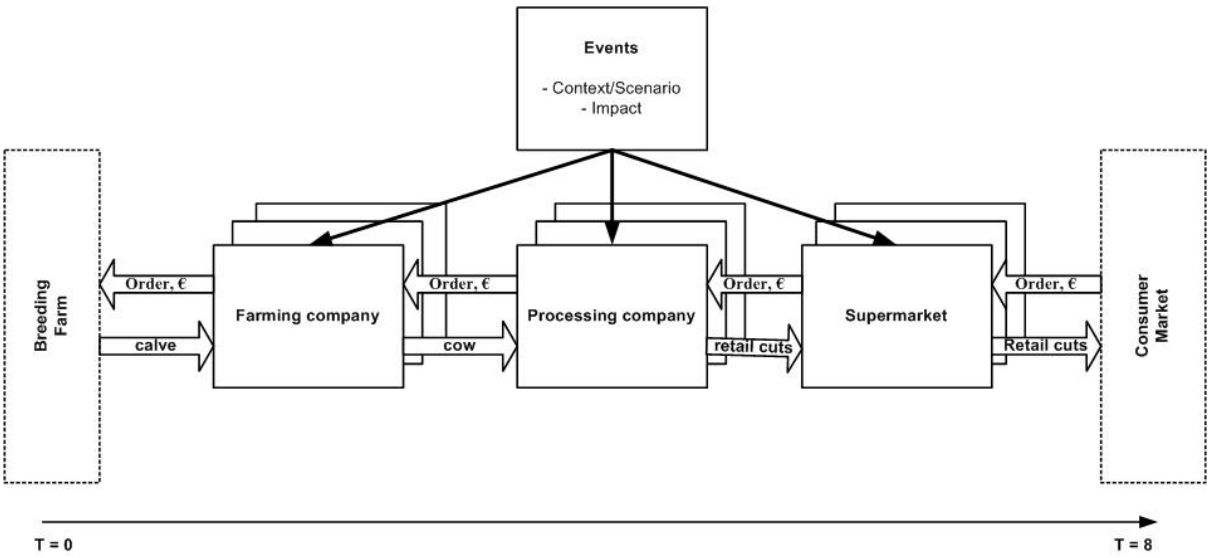


Figure 23: Supply Network Structure of the Supply Chain Risk Management Game

Model description

In Figure 23, the five roles, the linkages between the roles and the product and information flows are visualized. Products flow from the 'breeding company' to the 'consumer market'. The information stream (orders) and money flows from right to left in the chain; from the 'consumer market' back to the 'breeding company'. In first instance, the time to transport and produce the meat is equal for all steps in the chain. The time factor is important for dealing with disruptions (delays), but in first instance (as pointed out in 4.1 Game design method: '*Phase 3: Construction phase'*) the simplest form of the trade network is designed.

Design choice 3: Transportation time is not incorporated in the game. Production time is equal for all actors (production time is 1 game round (1 month))

Product

Different sub (products) are produced and sold within the supply network (see Figure 22). In terms of Paulsson (2007, p. 344), the 'natural resources' are calves. The 'focal components' are live animals (cows). The 'focal product' is retail cuts of meat. The 'end product' is also vacuum packed cuts of meat. These different subs (products) are adapted from Taylor (2005).

Role description

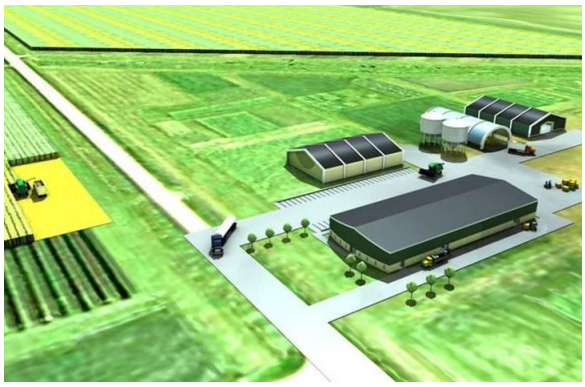
In the supply network structure, five roles are mentioned. The roles and the processes that take place within the companies are adapted from Taylor (2005, p. 751). In the next section of this

paragraph, the roles are further described. The player manuals are for a large part the same for each role. Only the role description differs. Therefore, this unique element in all role description is described next to describe the roles.

Breeding farm
The breeding farm is played by the game facilitator and has no goals in terms of revenue maximization. The breeding farm sells calves to the farmers. The farming companies have to close contracts to buy from the breeding company. The breeding farm sells all calves for the fixed price of € 100 per calve. The breeding farm is 'risk averse' and only signs contracts if all risks are allocated to the buyer. See 'Appendix D: Contract Form' for the contract and the risk allocation part. The farms have to pick up the calves at the breeding company and have to pay directly for the calves.

Farming company (Role description of U.K. farming)

Your role
CEO U.K. Farming



You are the newly assigned CEO of U.K. farming. The previous CEO is sent home after poor (risk) management. At the farm, the calves are raised to full-grown cows. When the cows are fully grown, the cows are ready to be transported to the processing company.

Inbound process
The only input for your farming activities are the calves that you buy from the Breeding Company. You buy calves for fixed price of € 100 per calf.

Processes within the farming company
At the farm, the calves are fattened. The calves eat grass that grows on the farm.

In the game, you place the calves you have bought from the Breeding Farm in the inbound section of the warehouse. The next round of the game the calves are changed into cows, which you can sell.

Capacity constraints
The **inbound section** of your warehouse cannot accommodate more than 15 calves. Also, the **outbound section** of the warehouse has a maximum capacity of 15 cows. In the game, 1 unit = 1 calf.

Outbound process
You sell the cows to the processing company. The average selling price is € 400 per animal. Depending on your negotiation skills you may be able to sell for a higher price!

Processing company (abattoir and processing plant)

The role of the processing company and the player manual is the most 'complex' one. The processing company has to – unlike the other roles - close contracts and negotiate the amount and prices with two players of the game: the farm (supplier) and the supermarket (customer). The other players (farm and supermarket) have to negotiate with only 1 other player. NB: The game facilitator is not a player.

See 'Appendix E: Player Manual' for the complete player manual of processing company 'de Rund & Zn'.

Supermarket (Role description of Halbert Ein)

Your role: **Manager Halbert Ein**

You are the newly assigned manager of a large Halbert Ein chain store. The previous manager is sent home after poor (risk) management. The goal of the supermarket is to maximize revenue. The supermarket buys portioned and labelled meat from the processing company and sells it in one of their chain stores.

Inbound process
The supermarket buys vacuum portion of meat from the processing company. The minimum order size is 100 kg (1 unit in the game). As the store is a large supermarket (hypermarket), you can easily cope with this quantity. 100 kg of vacuum portioned meat has an average price of € 700. Depending on your negotiation skills you may be able to buy for a lower price!

Processes within the supermarket
The supermarket buys the meat from the processing company and sells it in the stores. The added-value processes consist of breaking down the bulk and allocating and displaying the product. In the supermarket, the meat is stored in the warehouse at low temperatures (4 degrees maximum). The supermarket sells the meat in the meat department within the store.

In the game, you place the products (100 kg portioned meat) you have bought from the processing company in your warehouse. The next round of the game the bulk shipment is unpacked and displayed in the supermarket, ready to sell to your customers.

Capacity constraints
The maximum amount of meat your warehouse can accommodate is 1500 kg (15 units in the game). If you buy more than 1500 kg, the right temperature cannot be maintained and the product is destroyed as they it is not stored at the right conditions.

Outbound process
The meat is sold to the consumer market. The price is determined by the 'invisible hand' of the highly-competitive supermarket-industry. The price of meat for the consumer market is € 10 per kilo. This price is not likely to change in the near future according to the yearly market outlook from the 'planning & forecasting' department.

External events
In the game, events occur that simulate the 'risk sources' (see Figure 11) in the supply chain. These sources of risk can have negative or positive 'supply chain risk consequences'. Sometimes, no significant events occur in the month. The events should represent all types of risk (internal, external, supply and demand (after Jüttner 2005, see Figure 12) on all levels; 'level 1: value stream / product / processes', 'level 2: asset and infrastructure dependencies', 'level 3: organizations & inter-

organisational networks' and 'level 4: the environment' (Peck 2005, Figure 13). The chosen context (meat supply chain) makes it easy to incorporate different types of risks, on different levels.

The events will be derived from a combination of information sources. For several reasons, the risks incorporated in the game will be general as well as sector-specific risks. For instance, IT-systems failure is a 'general risk' (occurs in any supply chain) and the outbreak of a product related virus (BSE) can only occur in this specific agri-food chain.

Information & data sources for the events
For general risks in supply chains, the SCRAM-model (Treur 2008, see § 4.2.4) will be used as the main source of information. For sector-specific risks, a combination of scientific articles and internet-website are used. For example, risks that actually occurred are well documented on the website for '*managers in the meat and meal industry*' (www.meatandmeal.nl), this website offers lots of newspaper type articles covering a variety of risks. Further, (scientific) publications about the meat value chain are used to construct the context and description of the events.

A balance between *general* risks and *sector specific* risks must be chosen. The balance is chosen to be around 50:50. The final configuration and description of event cards is presented in 'Appendix I: Event Cards'.

Design choice 4: The balance between sector-specific risks and generic risks is 3:4.

Simulating events with event cards
The events are simulated through 'event cards'. Each round in the game, the 'event cards' are taken from the deck. Each card is in a different category. There are seven categories. There are three *generic categories* ('make', 'I.T. & Communications' and 'sites and facilities') after the SCRAM-model (Treur 2008, see §3.4.2). These categories reflect each level of the model of Peck (2005, see Figure 13). All these risks are internal to the supply chain.

The other four categories are *specific* to the meat supply chain. These categories reflect the external risks: the risks that are external to the supply chain. These risks are based on consultation of relevant literature and websites. These risk are the most important risk to the meat supply chain: Sickness, hygiene, regulation and 'others', such as accidents and labour issues. The category 'other' is often the most difficult to predict in advance. Therefore, in the game this category is termed 'unknown'.

Generic risks (Treur 2008)	**Meat-chain specific risks**
Internal to the supply chain (Peck 2005 – level 1 & 2)[25].	External to the supply chain (Peck 2005 - level 4)
Peck 2005 – level 1, SCOR-model): **Make**	**Regulation**
Peck 2005 - level 2): **IT & Communications**	**Disease**

[25] '*Level 3 - organizations and inter-organizational networks'* is simulated through negotiations and contracts concerning the trade of products. On level 3, 'the contractual & trading relationships (Peck 2005, p. 218)' are determined.

Peck 2005 – level 2): **Sites and Facilities**	**Hygiene**
Unknown (accidents, labour issues) (term from ISCRIM News Issue 2, p.1)	
NB: Peck's (2005) level 3 risks are "suppliers & Third parties", simulated through trading	

Table 7: Risk categories in the game

The final configuration and description of event cards is presented in Appendix I: Event Cards.

Vulnerability
The vulnerability of each player against six categories of risks is determined by their risk management systems they have put in place. For each of the categories of risk (except category 'unknown'), the players can invest to protect themselves against the category of risks. In the game, players can protect themselves for € 3.000 per category. For example, if players have invested in the protection of IT & communication systems, the risks concerning IT & Communication have no impact on them. So, the player's company is for 100% protected against the risks in that category.

Resilience
The participants can also invest in their overall resilience. If participants are not protected against a specific category, the level of resilience determines the impact/consequence of the event (as on event-card). The resilience is in the game visualized on the resilience meter, which has seven levels. The level of resilience reflects the power to continue with 'normal' operations.

The participants begin the game on level 0, and they can invest in order to make their company more resilient. After each two levels of resilience, the participants can throw with a different dice. The dice determines the impact of the event. For example, if a certain IT-failure risk 'fires', and the player is not protected against this category of risk (IT & Communications), then the dice determines the impact of the event in the following way: **€ impact (on card) * multiplication-factor (on dice) = € Total Impact.**

The dices are adapted from a normal 6 sided dice. The multiplication factor on the dice reflects the severity of consequences. With the use of a dice, randomness / uncertainty regarding the impact of events is simulated.

The marginal costs of improving resilience should increase in order to reflect reality (see Figure 19). So, the costs to move from level 0 to level 1 are lower than costs the move from level 4 to level 5. Only the costs of moving from level 0 (starting level) to level 1 are not in this line determined, because these costs are likely to be high. No resilience systems are put in place, so first developments to resilience can expected to be costly. Further, as Sheffi (2005) reports, the organizational culture is an important contributor to resilience. Especially changing the organizational culture towards a more resilient one can be difficult, lengthy and costly (see also Figure 7: Risk: beliefs -> awareness -> response). This rationale is incorporated in the player manual (Appendix E: Player Manual).

Resilience	Cost to move to this level from level-1	Marginal cost difference	New dice (with better impact-multiplier)	Multiplication factor? (6 factors on dice)	Average multiplication factor
Level 6	€9.000	€2.500	X final dice (green)	0,0,1,1,2,2	1
Level 5	€6.500	€2.500		1,1,2,2,3,3	2
Level 4	€4.500	€1.500	X 3rd dice (yellow)	1,1,2,2,3,3	2
Level 3	€3.000	€1.000		2,2,3,3,4,4	3
Level 2	€2.000	€500	X 2nd dice (orange)	2,2,3,3,4,4	3
Level 1	€1.500	€1.500		3,3,4,4,5,5	4
Level 0	Start-level.		Start-dice (red)	3,3,4,4,5,5	4

Table 8: Resilience, (marginal) costs, dice and multiplication factor

Instruments

The 'risk sources' lead to 'supply chain risk consequences'. The consequences of the risk sources are influenced by the 'supply chain risk mitigation strategies' (see Figure 11). In the game, these strategies are the instruments participants have.

Design choice 5: The instruments of the participants to manage risk are to 'control', 'accept' or manage risk through flexibility. Risks can be 'transferred/shared/reduced by cooperation through contract specifications. NB: 'avoid' is excluded.

The participants have four instruments to control risk (see Figure 24: Cause-effect model);

1) Control risk by investing in ex-ante risk management actions: decrease vulnerability.
2) Control risk by investing in ex-post risk management: increase resilience (=decreasing impact).
3) Control risk by increasing redundancy: Build up a buffer with safety-stock, through ordering more than customer demand. Hereby protecting against delays and product loss.
4) Control risk by increasing redundancy: Build up a financial buffer through keeping profit.

If the player chooses to not control risk, risk is automatically taken / accepted. In order control risks, the participants can invest their money. All participants start with a certain amount of money that will be determined in §4.2.3 Construction phase.

Game round: steps of play

The game rounds is described by the sequential activities that must be performed. A game round consists five phases, the simulation, order, delivery, event and risk management phase. The phase is structured according to the following sequence;

1) *Simulation phase.* The end market (consumer) demand at supermarkets is simulated.

[IN-GAME ACTION: All supermarkets take an envelope. In the envelope the consumer demand for this month is listed (fairly stable demand reflects real-life customer demand for meat[26])]

2) *Contract phase*. Products are ordered through the settlement of contract. The contract specifies the following information; round number, quantity, price per unit, total price, risk sharing agreements, buyer and seller name (see Appendix D: Contract Form).

[IN-GAME ACTION: contracts are filled in and are moved from buyer to supplier. There is no fixed price, except the price of feed]

3) *Event phase*. Participants the 'event cards' from the deck. The cards with events represent risks that have a financial impact. Participants can protect themselves against categories of risk. If participants are not protected, the impact/consequence is determined by throw of a dice. The status of their 'resilience meter' determines with which dice the participants throw.

[IN-GAME ACTION: Event cards are taken. After a check on vulnerability status, the 'resilience' dices are thrown. This results in product or financial gains or losses with direct effect]

4) *Delivery phase*. All companies deliver the products to their customers. Customers directly pay the supplier. The profit of the participants is the price difference between the buy and selling price. The products are delivered according to the following sequence;
   1) Supermarket delivers → Consumer market
   2) Processing company delivers → Supermarket
   3) Farming company delivers → Processing company
   4) Feed company delivers → Farming company

[IN-GAME ACTION: Products are moved by the participants from supplier to buyer, as specified in the contracts. All goods are directly paid upon delivery by the buyers]

5) *Risk management phase*. Participants have two options to manage risk; 1) reduce vulnerability (= reduce probability=ex-ante) or 2) improve resilience (=reduce impact= ex-post). The participants can decrease the vulnerability with investments. The participants can increase resilience with investments in the 'resilience meter'.

[IN-GAME ACTION: participants invest in decreasing vulnerability and/or increase resilience] This will determine their vulnerability to risks and the impact of risks in the next round. Participants can also choose to keep the profit and not investing anything.

Performance indicators

Participants profit is the only performance indicator, this implies that an economic view on the topic is adopted (as explained in Chapter 3). The participants sell their products for the agreed price (noted in the contract), the price difference between the bottom price and selling prices is the profit (NB: no taxes or interest).

[26] And distinguishes the game from the 'beer game', which deals with fluctuating demand and the consequences for supply chain partners. See also §3.2 and §3.4 for the separation of supply chain risks in two distinct categories as proposed by Kleindorfer and Saad (2005).

In order to maximize profits, the challenge for participants is to trade-off investments in risk management versus keeping the profits investments[27]. Further, participants have to choose which risk management strategy they adopt, the vulnerability or the resilience option or both. In reality, all business managers like a controlled environment, but not one that breaks the bank (see §3.2 and Figure 19 for an elaboration on financial trade-offs).

Competition can be stimulated by letting the participants know that the winner is the player with the most profit. Participants with the same roles compete against each other (i.e. farm vs. farm, supermarket vs. supermarket).

Summarizing the design phase, a cause-effect model is constructed (Figure 24: Cause-effect model). The cause-effect model is constructed based the list of requirements. The link between the variables is inspired by the literature review. For instance, during the literature review it became apparent that the 'investments' in 'resilience' and 'vulnerability' determine the impact of an 'event'. Both the cause-effect model and the game are an abstraction and simplification from reality.

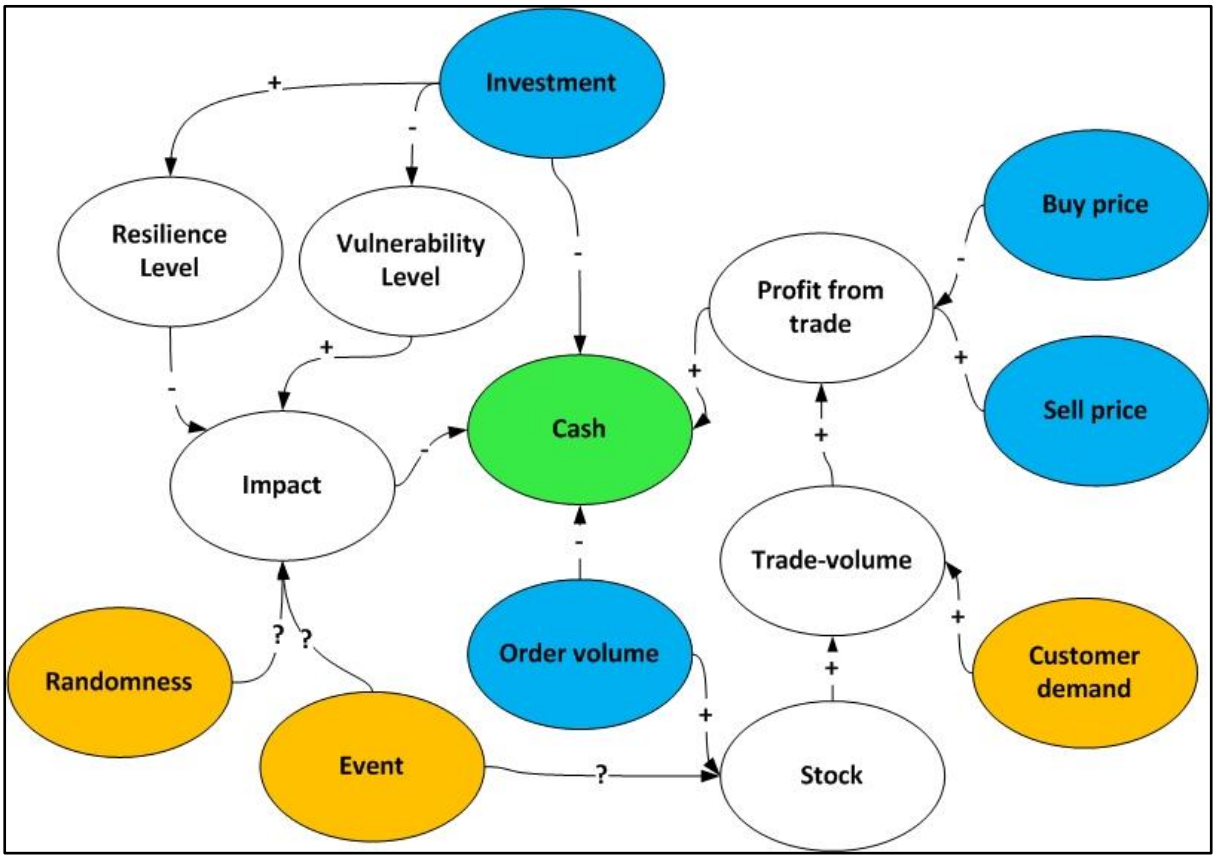


Figure 24: Cause-effect model

Legend: Blue=Instrument. Orange=external effect. Green: variable of interest (criterion, only incoming arrows)

The external effects (randomness, event and customer demand) are the input for the game. These variables have an indirect effect on the participant's cash position. The cash position of the

[27] Which can also be considered a risk management strategy because it increases companies' financial redundancy. This is an example of different perceptions to risk.

participants is influenced by three things; the profit from trade, investments in risk management and the (financial) impact of the external events.

The arrows give the relations and the direction of the relation between two factors. The plus sign indicates a positive causal relation between two factors and a minus sign indicates a negative causal relation (Enserink & Koppenjan 2004).

A '+' is a positive relationship and means that if factor A increases, factor B also increases. A '-'is a negative relationship and means that if factor A increases, factor B decreases. A question mark '?' means that the relation is can be a plus or minus. For instance, the effect of 'event' on stock can be negative (i.e. stock decreases because of damage) or positive (i.e. recount of stock reveals extra products). Further, some events do not have any effect, these are the 'empty cards'. The empty cards are formulated as: "no significant event occurs" and the "Consequence: nothing".

4.2.3 Construction phase

The conceptual design as described in the previous paragraph is the input for the construction phase. The construction phase consists of an iterative cycle of constructing, testing and evaluating the elements of the Supply Chain Risk Management Game. In this paragraph attention will be paid to multiple iterative cycles of constructing and testing the game. The seven steps during the construction phase are visualized in 'Figure 25'.

In the construction phase, the conceptual design of the game –as presented in 'paragraph 4.2.2 and Figure 22 and Figure 23' is further worked out. The game functions, concepts and requirements, as specified in the list of requirements (Table 20), §4.2.1 and §4.2.2 are now worked out. For these functions a form must be found. For instance, 'randomness' can be simulated with the throw of a dice. This is the creative part in the game design process. Inspiration for 'game components' has been gained while evaluating existing games (see §3.4 Evaluation of Supply Chain Management games; Appendix B). The end result indicates which choices have been made. The key design choices are (explicitly) formulated throughout this paragraph.

In the construction phase, the *design philosophy* of 'rapid prototyping' is used because of the limited time available and because of the 'out-of-the-box' character of the design task. If a prototype of the game is quickly created, the testing phase will be crucial in order to remove errors and to fine-tune the value of the variables. Further, attention is given to the clarity and readability of all game materials. All test-sessions and test-activities are reported in 'Appendix C: Testing log'.

Seven phases during the construction phase

The construction phase consists of constructing the different components of the game. After finishing the constructing phase, seven distinct phases are distinguished (see Figure 25). Phase 1, 2, 3 and 4 are about the construction of 'the game' (visualized in Figure 24). Phase 5, 6 and 7 can be started after phase 4 is completed. Logically, the introduction, debriefing and facilitator guide can be designed and developed only after the playable part of the SCRMG has been constructed.

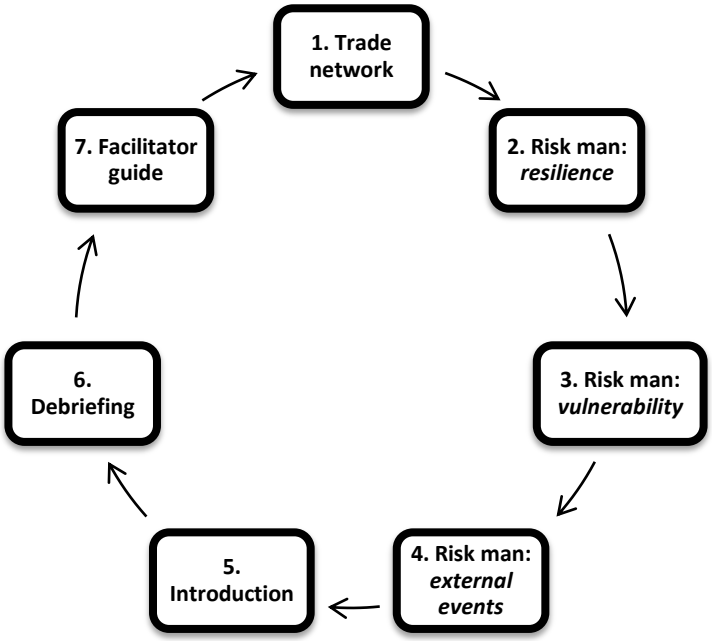


Figure 25: Seven phases during the construction phase

The first phase is the construction of a relatively simple trade-network: a 'rapid prototype'. This is the game infrastructure and is similar to the design as presented in paragraph 4.2.2 and visualized in 'Figure 22'. The game infrastructure is the supply chain which involves trading products and includes the basic revenue process. The second phase begun after testing this prototype.

The second phase is the incorporation of 'resilience' in the game (see Appendix E: Player Manual and Appendix F: Risk Management Overview).

The third phase is the incorporation of 'vulnerability' in the game (see Appendix E: Player Manual and Appendix F: Risk Management Overview).

The fourth phase is to extent the game with the design and incorporation of the external events in the game (see Appendix I: Event Cards).

The fifth phase is the construction of the introduction of the SCRMG (see Table 11: Outline of the introduction; Appendix E: Player Manual and the presentation on enclosed CD-ROM).

The sixth phase is the construction of the debriefing of the SCRMG (see Table 13: Outline of the debriefing and the presentation on enclosed CD-ROM).

The seventh phase is the design of the facilitator guide (see Appendix H: Facilitator Guide).

Load: setting the value of the variables (parameterization)

It is important to set the right prices on the risk management instruments, relating to the profit and expected impact of events. Only then the game is 'balanced'. Kriz and Hense (2006) provide a 'list of criteria for the quality of a simulation game [...]'. Criterion number 36 is: "*the simulation has adequate level of complexity for the target group (no permanent under- or over challenge)*". To construct the 'right challenge' for participants, the parameters and their value will now determined.

"The load of a gaming simulation is the value of the initial configuration parameters a gaming simulation has (Meijer *et al.* 2006, p. 6)." In the design phase, several variables are identified that need to be 'set' properly in order to make the game playable, to find a balance between luck/randomness and strategy (see Appendix J: Complete List of Design Requirements), and to contain the 'right' amount of complexity in the game. Further, the value of the parameters must be

precise so that the participants experience a real challenge in order to get them in the 'game flow'. For these reasons, the right balance for several parameters must be set[28]. The exact values of these variables have been adjusted after test activities (see Appendix C: Testing log). The variables that must be 'set' are listed in Table 9, with their final value.

Topic	Configuration
Configuration and division of roles	10 farming companies, 10 processing companies, 10 supermarkets. All played by 1 person. The breeding farm, consumer market and bank are simulated by the game facilitator.
Number of rounds	10 (+/-10 minutes per game round) → +/- 10 minutes playtime.
Starting amounts of money	Breeding farm: € 0. Farming company: € 10. Processing company: € 10. Supermarket: €20.300. Consumer market: € 10. Bank: € 0.
Starting amounts of product (stock)	Breeding farm: unlimited. Farming company: 10 units (animals). Processing company: 10 units (1 ton meat). Supermarket: 10 units (1 ton retail cuts of meat). Consumer market: none
Product price	The average end market price of meat is 10 € per kilo (Sanjuán and Dawson, 2003). So, the end market price is €10/ Ton retail cuts of meat. The feed company sells 1 unit of feed for € 10. So, the total profit than is made in the chain is € 10 **per traded unit**. This profit is initially equally divided among the farming company, processing company and supermarket. All actors have to negotiate on buy and selling prices and must close deals with contracts.
Number of events per game round	One game round simulates one month. Each actor must draw two events from the deck every game round.
Distribution of positive, negative and 'empty cards'	Positive: 25%. Negative: 50%. 'Empty' cards: 25% (no significant event).
Number of cards	If the game is played with 18 participants, the minimum number of cards is 36 (2 cards per player per game round).
Probability of events	Simulated through the number of event cards in the deck and the number of cards drawn per game round
Impact of events	All events have a direct financial impact or a direct impact on the companies' inventory. This is further illustrated in Figure 24: Cause-effect model.
Costs of decreasing vulnerability	The costs of decreasing vulnerability are € 10 per category (which is the same as the expected profit per game round). If the farm, processing company and the supermarket collaborate to decrease vulnerability to a certain risk category, the costs for each company are reduced by 10%. So, each player then invests € 10.
Vulnerability status	The vulnerability meter consists of 10 risk categories. These categories are the same for each player. Participants can invest to protect their companies against 10 risk categories. Participants cannot decrease vulnerability to the category of 'unknown' risks.
Resilience	Financial buffers, safety stock and investments on the 'resilience meter' increase resilience.
Coupling of the probability of events with the vulnerability status	If an event occurs (card is drawn) and player is protected, then there is no impact.
Coupling of the impact of the events with the resilience status	See 'Table 8: Resilience, (marginal) costs, dice and multiplication factor'
End market demand	The end customer demand is 10 ton (10kg) per game round. This is 10 units in the game. Each unit represents 10kg.

Table 9: Load

[28] The determination of the 'load' can also be visualized as a 'cycle' as in 'Figure 25: Seven phases during the construction phase'.

If the participants should have a real challenge to make a profit, the expected profit from trade in the first round of the game should be close to the average expected impact from event cards.

Design choice 5: the Expected Profit >= Expected Loss in Game Round 1

The result is that the participants initial starting amount of money ('cash' in Figure 24) will not grow too much (*no permanent under or overchallenge* (Kriz & Hense 2006)). Therefore, the average impact of events in the first game round is the same as the expected profit in game round 1.

Variability
The impact of negative events ranges from 10– 10€. The impact of positive events ranges from 10– 10€. This makes the game more fun to play, as the impact of the different cards varies: 'randomness'.

*Final configuration of event cards (*see Appendix I: Event Cards).
10empty cards (impact = € 0)
10negative cards (average impact = € 10* Dice)
10positive cards (average impact = € 10)
In total 10 cards are created, which allows for 10 game rounds. If cards are put back in the deck, the number of game rounds is unlimited.

Construction of the introduction to the game

In this paragraph research sub-question 1 is answered: **"What should be included in the introduction to the Supply Chain Risk Management Game?"**

In the introduction, participants should be prepared for the task at hand –playing the game-. In this specific game, a certain context has been chosen (as opposed to an abstract game) to make the subject of SCRM more 'tangible' for participants. To answer research sub-question 1, the 'list of Criteria for the Quality of a Simulation Game [...]' of Kriz and Hense (2006) is used. The player manual is considered to be a part of the introduction to the SCRMG.

Kriz and Hense (2006, p. 278-279) define a "list of quality criteria of simulation games [...] based on gaming simulation research", that consists of fifty general quality criteria. This list is "a good example for knowledge gained about simulation games, viewed as learning environments". "*That knowledge is based on the results of applied analytical science, which can also be **of relevance** for the design science and, more specifically, **for the design of simulation games***." Ten out of the fifty quality criteria relate to the introduction. These criteria are used to construct and ensure quality of the introduction. The quality criteria that relate to the introduction are presented in Table 10.

Criterion	Explanation (Kriz & Hense 2006, p. 278-279)
#1	*The learning objectives are clearly defined.*
#7	*The rules of the game are clearly defined.*
#8	*The roles of the players are clearly defined.*
#9	*The scenario of the game and the events occurring in the game are clearly defined.*
#13	*The understandability of the written materials (manual, facilitator and player guide, etc.) is very high.*
#14	*The written materials provided are adequately comprehensive.*
#26	*The simulation offers a motivating and interesting game scenario.*

#29	*The simulation activates the participants to develop strategies.*
#34	*The simulation offers an adequate link to reality for the target group; rules, roles, and simulated resources correspond to real, authentic situations.*
#37	*The simulation offers several different alternatives of acting and deciding.*

Table 10: List of quality criteria for the introduction (Kriz & Hense 2006, p. 278-279)

Research sub-question 1: **"What should be included in the introduction to the Supply Chain Risk Management Game?"** is thus answered through an adaptation of the ten quality criteria. If quality criterion number 1 *(The learning objectives are clearly defined.*) is adapted, the answer to the research sub-question is: **The introduction to the Supply Chain Risk Management Game includes clearly defined learning objectives**. In this way, all ten quality criteria are adapted into things that should be included in the introduction of the Supply Chain Risk Management Game.

Result

To introduce the participants to the game, -next to the player manual (see Appendix E: Player Manual)-, a PowerPoint 2007 ™ presentation is constructed. The actual introduction consists of ten slides and takes approximately fifteen minutes to present. Slide number 11 till 18 can be showed during the actual game play, to help people remind in which round and phase the game is at and what actions participants can perform. The slides and the content are listed in the underneath table. For several reasons, one can expand or shorten the introduction by adding or removing slides. Comments are added for each slide to help the game facilitator during the introduction. The participants of the game cannot see these comments. All information the game facilitator needs to introduce participants to the game session are presented in the facilitator guide (see Appendix H). The presentation is located on a CD-ROM enclosed to this thesis.

Slide *(number and title)*	Content
1. Introduction	Name of game facilitator(s) Welcome! Reason to conduct the game session
2. SCRM	Supply Chain Risk Management (Definition)
3. Learning goals	Learning goals
4. Relevance	Academic and Business Relevance
5. Theoretical Background	Theoretical Background (NAT, HRT, TCA) is illustrated
6. Different views on supply chain risk (1)	Figure 12: Supply Chain Risk Sources (Jüttner 2005, p. 123)
7. Different views on supply chain risk (2)	Figure 13: An integrative model of a supply chain as an adaptive system (Peck 2005, p. 218)
8. Economic perspective	Figure 19: Cost of disruptions vs. cost of mitigations (Husdal 2007)
9. Various steps in risk management	Figure 28: Risk intelligence framework
10. Schedule of this session	Each player get a player manual and +/- 15 minutes to read it.
11. Game Round 1	Shows the phases of the game and what actions participants should take
Slide 12 till slide 18	Shows the phases of the game and what actions participants should take

Table 11: Outline of the introduction

Construction of the debriefing of the game

In this paragraph research sub-question 3 is answered: **"What should be included in the debriefing of the Supply Chain Risk Management Game?"**

The approach to answer this sub-question is the same approach used to answer research sub-question 1. To answer research sub-question 3, the 'list of Criteria for the Quality of a Simulation

Game [...]' of Kriz and Hense (2006) is used. Two out of the fifty quality criteria relate to the debriefing. These criteria are used to construct and ensure quality of the debriefing. The quality criteria that relate to the debriefing are presented in Table 12.

Criterion	Explanation (Kriz & Hense 2006, p. 278-279)
#42	*The guidelines in the facilitator manual about debriefing ensure the learning objectives that should be achieved (i.e., there are hints about topics, structure/schedule, and methods of debriefing).*
#43	*The guidelines about gaming simulation didactic ensure the realization of desired learning objectives in practice (e.g., there are explicit hints about connecting the simulation with the real work processes of the target group).*

Table 12: List of quality criteria for the debriefing (Kriz & Hense 2006, p. 278-279)

Research sub-question 3 **"What should be included in the debriefing of the Supply Chain Risk Management Game?"** is thus answered through an adaptation of the two quality criteria. The guidelines (see #42 and #43 in table 13) are incorporated in the facilitator manual.

Result

To support the debriefing process, a PowerPoint 2007 ™ presentation is constructed. The debriefing consists of eight slides and takes approximately fifteen minutes. If Deloitte uses the game at a client, other questions are relevant. Slide number six and seven may be used by Deloitte when playing the SCRMG at a client's organization.

The game facilitator asks the participants about their experiences during the game. The slides and the content are listed in the underneath table. For several reasons, one can expand or shorten the debriefing by adding or removing slides. Comments are added for each slide to help the game facilitator during the debriefing. The participants of the game cannot see these comments. All information the game facilitator needs for the debriefing of the game session are presented in the facilitator guide (see Appendix H). The presentation is located on a CD-ROM enclosed to this thesis.

Slide (number and title)	Content
1. Supply Chain Risk Management	Recall: definition of Supply Chain Risk Management.
2. Different views on supply chain risk	Recall: Cost of disruptions versus costs of mitigations.
3. What strategy did you choose?	Questions that the game facilitator can ask the participants. Participants can tell about their experiences and the trade-offs they have made. This stimulates discussion between participants.
4. Winner!	The winner is determined based on the cash position.
5. Real world implications	Links game experience to the real world.
6.... (company name)	For implementation at Deloitte Clients, the status of Supply Chain Risk Management within the client's organization and across the supply chain can be discussed.
7. Service offerings	Presentation and discussion of relevant Deloitte Service Offerings.
8. Questions / remarks	Are there any questions or remarks?
9. Thanks	Word of thank and contact information

Table 13: Outline of the debriefing

Schedule of the game session

Now the introduction, the game itself and the debriefing are constructed, the game can be played in a game session. The first times the game is played, it can be considered as testing the game. The

schedule of the game session is presented in the introduction of the game. This schedule is used, starting with 'test session 4' (see Appendix C: Testing log).

The schedule is:

15 minutes for the introduction to the Supply Chain Risk Management Game
15 minutes to read the player manual
5 minutes to hand out all game materials
70 minutes for the actual playtime (+/- six game rounds)
15 minutes for the debriefing of the Supply Chain Risk Management Game

The duration of the introduction depends on the number of slides that the game facilitator wants to use. The duration of playtime depend on the number of game rounds. The duration of the debriefing depends on the number of slides that the game facilitator wants to use and the time the game facilitator reserves for the discussion between and with participants. Without stopping moments, the game session has a duration of +/- 120 minutes=2 hours.

Design of the facilitator guide
The facilitator guide is constructed now the elements of the Supply Chain Risk Management Game are designed and developed (introduction, game and debriefing).

Design approach
Kriz and Hense (2006, p. 278-279) define a "list of quality criteria of simulation games [...] based on gaming simulation research", that consists of fifty general quality criteria. This list is "a good example for knowledge gained about simulation games, viewed as learning environments". "*That knowledge is based on the results of applied analytical science, which can also be of relevance for the design science and, more specifically, for the design of simulation games*." Twelve out of the fifty quality criteria relate to the role of the facilitator and the facilitator guide. These criteria are used to design the facilitator guide and to ensure the role of the facilitator is clear. The criteria are presented in Table 14.

Criterion	Explanation (Kriz & Hense 2006, p. 278-279)
#3	*The possible areas for implementation are clearly defined.*
#4	*The schedule and the structure of the game are clearly defined.*
#5	*The spatial game setting is clearly defined*
#11	*The facilitation skills that are needed are clearly defined.*
#20	*The design of the game supports an easy and intuitive usage of the simulation for facilitator and players*
#25	*The simulation offers adequate adaptability for changed framework conditions (e.g., for smaller/larger number of participants or for longer/shorter schedule, etc.), and the facilitator guide offers suggestions and hints for a flexible usage under changed framework conditions.*
#40	*The facilitator guide contains explicit hints for briefing the simulation game (e.g., role-taking processes, basic information, guidelines for tolerated and not-tolerated behaviour of the participants, etc.).*
#41	*The instructions in the facilitator manual for gaming simulation didactic contribute to a perfect workflow (the tasks of the facilitator—e.g., the roles the facilitator has to take—during the game are clearly expressed).*
#42	*The guidelines in the facilitator manual about debriefing ensure the learning objectives that should be achieved (i.e., there are hints about topics, structure/schedule, and methods of debriefing).*

#43	*The guidelines about gaming simulation didactic ensure the realization of desired learning objectives in practice (e.g., there are explicit hints about connecting the simulation with the real work processes of the target group).*
#44	*There are explicit hints in the manual about embedding the simulation game in a whole teaching/learning context (e.g., with regard to the curriculum).*
#45	*Beside the simulation game, there are complementary learning modules (i.e., in addition to the debriefing modules), which are target-group oriented and help link the experience of the simulation game with important knowledge and competence components in the sense of a higher qualification concept (e.g., case studies, texts for teaching, professional teaching videos, etc.).*

Table 14: General quality criteria concerning the facilitator role and facilitator guide (Kriz & Hense 2006, p. 278-279)

Result

The facilitator guide is presented in Appendix H, and is constructed with the quality criteria as presented in Table 14. As earlier mentioned (at the construction of the introduction) the quality criteria can be adapted into requirements.

Now the construction phase is finished, the Supply Chain Risk Management Game can be evaluated. This is the topic of the next Chapter.

5. Evaluation of the Supply Chain Risk Management Game

In Chapter 4 the Supply Chain Risk Management Game has been designed and constructed. In this Chapter the evaluation of the Supply Chain Risk Management Game will be described. The evaluation is the last activity in the construction phase, according to the game design process of Duke (1981) (see Figure 5: Duke's (1981) Game design process in alignment with the thesis structure and research questions).

Kriz and Hense (2006, p. 269) report that two elements should be incorporated in the assessment: "it is essential that the artefact assessment takes the evaluation of a simulation game as a product into account, as well as its effect on the process of change". In this Chapter, the evaluation of the SCRMG *as a product* is evaluated as well as *its effect on the process of change*. The evaluation of the SCRMG as a product is 'verification (by designer)'. The evaluation of the SCRMG on the process of change is the 'validation (by participants)'. To illustrate this approach, an overview is provided in Figure 26.

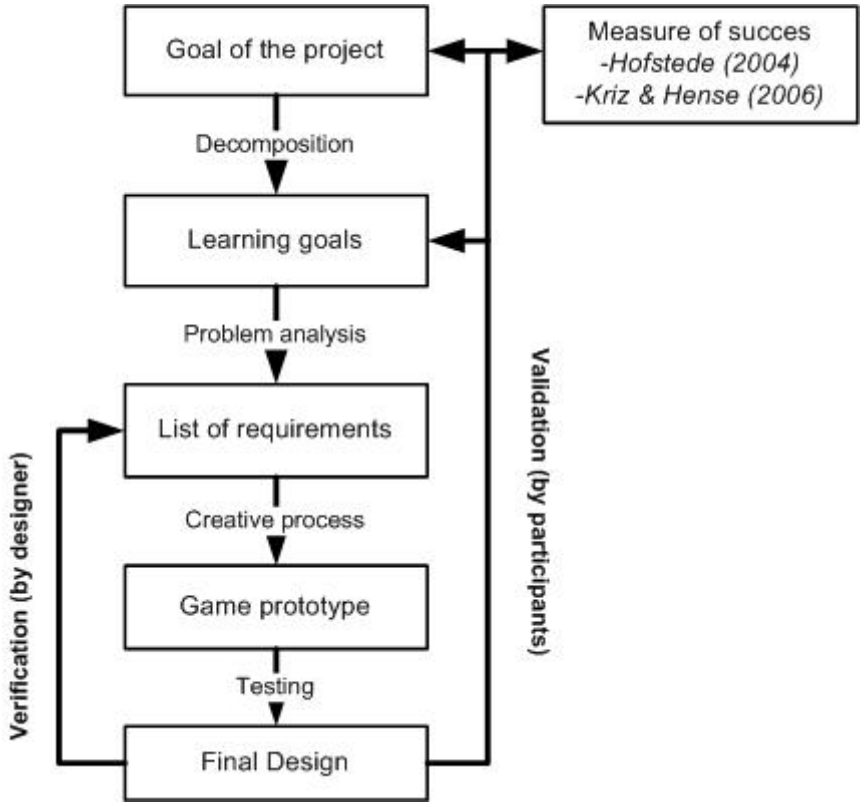


Figure 26: Evaluation approach

In this Chapter the verification of the SCRMG is discussed (§6.1). Then, the validation is discussed and descriptive statistics on performance are presented (§6.2). This Chapter ends with the formulation of conclusions based on the verification and validation of the SCRMG (§6.3). The qualitative data gathered during the game session and test activities is extensively discussed in 'Appendix C: Testing log'

5.1 Verification

The performance of the Supply Chain Risk Management Game is tested by a check whether or not the design requirements are fulfilled. All requirements that have been labelled as a 'need to have' are discussed next. The 'need to have' is introduced, and then it is argued how these important requirements are incorporated in the SCRMG. For each 'need to have', the argumentation is kept short and sometimes only gives one example of how this requirement is incorporated in the SCRMG.

NEED TO HAVES FROM CATEGORY 'SUPPLY CHAIN RISK MANAGEMENT'

1. SCRMG incorporates Normal Accident Theory. Each game round, each participant takes 2 event cards from the deck. So, 'accidents' are 'normal' in the SCRMG.
2. SCRMG influences risk related beliefs. The goal of participants in the game is to 'manage risk pro-actively (instead of passive)'. Further, the participants are able to successfully manage risk, so a positive message is included in the game. The participants should have a low pre-knowledge level.
3. SCRMG increases risk awareness*. This is incorporated as a proposition in the evaluation form.*
4. SCRMG incorporates High Reliability Theory. "High Reliability Theory (HRT) argues that organizations facing the conditions of tight complexity and interactiveness may be vulnerable to accidents but can manage these conditions through application of countermeasures." In the SCRMG multiple countermeasures can be applied. See 'Figure 24: Cause-effect model'.
5. SCRMG incorporates Transaction Cost Analysis: 1) coordination costs & 2) transaction risk. All transactions can only be closed by contracts form. In the contract form, participants are *forced* to allocate risk relating to the transaction (Appendix D: Contract Form). Risk relating to the transaction the result of 'opportunistic behaviour' see 'need to have #11'. Further, the participants have limited time to take decisions, the 'time constraints of each game round' are the 'costs to coordinate economic transactions'.
6. SCRMG incorporates competition. If played with six or more participants, competition is included in the SCRMG. Participants can compete with setting prices.
7. Risk sources have Supply Chain Risk consequences, but can be mitigated by Supply Chain Risk Mitigating Strategies. Risk sources are simulated through 'event cards'. Several mitigating strategies (increase resilience, decrease vulnerability) can be applied to mitigate risk sources. 75% of the event cards have (financial) consequences. See Appendix I: Event Cards. Another source of risk is related to the transaction and is discussed at 'need to have #5'.
8. In the SCRMG, risk management is a continuous effort. Each game round participants can (and should) manage risk.
9. SCRMG incorporates 'vulnerability'. Each game round participants can decrease vulnerability.
10. SCRMG incorporates 'resilience'. Each game round participants can increase resilience.
11. Participants can behave opportunistically. Sellers can behave opportunistically if they allocate risk to the buyer and not deliver any products. Buyers can behave opportunistically if they allocate risk to the seller and not pay for the products.
12. SCRMG incorporates different risk factors. The event cards are based on 7 different risk categories. The risk factors of the event cards are partly adapted from the risk factors from the SCRAM-model.
13. SCRMG incorporates risk management strategies that can be implemented by a single actor. Participants can decrease vulnerability and increase resilience.
14. SCRMG incorporates risk management strategies that can be implemented by multiple actors.

Participants can cooperate to decrease vulnerability. Participants can split transaction risk in the contracts.

15. SCRMG incorporates cost of disruptions. Disruptions are simulated through event cards. The events (disruptions) have financial consequences.

16. SCRMG incorporates costs of mitigations. Mitigation costs range between € 2.000 and € 18.000.

17. Participants must trade-off the costs of disruptions versus the costs of mitigations. In the game, the costs of disruptions are –almost always- higher than the costs of mitigations.

18. Participants have limited information about probability. Participants do not know the distribution of event cards. Therefore, they do not know the probability of picking a particular event card from the deck. The probability of the consequences is determined by the 'resilience dice'.

19. Participants have limited information about impact. Participants cannot know the impact of all event cards.

20. Participants have limited budgets. All participants start with € 20.300.

21. Participants have limited time to take decisions. Game round #3 till #8 has a maximum duration of 12 minutes. In this way, participants are likely to make mistakes and learn.

NEED TO HAVES FROM CATEGORY 'GAMING'

22. SCRMG facilitates interaction. Participants have to negotiate on prices and multi-actor risk mitigation strategies (see #14). Further, they have to agree on contracts to buy and sell products. The SCRMG is a role playing game, as the SCRMG cannot be played without interaction.

23. Participants should know how they can win the game. "The company with the most profit in the end wins the game" is reported in each player manual.

24. The game session must have a powerful message (through simplicity)

The (overall) message is the definition of Supply Chain Disruption Risk Management (as in §3.2), defined as *"the process of systematically identifying, analyzing and dealing with disruption risks to supply chains (=WHAT), through coordination or collaboration (=HOW) among the supply chain partners (=WHO), to reduce risk exposure (decrease supply chain vulnerability and increase supply chain resilience), so as to ensure profitability and continuity for the whole supply chain (=WHY)."*

25. The game must be fun. *This is incorporated as a proposition in the evaluation form.*

26. Participants have a low pre-knowledge level. The intended audience should have a low pre-knowledge level.

NEED TO HAVES FROM CATEGORY 'PRACTICAL'

27. The game session can be attended by 4-10 people. Six, nine, twelve, fifteen or more participants can participate in the game session.

28. The total duration of a game session does not exceed 4 hours. The game session takes about 2 hours, depending on –*inter alia*- the length of the introduction, debriefing and number of rounds played.

NEED TO HAVES FROM CATEGORY 'DELOITTE'

29. The game session should be tailored to specific issues and needs, therefore the game must be customizable and adaptable to the requirements of a specific target group. Major game components are the introduction, the player manuals, the event cards, the costs of risk management and the debriefing. All these elements can be easily adapted to the requirements of a specific target group. All game materials are located on the enclosed CD-ROM. The materials are published in Office 2007 format. The SCRMG is a playable game as much as it is a framework to create games.

The author is confident that the 'need to haves' are incorporated in the design of the SCRMG. In similar lines, the 'nice to haves' and the 'add-ons' can be discussed. However -*for readability purposes and because the 'need to haves' are the most important*- this discussion is excluded from this thesis.

5.2 Validation

In this paragraph an answer is provided to research sub-question 4.1**: 'What instrument can be developed to measure the performance of the game session?' and 4.2 Which performance measures should be included in this instrument?**

An evaluation form has been developed to validate the SCRMG. The results provide a measure of the success of the game –*from a participant's perspective*-. The evaluation form consists of fifteen propositions that are rated on a 'seven-point Likert scale'. All participants from the first game session have filled in the evaluation form.

The propositions included in the evaluation form relate to general quality criteria of the serious games (proposition #1, #2 & #12). A question about (self-reported) learning effects is formulated for each of the six learning goals (proposition #3 - #8). Hofstede (2006, p. 544) writes about success in serious games; "*if a simulation gaming session makes the participants reflect on the netchain as a whole, its behaviour and their role in it, then it has been successful.*" This statement is re-written and included as a proposition (#9). A proposition adapted from Kriz and Hense (2006) is included which they found to be particularly important in the evaluation of their 'rigid rule board game' (proposition #15). Lastly, the main research question of this project is two times incorporated in the evaluation form (proposition # 13 & #14). Proposition #10 is based on the goal of this project. Proposition 11 is an alternative interpretation of this goal. The propositions with the descriptive statistics on performance are the results from the validation. The results are discussed in the next section.

Results

For each proposition in the evaluation form, the performance is discussed. The results are derived from the first game session. Nine participants participated in this game session. See 'Appendix C: Testing log' for the qualitative results of this game session. All propositions have been rated on a seven-point Likert scale (Table 15).

Strongly disagree 1	**Disagree 2**	**Slightly Disagree 3**	**Neither Agree nor Disagree 4**	**Slightly Agree 5**	**Agree 6**	**Strongly Agree 7**

Table 15: Seven-point Likert scale

A 'non-parametric reliability measure' (Baarda & de Goede 2001, p. 282) showed that the variables cannot be combined to a 'total score'. Therefore, each proposition, the lowest and highest rating, the mean and standard deviation is presented in 'Table 16'. Conclusions are formulated in paragraph 6.4, based on the descriptive statistics.

Proposition	Lowest	Highest	Mean	SD
1. The goal of the game is clear.	5	7	**6.1**	0.9
2. The game instructions are clear.	3	6	**4.7**	0.9
3. I reached (a further) understanding about the theoretical background of Supply Chain Risk Management.	3	6	**4.7**	1.0
4. I reached (a further) understanding about different types of risk.	5	7	**5.5**	0.8
5. I reached (a further) understanding about risk management strategies.	1	6	**3.9**	1.5
6. I reached (a further) understanding about the need for collaboration and coordination in supply networks.	1	7	**5.2**	2.0
7. I reached (a further) understanding about the need to manage risk pro-active instead of passive.	2	6	**4.7**	1.6
8. I reached (a further) understanding about the risk management approach in a network situation.	*No results due to print error*			
9. The game session made me reflect on the network/supply chain as a whole, its behaviour and my role in it.	3	7	**5.3**	1.2
10. The game session effectively facilitates learning and understanding about the key concepts of Supply Chain Risk Management.	3	6	**4.8**	0.8
11. Game session increases 'risk awareness'.	3	6	**4.7**	1.3
12. I enjoyed playing the game.	4	7	**5.9**	0.9
13. The key concepts of Supply Chain Risk Management can be learned by participating in the game session.	1	6	**4.7**	1.5
14. The key concepts of Supply Chain Risk Management can be learned *effectively* by participating in the game session.	2	6	**4.6**	1.3
15. The game has an adequate level of complexity (no permanent under- or overchallenge).	2	6	**4.2**	1.4

Table 16: Results evaluation form (N=9)

5.3 Conclusions

The 'need to haves' are discussed in the verification process. This process shows that all 'need to haves' are included in the SCRMG. The results indicate that the most important requirements from 'Supply Chain Risk Management', 'Gaming', 'Practical' and 'Deloitte' are fulfilled. Further, all game materials can be easily customized to the requirements of a specific target audience.

The results from the validation (with evaluation forms) indicate that 'the goal of the game is clear', that participants 'reached a further understanding about different types of risk' and that participants 'enjoy playing the game'.

All other propositions are rated –on average- between 3.9 and 5.3. The standard deviation of these other propositions is relatively large. The relative large value of the standard deviation shows that the opinion of participants varies. Because the sample size is small (N=9), these results do not give any certainty. Further, -except for proposition 5- the mean score on all propositions ranges between 'neither disagree nor agree' and 'strongly agree'. These propositions have thus been rated on the

'positive' side of the 7-point Likert scale. The design should be improved and more game sessions should be conducted to increase the average score on the propositions and to decrease the standard deviation.

The final conclusion from the evaluation of the SCRMG it that there are indications that we are 'on the right track'. The verification process indicates that the key concepts are included in the SCRMG (but it is a subjective process). The validation indicates that fourteen out of fifteen propositions have been rated 'on the positive side' of the 7-point Likert scale. Qualitative observations indicate that there are little *structural* flaws in the design of the SCRMG. Based qualitative data gathered by the first game session, intended changes are formulated. All the changes to improve the SCRMG are carried through, and can be tested in future game sessions.

More sessions –with different audiences- are necessary in order to further improve the design and to gather more qualitative and quantitative data to support these indications.

In this Chapter the SCRMG has been evaluated. Now we are able to formulate conclusions. This is the topic of the Chapter 6: Conclusions.

6. Conclusions

All previous Chapters describe one or multiple design or research activities undertaken to fulfil the goal of this project: '*...to design, construct, test and evaluate a serious game that facilitates learning about the key concepts of Supply Chain Risk Management.*

The final design of the SCRMG consists of an introduction, a playable game, and a debriefing. This enables us to answer the research question. In this Chapter the answer to the research question will be provided.

In §6.1 the research sub-questions will be answered. This enables us to answer the research question (§6.2). The reflection is provided in §6.3. The last phase of Duke's (1981) game design process is the 'use phase' (see Figure 5). 'Recommendations for use' are the topic of §6.4. Concluding this Chapter, we will provide 'recommendations for future research' in §6.5.

6.1 Research sub-questions

In this paragraph the research sub-questions are answered.

1. What should be included in the introduction to the Supply Chain Risk Management Game?

The introduction should prepare participants to the task at hand, which is playing the SCRMG and reflect on the outcomes in the debriefing. In the introduction, Supply Chain (Disruption) Risk Management is introduced by a definition and the focus on economic trade-offs is stipulated. To answer the research sub question, ten quality criteria of the "list of Criteria for the Quality of a Simulation Game [...] (Kriz & Hense 2006)" have been interpreted as 'what should be included in the introduction to the SCRMG'. Three examples are: (1) The introduction to the Supply Chain Risk Management Game includes clearly defined learning objectives, (2) clearly defined roles and, (3) clearly defined rules.

2. What are the key concepts of Supply Chain Risk Management, and how can these concepts be included in the game?

This research question has been decomposed (in Chapter 2) into four research sub-questions: 2.1, 2.2, 2.3 and 2.4. The answer to research sub-question 2 is provided by answering these four research sub-questions.

2.1 What is the theoretical background of Supply Chain Risk Management?

Normal Accident Theory, High Reliability Theory, Transaction Cost Analysis, Supply Chain Management, Risk Management, Agency Theory, Utility Theory and Network Management provide a scientific foundation for Supply Chain Risk Management. These theories each have a different 'unit of analysis' and are thus suited to understand different parts of complex socio-technical systems, such as (global) supply chains/networks and the occurrence of 'disruptions to normal activities' in within these systems.

In this thesis we have interpreted '(system) failures', 'disruptions' and 'unavoidable system accidents' as 'disruptions to normal activities', following Kleindorfer and Saad (2005) who report: *"There are two broad categories of risk affecting supply chain design and management: (1) risk arising from the problems of coordinating supply and demand, and (2) risk arising from disruptions to normal activities."*

2.2 What are the key concepts of Supply Chain Disruption Risk Management?

In this thesis, *based on several existing definitions of SCRM with a delineation to 'disruptions'*, Supply Chain Disruption Risk Management has been defined in 3.2 as: '*... the process of systematically identifying, analyzing and dealing with disruption risks to supply chains, through coordination or collaboration among the supply chain partners, to decrease supply chain vulnerability and increase supply chain resilience, so as to ensure profitability and continuity for the whole supply chain.'*

Coordination and collaboration can be summarized as 'integration'. In the SCRMG, 'decreasing vulnerability' is an *ex-ante* Risk Management strategy and 'increasing resilience' is an *ex-post* Risk Management strategy. On a lower abstraction level, more SCRM strategies are distinguished. Supply Chain Risks derive from several 'risk sources': *supply, process, control, demand and environmental risk sources.*

2.3 How can the theoretical background and key concepts of Supply Chain Risk Management be included in the Supply Chain Risk Management Game?

The general game design method of Duke (1981) has been adopted to structure the process of including the theoretical background and the key concepts to elements of the SCRMG. This method distinguishes several activities. The activities are (in sequential order): *problem analysis, list of requirements, design, discussion, construction, testing, evaluation, and transfer to operator.* These activities are performed and have been reported in this thesis. Further, guidelines of Peters, Vissers and Heijne (1998) and Duke (1995) have been used to guide the designer in the creative, iterative and episodic game design process. An extensive elaboration on the way in which the theoretical background and key concepts are included in the final design of the SCRMG has been provided in the verification (6.1). In this part of the evaluation, twenty-one identified 'need to haves' from category 'Supply Chain Risk Management' have been discussed, and it has been argued that these most important requirements are included in the SCRMG. There are multiple ways to include the theoretical background and key concepts in the SCRMG. In this thesis, one variant has been worked out into a final design. The final design can be characterized as a "subjective human creation (van Houten 2007)".

2.4 In what way are risks incorporated in (a selection of) Supply Chain Management games?

Ten existing SCM games have been evaluated to answer this research sub-question.
In the Trust and Tracing Game (Meijer *et al*. 2008; Meijer 2009), players can either *trace* or *trust* their suppliers, and therefore have a risk to trace someone when it is not needed or to mistrust someone. In the Risk & Control game (Deloitte 2008b) players get a limited budget to implement 'controls' to reach certain goals. In the Distribution Game (Supply Chain Consulting Ltd. 2005), risk is related to setting the right amount of production capacity. In the game Shortfall, risks are incorporated with 'event cards' that are drawn after each round of the game. These events will

"affect game play for the next round", and "affect one or all tiers of your team" (Qualters *et al*. 2006). Mehring (2000) has constructed a game that is about matching supply and demand. In the game CODEPRO (Korhonen *et al*. 2007) players have to deliver products on time and without defects.

The Mango Chain Game (Zúñiga-Arias *et al*. 2007; Meijer 2009) incorporates 'uncertainties'[29]. "Risk allocation refers to three types of uncertainties present in the gaming simulation: (1) variability in the supply from the simulated producers, (2) quality loss with a chance of 1/6 in each transport stage, and (3) uncertainty about the consumer market price." In the Supply Chain Game (Involvation 2009), customer demand is uncertain (determined by the throw of a dice). In the Distributor Game, players are able to not pay for delivered products. Further, negation about prices implies the risk of paying too much for products. Lastly, the Beergame (Sterman 1989) is dedicated to Kleindorfer and Saad's (2005) risk category 1: 'matching supply and demand'.

In most of the evaluated games, risks have financial consequences. One reason to formulate this research sub-question was to gain *inspiration*. The present design includes 'contract forms' that are adapted from Zúñiga-Arias *et al*. (2007). The SCRMG includes 'event cards', as used by Qualters *et al*. (2006). Price negotiations are inspired by Corsi *et al*. (2006). Lastly, a dice is used to simulate 'randomness'/'uncertainty' (as by Zúñiga-Arias *et al*. 2007 and Involvation 2009) regarding the impact of an event.

3. What should be included in the debriefing of the Supply Chain Risk Management Game?

The actual debriefing in a game session depends on the observations of the game facilitator during the game session. The participants and situation differs every time a game session is conducted, as it is expected that participants will attend a game session only one time. Human behaviour is difficult to predict, and therefore the debriefing will be different each time. The quality of the debriefing depends on the skills of the game session facilitator. A certain quality level of the debriefing has been ensured by using the list of general quality criteria of Kriz and Hense (2006).

The debriefing process is guided by a PowerPoint™ presentation. In this presentation, several questions that the facilitator may present to participants are formulated. These questions are based on the game mechanics and elements that have been used to design and develop the SCRMG. The final debriefing has been designed in such a way that the link between game and reality can be made. Guidelines for the debriefing process are presented in the debriefing presentation and facilitator guide.

The link between game and 'day-to-day' reality of the participants depends on the reason to conduct the game session, the 'situation' and (professional) background of the participants. Based on interviews with Deloitte employees, it became apparent that knowledge concerning the 'connection' between game and 'day-to-day' reality of the Client organization is available and does not have to be developed. However, the debriefing presentation includes two slides concerning relevant Deloitte Service Offerings.

[29] "The terms risk and uncertainty are frequently used interchangeably (Ritchie & Brindley 2007)", see also §1.5.

4. How to measure the performance of the game session?

This research question is decomposed into research sub-question 4.1 and 4.2. The answer to research sub-question 4 is provided by answering these two research sub-questions.

4.1 What instrument can be developed to measure the performance of the Supply Chain Risk Management Game?

Several instruments can be developed to measure the performance of the game session. To measure the performance of the first game session, an evaluation form has been developed. The performance of the game session has been measured by both quantitative and qualitative data gathered by the performance measurement instrument. Several 'insurmountable' problems (see §6.3.1) relate to the design of a 'perfect measurement instrument'. As the intended audience (see §4.2.1) of the SCRMG should have a low pre-knowledge level about Supply Chain Risk Management, the need to measure the pre-knowledge of participants has been reduced.

4.2 Which performance measures should be included in this instrument?

The performance measures should be based on the (learning) goals. In this way, the performance measure reflects the educational value of the SCRMG, through a measurement of 'self reported learning effects'. Several performance measures are included in the performance measurement instrument because participants themselves are part of the learning experience and thus may learn different things from participating (in the same) game session.

An evaluation form with fifteen propositions that are rated on a '7-point Likert scale' has been developed to measure the performance (effectiveness) of the SCRMG. These propositions derive from different 'measures of effectives'. The propositions in the evaluation form are based on:
1) Six learning goals of the SCRMG;
2) The overall goal of the project;
3) A measure of success from Hofstede (2004);
4) A measure of success from Kriz and Hense (2006);
5) The goal of this project;
6) An alternative measure of success (i.e. increase of risk awareness);
7) Three 'general' requirements from gaming.

6.2 Research question

The research sub-questions have been answered. In this paragraph the answer to the research question is provided. The research question is: **'*How well can key concepts of Supply Chain Risk Management be learned through participating in the game session?*'**

The answer to the research question is based on three arguments:

(1) The verification process indicates that the key concepts are included in the SCRMG.
(2) The validation indicates that fourteen out of fifteen propositions have been rated 'on the positive

side' of the 7-point Likert scale of the evaluation form.
(3) Qualitative data indicates that there is much interaction between participants and there are little *structural* flaws in the design of the SCRMG.

Based on (1) the results from the verification, (2) 'self reported' learning effects from the evaluation form , and (3) qualitative data gathered through a game session, the final answer to the research question is formulated as:

There are strong indications that the key concepts of SCRM can be learned through participating in the game session. However, more game sessions –with different audiences- are necessary in order to further improve the design, and to gather more qualitative and quantitative data to support our indications. A limitation of this research is that the performance (effectiveness) –in terms of learning- of the designed artefact cannot be proved.

We will critically reflect upon the research question and the answer in §6.3.1. In §6.3.2 the transferability of the SCRMG is discussed by a 'generalization of the criteria' that have been used (see §4.2) to choose the European meat sector for the SCRMG.

6.3 Reflection

In this paragraph a critical reflection on two topics is provided. The first topic is 'the concept of learning' (§6.3.1), in which we will critically reflect upon the formulation and answer to the research question. The second topic addressed in this paragraph is the transferability of the SCRMG to other sectors (§6.3.2).

6.3.1 The concept of learning

There is limited consensus about the learning effects that arise from playing serious games. Throughout this thesis, game-guru Duke is referred to as an authoritative source and his insights have been used to structure the game design process. Further, Duke's (1995) guidelines were used to design and develop the SCRMG. To start the reflection on the concept of learning, Duke (as cited by De Caluwe[30]) states: "it works, that's all we know". From a scientific perspective, this is a dramatic statement. Scientists like to know, measure and significantly *prove* what processes occur that contribute to a certain (positive or negative) outcome.

"Gosen and Washbush (2004) studied the effectiveness of gaming simulations for learning [...] they conclude that at face value the effectiveness of both computer-supported simulations and experiential exercises (gaming simulations) is clearly supported by these papers (Meijer 2009, p. 28)." However, Gosen and Washbush (*ibid.*) argue that the concept of learning is 'illusive' as the participants themselves are part of the learning experience. This rationale implies that 'learning' cannot be proved –*also 'learning' by case-studies, textbooks etc.* Similarly, Meijer (2009, p. 28) reports: "to our knowledge, every attempt to concretise this variable has failed".

The instrument to measure the learning effects can be improved. Gosen and Washbush (2004) suggest criteria to overcome "instrumentation problems (Wolfe 2004, p. 6)". The limitations of quantitative measurement instruments may not apply to qualitative ones. Wolfe (*ibid.*) stresses the

[30] 24-5-2007 in SPM 9235: Game Design Course.

importance of developing and using more qualitative measurement instruments and states: "[...] *the true nature of what is happening in the experiential approach should be better captured through qualitative research*". Wolfe (*ibid.*) continues with: "*Rigorously applied qualitative observational techniques should come closer to capturing and authenticating what is being brought about.*"

However, the application of 'rigorously applied observational techniques' has its own (traditional) problems as Wolfe (2004) points out: "[...] although having its own problems of observer reliability and validity, [it] does not have to deal with what may be insurmountable problems associated with creating the perfect learning measurement instrument."

Learning and future behaviour
In the view of the 'theory of reasoned action' and 'theory of planned behaviour' (Ajzen & Madden 1986) it is believed that human behaviour depends on their beliefs and intention towards that behaviour (see Figure 7: Risk: beliefs -> awareness -> response). The change of (risk related) beliefs, which is learning, is thus no guarantee for the change in future behaviour. One way to overcome this problem is by using 'standard correlations'. In this case, one still has to prove the increase of knowledge during a longer period to measure a change in behaviour. This implies even more measurement problems that have not been addressed in this thesis.

Conclusion regarding the 'concept of learning'
Both qualitative and quantitative measurement instrument have their limitations. Both qualitative and quantitative data gathered by an evaluation form and game session observations have been used to formulate the answer to the research question. The final answer purposefully avoids a definitive positive answer on the occurrence of learning effects. We have formulated the answer to the research question by using the word 'indications'. Hereby reflecting the 'intangibility' and 'immeasurability' of the occurrence of learning effects. The answer to the research question is based on three arguments. Only one argument relates to 'learning' and we have used to word 'self-reported' in this answer.

6.3.2 Transferability of the SCRMG to other sectors

The scenario of the present design of the Supply Chain Risk Management Game is the European meat sector. This particular sector has been chosen for several reasons. The criteria that have been used to choose the European meat sector as the context of the SCRMG (see §4.2) can be generalized to identify the transferability of the SCRMG to other sectors.

Our –partly subjective- generalization of the criteria to transfer the present design to other sectors yields the following criteria for the transferability to other sectors (can be used as a checklist):

- Multiple 'disruptions to normal activities' should be relevant in the sector.
- The context should be easy to understand in a short timeframe.
- Information about the sector, risks, actors and processes is available.
- The end market demand can be simulated for every game round.
- All actors operate on the 'make-to-stock' mechanism (a build ahead production approach in which products are sold from the inventory)
- The sector can be characterized as a 'spot market' – no long term contracts or monopolies.
- Ideally, the characteristics of Normal Accident Theory (interactive complexity and tight coupling) can be applied to the 'reference system'.

- Ideally, the sector's risk exposure increased the last decade(s).
- Ideally, the sector is competitive.

If the proposed sector (or supply chain, supply network, value chain or industry) fulfils above mentioned criteria, the next step would be to construct the game. The requirements to (re-)construct the game materials are;

- At least three (sequential or reciprocal dependent) actors that buy and sell 'products' can be distinguished.
- These actors 'add value' to the product.
- All actors have an inbound and outbound section of the warehouse.
- The profit (#products * price / game round) is the same for all roles (or more 'construction work' is required).
- The trade of products is repeatable (in multiple game rounds).
- Several 'event cards' can be constructed.
- The event cards can be divided into distinct categories.

Above mentioned criteria must be fulfilled if one wants to construct a game based on the present design of the SCRMG (in a short timeframe). To determine if a particular sector can be used and/or to speed up the game design and construction process, the models used in Chapter 4 of this thesis can be adapted (*for instance* Figure 24: Supply Network Structure and Figure 24: Cause-effect model). One basically has to repeat all phases of the construction phase. These phases are presented in Figure 25: Seven phases during the construction phase.

Logically, the SCRMG can be easily transferred to a number of 'agri-cultural industries'. For example, the trade of fresh fish, cheese or other types of food products in a regional, national or global supply network. Another example would be the automotive industry (factory → importer → dealer). Cheap cars are typically 'build ahead' and disruptions to normal activities are relevant. Also, the mismatch between supply and demand is relevant.

Finally, 'intentional and man-made' '*disruptions to normal activities* (terrorism) could be simulated in the same (or another) sector through using the SCRMG.

The SCRMG has been designed, constructed, tested and evaluated to reach the specified learning goals. Therefore, the learning goals of the to-be-designed game should overlap with the learning goals of the SCRMG to maximize educational value.

6.4 Recommendations for use

In this paragraph, the 'recommendations for use' are formulated. The SCRMG is a playable game but the design could also be used to create new games (explained in paragraph 6.3.2). Based on the interviews conducted with Deloitte employees it became apparent that the game should be designed for 'adaptability'. The final design is suited for flexible use in terms of the number of participants, duration and content of the introduction and debriefing. Further, all game components can be customized to meet the demand of a specific target audience.

The results from the interviews and evaluation of existing SCM-games show that the Supply Chain Management games can be used for different purposes. The design should be 'fitted' to the demands of the intended audience.

First, the possible ways to use the SCRMG will be discussed in §6.3.1. Then, in §6.3.2 it will be argued that several design variables must be 'balanced' to meet the intended audience's demand.

6.4.1 Multiple ways to use the Supply Chain Risk Management Game

The starting point to use the SCRMG by Deloitte is 'Risk Consulting' activities. We will discuss several purposes to use the SCRMG.

1) Purpose: to use the SCRMG for Deloitte recruitment purposes

A recent report of Forrester (2009, p. 7) explains the relevance of serious games for recruiting Gen Y. "*Business leaders, worried that they will not be relevant to them, are looking for innovative ways to reach Gen Y. This provides a great opportunity for serious game vendors. The successful vendors in this space will be those who can demonstrate that their game designs and content effectively reach Gen Y*." To successfully use the SCRMG for recruitment purposes, the SCRMG could be adapted in a short timeframe.

2) Purpose use the SCRMG for Risk Management Training

If used in a Risk Management learning context, one can start with the normal curriculum and then (in the end) conduct a game session with the participants. In this way participants can first familiarize with Supply Chain Management and then 'learn' more about Supply Chain Risk Management (SCRM). SCRM is regarded as a special topic of Risk Management.

3) Purpose: use the SCRMG for Supply Chain Management Training

If used in a Supply Chain Management learning context, one can start with the normal curriculum and then (in the end) conduct a game session with the participants. In this way they can first familiarize with Risk Management and then 'learn and understand' more about Supply Chain Risk Management. SCRM is regarded as a special topic of Supply Chain Management.

4) Purpose: use at Clients

Based on interviews with Deloitte employees several requirements were identified (Table 20). A number of changes must be made in order to increase the chances of success when playing an adapted version of the SCRMG with clients. One way to use the SCRMG is to adapt it to meet / stress the importance of relevant Deloitte Risk Consulting Service Offerings.

Relevant Deloitte Risk Consulting Service Offerings are (Pers. Comm. P. Weel & D. Janmaat, June 2009): 'Third Party Assurance' , 'SAS 70' , 'Risk Awareness Training', 'Risk Management workshop', 'Supply Chain Vulnerability Assessment', 'Supply Chain Risk Management' and 'Contract Risk and Compliance'.

Several purposes to use the SCRMG have different demands. It is up to Deloitte to determine if the SCRMG will be adapted to one or multiple purposes. For all above listed purposes, the balance of several 'game session aspects' must be chosen.

6.4.2 Customization of game session aspects to meet target audience's demand

Several aspects of the game session (and of the SCRMG) should be balanced to meet demand. In the next figure these variables are indicated, with their 'extremes'. The target audience's demands can be identified by *for instance* interviews (the 'success factors', see Appendix G - #1). Subsequently, the SCRMG can be adapted to meet the demands and the SCRMG can be used.

For different target audiences, several requirements can be distinguished:

- The type of game (serious or fun);
- Game outcomes (based on luck or strategy);
- Focus of the session (theory or practice);
- The duration (from 1 till 4 hours);
- The task complexity (easy or difficult);
- The variety of risks (few or many), and
- The type of Supply Chain Risk (matching supply and demand or disruptions to normal activities).

This are all important aspects to take into consideration when the SCRMG must be adapted to a specific target audience. The present design of the Supply Chain Risk Management Game on all aspect is visualized with vertical green lines. The game session aspects are presented on the horizontal black lines, and the extremes for each game session aspect are presented in red (Figure 27).

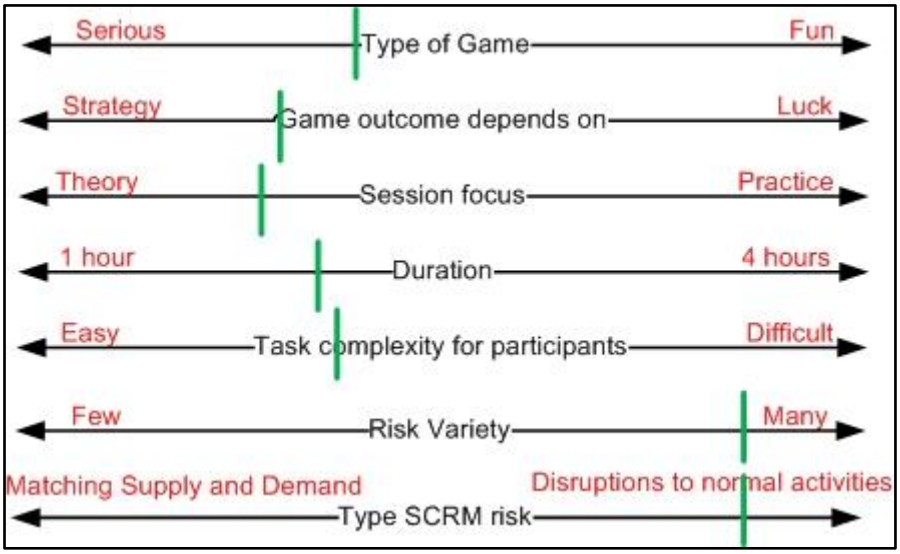


Figure 27: Game session aspects in present design

Figure 27 is provides clarity on possible game session adaptations on several important aspects. Further, the aspects can be adapted in all game materials (player manual, event cards, risk management overview, introduction and or debriefing).

6.5 Recommendations for future research

In the last paragraph of this thesis our recommendations for future research are provided. Based on the research undertaken on the domain of Supply Chain Risk Management (see §3.1 and §3.2), two suggestions for future work are formulated.

Recommendation (1): *The development of a model that incorporates both a horizontal view (see Fig. 12) and vertical view (see Fig. 13) on the sources of supply chain risk.*

Such a model provides a starting point to further understand the complexity of Supply Chain Risks and would visualize how risk arising from different sources is transferred through the supply network: between different actors and layers. The model should incorporate multiple levels of risk in the network (Network Analysis) and multiple supply chain risk sources (Supply Chain Analysis), it would therefore be a direction towards a model to support 'Netchain Risk Analysis' (Lazzarini *et al.* 2001). A first recommendation for future work would therefore deal with this question:

What model can be designed to support 'Netchain Risk Analysis'?

Next to the horizontal and vertical view on the sources of risk in supply chains, the time dimension could be included (as in Li & Chandra 2007, p. 1052). Lastly, there are multiple dimensions of loss; "financial, performance, physical, psychological, social and time loss (Harland *et al*., 2003; p. 52-53)". Different dimensions of loss could also be included. The model could evaluate ex-ante or ex-post the impact on of a (disruption) risk in the supply network. For instance, one could visualize the origin of a disruption and its pathway during time through (a conceptual or real-life) supply network: the path between different actors (horizontal direction) levels (vertical direction) and different dimensions across time. It would be a multi-dimensional model that would visualize complexity.

Recommendation (2). *The development of a more comprehensive and multi-actor model to present the costs of disruptions versus the cost of mitigations.*

In the model of Husdal (2007) 'resilience' is excluded. In this thesis it has been argued that the reliability of a supply chain depends on both its 'intrinsic vulnerability to risks' and the 'ability to ride the shocks'. A conceptual model of the strategic cost-risk trade-off may advance cost effective mitigation practices. Such a model must include the costs of disruptions and mitigations for multiple actors. This may yield an optimal co-investment amount –from an economically most efficient level - as actors are reciprocal dependent on each other in a network situation. The rationale and method can be borrowed from the book 'Managerial Economics' (Png 2002), which can be used to view supply chains as an 'imperfect market' in which positive and negative externalities occur. Risks are transferred which we may consider to be 'externalities' (Png 2002, p. 387). "An externality arises when one party directly conveys a benefit or cost to others *(ibid.)*". "Externalities can be resolved through merger or joint action *(ibid.)*". In this thesis (see Figure 18) it has been argued that 'joint action' is the key to the management of risk in networks. Such a model can be used by a company to encourage their suppliers or customers to co-invest in SCRM. With the model, we may illustrate that 'joint action' implies higher reliability as the total costs of a certain risk are higher for multiple actors, as opposed to a single actor cost evaluation of a certain (disruption) risk.

The boundaries of this model may be based on the conclusions of Normal Accident Theory (NAT) and High Reliability Theory (HRT). NAT states that 100% systems reliability is impossible as accidents in complex socio-technical systems are 'normal'. HRT states that organizations can become High Reliability Organizations: the reliability of the system can be improved. The second recommendation for future work would therefore deal with four sequential research questions:

1) What model can be designed that includes the reliability of a supply chain in terms of its vulnerability and resilience to risk and the cost of disruptions and mitigation actions?
2) What economically most efficient co-investment level can be derived from the multi-actor analysis of (a certain) risk in a supply network when externalities occur?
3) What level of reliability is the result of the co-investment?
4) What increase in reliability is the result of the co-investment?

The reader is referred to §6.2, §6.3.3 and §6.4 for recommendations concerning the SCRMG. These recommendations can be summarized as: 'adapt and test the SCRMG to meet customer demand'.

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Appendix A: Risk Intelligence Framework

Business thrives by taking risks, but can falter when risks are managed ineffectively. The **Risk Intelligence Framework,** created by a team of cross-function and industry professionals, illustrates how an enterprise can create and preserve value by managing risk. The coloured circles represent the organization, while the outer dotted arrows represent external factors that can have an impact on the organization. The framework is developed by Deloitte (2008c).

Read more below about how the Risk Intelligence Framework works, including the seven steps that comprise risk management and the four pillars of intelligent risk-taking.

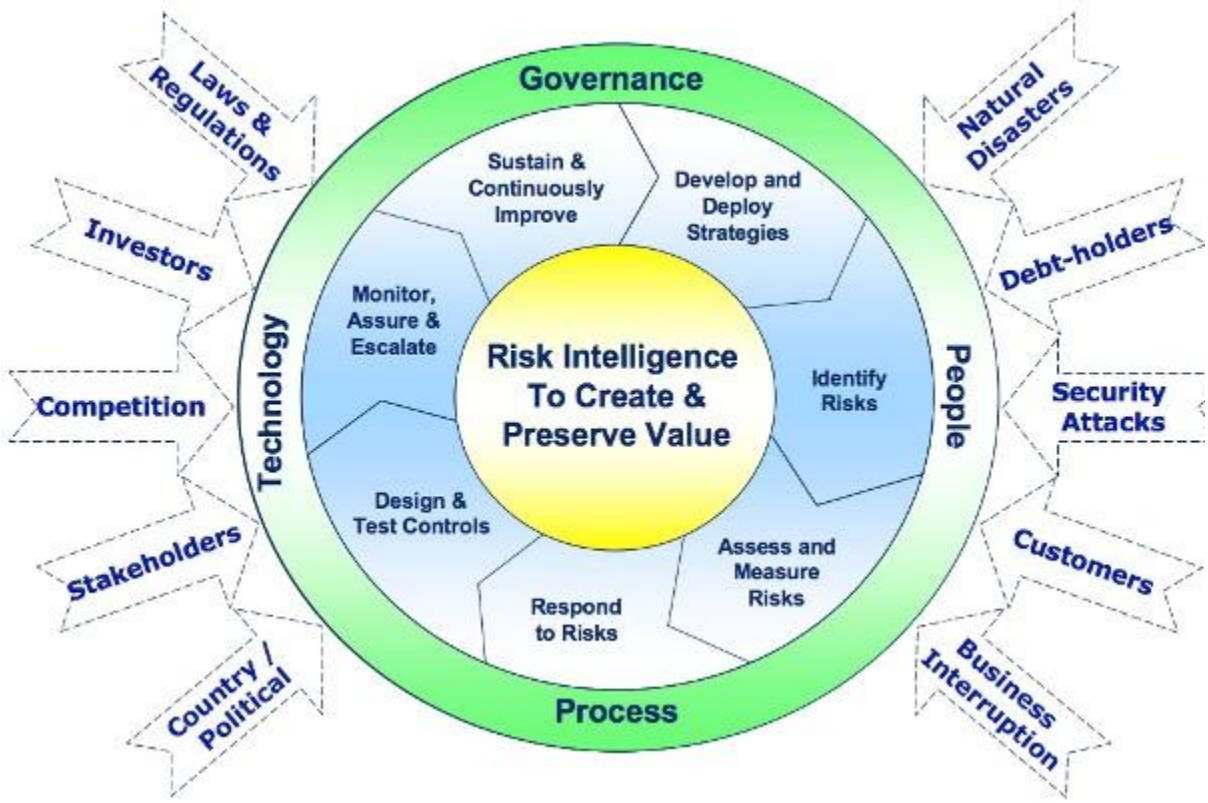


Figure 28: Risk intelligence framework (Deloitte 2008c)

The three levels of the Risk Intelligence Framework

Level I - The outer dotted arrows on the Risk Intelligence Framework are **external factors** that can adversely affect an enterprise, including changes in customer preferences, political pressures, regulatory requirements, and competitor actions. External factors are increasingly characterized by uncertainty, complexity, connectivity, and speed.

Level II - The outer coloured circle represents the organization's risk **management capabilities,** the four interdependent foundational pillars of intelligent risk-taking. Weakness in one pillar can reflect systemic weakness for the enterprise. The pillars of risk management capability are:

- *Governance:* The ability to calculate risk and reward, make risk intelligent decisions, and execute those decisions in a timely and effective manner. Included are the roles and responsibilities of the board and its committees, management, internal audit and risk management functions, tone at the top, risk management policies such as risk appetite and tolerance, the code of ethics, and delegation of authority.
- *People:* This pillar focuses on management capabilities and related risks such as having the right number of people, with the right training and awareness.
- *Process:* Includes core operational and infrastructure business processes necessary to run the business in an efficient manner, and create and protect value.
- *Technology:* This pillar establishes capable systems to analyze and communicate risk information throughout the organization and enable risk intelligent decision-making and timely response.

Level III - The two inner circles demonstrate the **seven steps an organization must achieve to become a risk intelligent organization.** The seven steps are:

1. *Develop and Deploy Strategies:* Strategies such as revenue growth, operating margin, asset efficiency, and meeting expectations are developed to create and preserve value.
2. *Identify Risks:* Internal and external risks can compromise the achievement of the entity's objectives. Risks are considered scenarios and chains of events rather than isolated incidents. This includes risks to both future growth objectives and risks to existing assets.
3. *Assess and measure risks:* Consider (1) the extent that events may negatively impact objectives and the speed at which they could occur, and (2) the net exposure to the business after considering current risk mitigation and controls.
4. *Respond to Risks:* The response plan considers all possible alternatives, including whether to avoid a risk, accept it and mitigate where possible, and/or transfer it. Resources are prioritized and allocated, and the selected plan is executed.
5. *Design & test controls:* Control activities are the policies, procedures and systems that manage risks effectively. Management has the primary responsibility for the appropriate design and testing of controls.
6. *Monitor, assure & escalate:* Monitoring is the periodic observation of the enterprise's portfolio of risk exposures (individually and in aggregated) to detect and give timely warning of change. Assurance is provided by management that the system of control is working as intended. Controls should be periodically tested by independent functions to provide reassurance that management's reports can be relied upon and that controls are designed appropriately and operating as intended. Escalation is a procedure by which risks that exceed specified thresholds or triggers are elevated to the appropriate level of authority for quick resolution.

Sustain & continuously improve: Risk intelligence should be sustainable and depends on the capabilities of people, processes, and systems to act in an integrated, coordinated and timely manner. Improvement is always possible, so risk management processes should be evaluated regularly and improvements implemented.

Appendix B: Evaluation of existing games

In this appendix the results from the evaluation of existing serious games are reported. In §3.4 Evaluation of Supply Chain Management games' the reasons and the selection process has been clarified. Table 17 presents the game title, institute, reference, purpose, audience, computer use, products/components, actors, dilemma/trade-off, risk, competition, external events, miscellaneous and if the game has been played by the author.

Game title	Institute	Reference	URL	Purpose	Audience
Trust and Tracing Game	Wageningen University	(Meijer *et al.*, 2008, Meijer, 2009)	N.A.	Research	Students and professionals
Risk & Control game	Deloitte (Enterprise Risk Services) (private company)	(Deloitte, 2008b)	N.A.	Learning	Mainly students
Beergame	Massachusetts Institute of Technology	(Sterman, 1989)	[31]	Learning	Students and professionals
Distribution game	Supply Chain Consulting Ltd. (private company)	(Supply Chain Consulting Ltd, 2005)	[32]	Learning	Mainly students
Shortfall	Northeastern University	(Qualters et al., 2006)	[33]	Learning	Students and professionals
Siemens Brief Case Game supply chain simulator	Siemens (private company)	(Mehring, 2000)	N.A.	(experiential) Learning	Students
CODEPRO	University of applied sciences, Finland	(Korhonen et al., 2007)	N.A.	Learning	Students
Mango Chain Game	Wageningen University	(Zúñiga-Arias et al., 2007)	N.A.	Research	Students and professionals
Supply Chain Game (fun version)	Involvation (private company)	(Involvation, 2009)	[34]	Learning / fun	Anybody (even kids)
Distributor game	Delft University of Technology (with others)	(Corsi et al., 2006)	[35]		Students and professionals

[31] http://beergame.mit.edu/ (accessed 20 march 2009)
[32] http://www.supplychaingame.com/about.htm (accessed 20 march 2009)
[33] http://www.coe.neu.edu/Groups/shortfall/ (accessed 20 march 2009)
[34] http://www.involvation.nl/Page/sp75/ml1/Index.html (accessed 20 march 2009)
[35] http://www.gscg.org:8080/opencms/opencms/gscg (accessed 20 march 2009)

Fully computer aided. Online playable with multiple players	Computers and computer components	Distributors. *suppliers, markets, and competing distribution centers are represented by computer-controlled actors*
No	Not specified	Only manufacturers. Manufacturer has its own transport company. Six players can play the game.
No	Mango's	4 actors. producer association, independent exporter, multinational, retailer
No	*The products of the game are sheets of paper with number codes, simulating 540 product variations.*	4 actors. The focal company, a supplier, a subcontractor and a customer. The focal company is divided into four departments.
No. Siemens offered a *briefcase* with supply chain simulation materials. You must construct exercises yourself, with provided materials.	Lego blocks represent materials.	9 participants; a customer, a supplier, SCR's Sales division (=4 activities), Bcc's manufacturing division (=6 activities).
Original game was a 'paper game'. Later, a computer version has been build.	Automotive supply chain with parts, materials and cars.	Three actors are included: OEM with 1st and 2nd tier supplier. Four roles within one company: the CEO, the Environmental Manager, the R&D manager, Production manager.
Yes. Excel spreadsheet is used for accounting purposes.	Engines	Four business units of focal company. 4 actors are external to the supply chain (SCM-consultants, 3PL, 3PL, customer)
Original game was a 'paper game'. Later, a computer version is made.	Beer	Retailer, Wholesaler, Distributor, Manufacturer.
Excel sheet is used for the accounting system to calculate points.		One type of actor, but different teams.
No.	*Generic food supply network.* No specific product mentioned	4 actors. Producer, middlemen, retailer, consumer
Computer use?	**Product(s) / Components**	**Which actors are in the chain?**

Winning orders by setting the right price for products. Maximize revenue.	Player with most profit wins the game.
Lean or agile supply chain network. Matching supply and demand through setting the production capacity.	Player who has sold 15 units wins the game.
Who do you do business with? How to maximize revenue?	Revenue maximisation
The game is played at the start of a supply chain management improvement program.	The performance of these two configurations is measured by productivity, quality, delivery reliability and the total inventory investments in the supply chain.
Objectives are to commit to orders at requested times, to deliver the complete orders at the time committed, and to make a substantial contribution to profit.	Manage the lead times and costs to achieve good performance with respect to delivery capability, delivery reliability, profit contribution and quality. Profit contribution is measured by calculating the revenue from items delivered and costs incurred in production.
Exploration of the tradeoffs in the triple bottom line (economic, environmental and social performance)	Points are awarded based on five performance indicators: 1) total profit 2) total Greenscore 3) Total waste removed 4) waste disposal expenses 5) total cars sold. Team with most high scores wins.
It is up to the management to try and co-ordinate and optimize all the business units so that they work together effectively and profitably. Capacity and Production management	*The purpose of the game is to meet customer demand for cases of beer, through a multi-stage supply chain with minimal expenditure on back orders and inventory*
The players' objective is to minimize total team costs	*The players' objective is to minimize total team costs*
To implement the right control measures given the case description	The team with the most points wins. Points are earned by right selection of controls. Fines are imposed when budget is overspent.
Rely on trust or spend money on tracing when trading a product with a hidden quality attribute	*The producer who earned the most is the winner. For consumers, the winner is the one with the most points.*
Dilemma / trade-off	**How to win the game?**

Yes. Customers are able to not pay bills. Much negotiation about prices	Yes. Multiple distributors compete for orders.	No.
Customer demand is determined by the throw of a dice.	Yes. Each player has the same role (manufacturer)	No.
Risk allocation refers to three types of uncertainties present in the gaming simulation: (1) variability in the supply from the simulated producers, (2) quality loss with a chance of 1/6 in each transport stage, and (3) uncertainty about the consumer market price	Yes.	Yes, by game facilitator
Defected products, delivery reliability, right order fulfilment (amount). On-time delivery is most important.	Multiple actors, but competition is not mentioned in the paper.	No.
Customer deliver capability, customer delivery reliability, quality and profit contribution. Performance is reported for different functions.	No	No, everything is pre-described (in case 1). Complexity comes from coordination different functions. Game shows complexity and importance of logistics.
Risks are included through event cards. Further, matching supply and demand is incorporated in the game: planning risks.	No	*At the end of each round, an event occurs that will affect game play for the next round. These events can affect one or all tiers of your team. All teams playing the same game number will see the same current events.*
Yes. The risk of not being able to produce / too much production capacity / too little production capacity Inventory holding and backlog costs.	Yes, but limited to the 3PL's in the game	No
Inventory holding costs and backlog costs. Demand amplification leads to over-ordering and high inventory levels.	No	No
Yes. The risk of not implementing the right control mechanisms. Too much spending leads to fines and spending under-budget gives a bonus.	No	No
Yes. Risk of getting caught cheating. Risk of tracing people that are not cheating. These risks have financial consequences.	Yes	No.
Are risks included? How?	**Competition? (chain vs. chain or actor versus actor)**	**Events external to the supply chain (game facilitator roles are excluded)**

The designed suite enables developers to build SCM games in a short time frame. Internet based suite for play in a distributed context. Simulates 'a real life experience'.	Played game online
Very simple game, build for fun. (Involvation has also build a 'serious game', available as a (expensive) training exercise for professionals.	Yes
'round 0': a game round that does not have any consequences for the outcomes as the actions are undone after the round ends.	No
Presented as a workshop, including a role game. Good arguments for '*the game approach as an organizational development tool*'	No
Extensive case-introduction players have to read before the simulation exercise. Main challenge is to meet customer demand by inventory and time-management. Explains the concept of experiential learning	No. Further, no additional information has been found (Siemens briefcase SCS has been introduced in 1995)
Introduction is credible. How to win the game is quickly introduced (page 1). - nice tech. innovation system, with three levels. - buy/sell prices and max buy/sell amounts are determined by game leader/computer. Lots of investments ($800K) were needed to develop the game	Played game online
Customers can impose fines on suppliers if contracts are not fulfilled. Players get fines if they cheat or do things wrong. Supply chain partners can fine each other if contracts are not fulfilled	No
Game is easy to understand. Has a valuable learning lesson. Nice game board Players are told the game will run for 50 simulated weeks, but play is actually halted after 36 weeks to avoid 'horizon effects'.	Yes. Attended a variant; *Shampoo Game* (Ludema, 2008). Played 'Beergame' online.
Game description is well written. Structure of risk and control mechanism is derived from 'audit' field. Risk reducing strategies can be audited; a small fee is paid in order to gain certainty. Randomness is simulated with throwing a dice.	Yes
Few rules. Physical setting reflects chain. Flexible time distribution: predetermined stopping moments. Financial mechanism for increased costs when risk 'fires' more downstream the chain. Trace-agency is simulated by the game facilitator.	No
Miscellaneous	**Game played by author?**

Table 17: Evaluation of existing serious games in the field of logistics

Appendix C: Testing log

In this appendix the most important improvements after the testing sessions are listed. The participants and location, what is tested, and the changes, outcomes and/or observations are listed in Table 18.

Test activity	Participants & Location	What is being tested?	Observations & Changes
#1: 10 march 2009	Rob. Home.	Basic game infrastructure (see Figure 25) with three actors, which can sell and buy products with contract forms.	**Observation**: As expected, profit per round is € 3.000. **Change**: delivery and payment sequence is determined. 1st: supermarket. 2nd: processing company. 3rd: farm. **Change**: risk allocation description must be altered
#2: 8 April 2009	Three Deloitte interns. Deloitte, Amstelveen office	The complete game, with a short introduction and debriefing. Participants were asked to write down on all paper game materials what they think that should be improved (typical suggestions: text errors, too much text, too little explanation etc.)	**Observation**: The movement of inventory from inbound to outbound conflicts with incoming products. **Change: steps of play are altered** **Observation**: It was not clear in which phase of the game the game starts. **Change**: game starts in phase 2 (simulation phase). **Change**: readability of the game manual is improved. **Observation**: good game 'flow' and lots of discussion. **Observation**: not clear when to throw with the 'resilience dice'. **Change**: better description and explanation the event cards regarding the throw of the resilience dice.
#3: 9 April 2009	J. Moll. Home.	The player manual	**Change**: Improvement of readability and 'understandability' of the player manual.
#4: 12 may 2009	H. de Graaf. (internet)	The player manual of the processing company	**Change**: Improvement of readability and 'understandability' of the player manual.
#5: 14 may 2009	E. Anthony. Home	Concept of the game is explained	**Change:** the role of the feed company is changed into 'breeding farm' (after Taylor 2005), because otherwise 'feed' can be processed in one month into full-grown cows. This is not realistic. Implementing this change leads to a more external valid, credible and realistic game scenario.
#6: 15 may 2009	11 students of SPM 9423 course. Faculty TPM	The SCRMG and the evaluation form	Please find below an extensive report of the game session.
#7: 21 June 2009	Six friends and family members.	The SCRMG, without the introduction and debriefing presentations.	The SCRMG can be perfectly played by other people than the intended audience. The participants liked playing the game.

Table 18: Test session log

Game session report **Friday 15 May, 15.00 – 17.00, Faculty TPM**

On Friday 15 may, the first test session was conducted. The first game session with more than three participants primarily focused on testing the processes and interactions in the game. Although the

designer had certain ideas about the processes that would be taking place, human behaviour is difficult to predict. Further, the readability and understandability of all written materials and the time schedule were important focus points.

An evaluation form has been designed to gather both quantitative and qualitative data. The participants of the game session were eleven students from the course 'SPM 9423: Design of business logistic games', instructor M.W. Ludema. Nine students had a role in the game (i.e. three supermarkets, three processing companies, three farms). 1 student played the role of bank, consumer market and breeding farm. Another student was asked to observe and to make notes of all interactions, processes and problems during each round. The game facilitator was R.P. Kuijpers.

Data sources
The conclusions from all activities are now discussed. All qualitative data gathered by:
A) the evaluation forms (suggestions);
B) the report of the game session observer;
C) the game facilitator;
D) comments by M.W. Ludema, and
E) text comments written by participants on the game materials are input for the intended changes.

The quantitative data derived from the evaluation forms is discussed in Chapter 5. Next, all observations of each sequential activity during the game session are pointed out. All intended changes are directly formulated after the observations. This game session report ends with the formulation of overall conclusions and 'key' changes to improve the SCRMG that are based on the qualitative data gathered during the game session.

Observations and intended changes in sequential order

1) Reading the player manual

Observation (C). Some participants read relatively slow and need 15 minutes to read the player manual. **-> Intended change**. Participants should get 15 minutes –or longer- to read the manual. The manual may be shortened a bit. **Observation (E)** The capacity constraints are unclear. -> **intended change**: improve description of capacity constraints.

2) Introduction Presentation

Observation (C & D) some topics are not interesting for participants. The introduction presentation may be shortened, and should take for instance 5 minutes. → **Intended change**: A slide with the overview of the supply chain should be added. Some slides are removed to save time.

3) Hand Out of all player materials

Observation. None. → **Intended change**. None.

4) Round 1 (30 minutes)

Observation (A, B, C, D & E). Round 1 takes about 30 minutes. **Intended change**: the game facilitator should explain beforehand what will happen in the first game round. This explanation should be very practical.

5) Round 2 (20 minutes)

Observation (C & D): One participant who played the supermarket did not understand the instructions (and only sold 10% of the end market demand). 1 Ton = 1000 KG = 10 units * 100 kg. Subsequently, the first and second tier supplier were not able to sell the maximum amount, this negatively influenced their 'experience'.
Intended change: Include the number of units in the simulation of end market demand.

6) Round 3 (14 minutes)

Observation: after two game rounds, the game goes 'smoother'. The game facilitator has to check if participants act in the right sequence. The game leader announces that people are able to bargain on prices. Participants start to collaborate and negotiate.

7) Round 4 (10 minutes)
8) Round 5 (10 minutes)

Observation (A, B, C & D): The game leader announced this was the final round. 'Horizon effects' occurred and nobody invested in risk management in this last game round. **Intended change:** do not announce the last game round.

9) Debriefing

Observation: Winner of the game may be based on multiple Key Performance Indicators. For instance: The winner is the player with the highest Y. Y = The cash position + 50% of the value of investments in vulnerability and resilience.

10) Evaluation Form

Observation (C): Printing error at question 8. **Intended change**: fix error.

Resilience dice
Observation (A, C & E). Imbalance between investments in resilience and vulnerability. **Intended change:** Participants get a 33% discount. Participants thus pay €2000 per category if they collaborate.

Overall conclusions
There are little *structural* flaws in the design of the SCRMG. There are no (or little) problems relating to the external validity. Some things can easily be improved. Several things went well, like the buying and selling of products, the event cards and the investments in decreasing vulnerability. The overall conclusion is that the participants should be better prepared to game and the actions they should take. Because, if only 1 player does not understand what he/she should do, the rest of the chain cannot buy and sell the maximum amounts of products. All participants are reciprocal dependent on each other. Lastly, the investments in resilience should be '**re-parameterized'**.

Key changes to improve the Supply Chain Risk Management Game.

1) **A shorter and adapted version of the introduction.**
2) **A shorter and adapted version of the debriefing.** A slide for discussion on each of the elements should be included. 1 slide about vulnerability. 1 slide about resilience. 1 slide about strategy.
3) **All game rules, processes, amount and quantities should be even easier to understand.** Several textual changes.
4) **Player manual.** Shorter player manual. Remove information that is not important.
5) **End market demand**
   Some fluctuations in demand may be more interesting. For instance, in the summer (barbeque) and in December (Christmas) demand could be higher. The new end market demand is between 900 and 1100 kg per month. Further, the exact amount of units will be specified in the description of the end market demand. As supermarkets have some certainty about the demand for meat each month -based on historical data- the demand for each month will be simulated before the game starts. The result is that the duration of the game rounds will be shorter.
6) **Evaluation form.** Error is fixed.
7) **Event cards.** Three event cards per game round (instead of two).
8) **Contract forms. '**Other agreements' is added. Participants are able to create their own game by using 'advanced techniques' reflecting real-life situations, such as risk pooling, integration, long-term contracts, mergers /acquisitions, co-investments. Further, the mandatory character of risk allocation is stressed.
9) **Facilitator explains all game components <u>before</u> the participants start playing (='walkthrough').** Roles and tasks of the facilitator are better described.

All the changes to improve the SCRMG are carried through and should be tested in a next game session.

A student interacts with game materials during the first game session.
(15-5-2009)

Appendix D: Contract Form

Round # ____

Contract

Quantity	
Price per unit:	€
Total Price:	€

Risk Allocation

Effect of breaking or not fulfilling the contract. Choose one of the four options (mandatory):

1. Cancel Contract
2. Seller takes risk
3. Buyer takes risk
4. Risk is split 50:50

Other agreements:_____

_____

Company Names

Seller:_____ Buyer:_____

Appendix E: Player Manual

Dear participant, please read the information provided to you in this document to prepare for the Supply Chain Risk Game. Take 15 minutes to prepare yourself.

Introduction

Value Chain / Supply chain

In the game you are about to play, multiple companies are involved in the buying, selling and delivery of meat-products for the consumer markets throughout Western Europe. A farm buys calves from a breeding farm and sells cows. The processing company buys cows from the farm and sells vacuum portions of meat to a supermarket. The supermarket displays the vacuum portions of meat (retail cuts) in their stores to serve their customers. Each company has its specific processes. The processes within your company and your role in the organization are described below.

Your role

CEO De Rund & Zn. (Processing Company)

You are the newly assigned CEO of De Rund & Zn. The previous CEO is sent home after poor (risk) management. The goal of the processing company is to maximize revenue. The processing company buys cows from the farm, processes them and finally sells vacuum-packed retail cuts of meat to the supermarkets.

Inbound process

The processing company buys cows from the farm. A full-grown cow has an average price of € 10 Euro. Depending on your negotiation skills you may be able to buy for a lower price!

Process within the processing company

The processing company exists of the abattoir (slachthuis) and the processing plant. At the abattoir, cows are killed, gutted and cleaned. Then the carcass is transported to the processing plant. Here, the primal cuts (see figure 1) are made. The butcher does his job and finally the product is portioned, weighed and packed into consumer portions. Finally, the product is labelled according to customer requirements. Now, the product is ready to be transported to the supermarket. One live animal is processed into 10kg of end product.

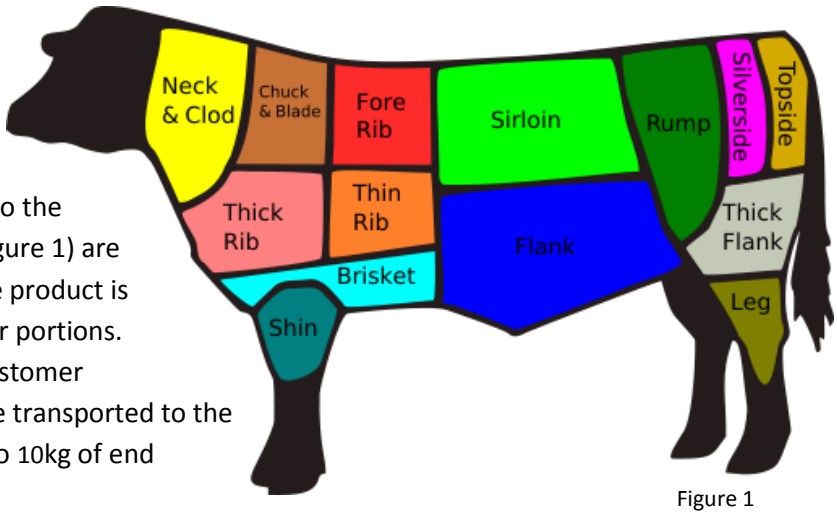


Figure 1

Capacity constraints

When the product leaves the processing plant, it is stored in the low-temperature outbound section of the warehouse. The processing company makes-to-stock, but cannot stock too much because of refrigerating-capacity constraints. \The warehouse has limited capacity to store meat: the maximum storage capacity is 10 kg (15 units in the game). If more than this amount is stocked, the right temperature in the warehouse (4 degrees Celsius) cannot be maintained and the product is destroyed.

In the game, you place the livestock you have bought from the farm in the inbound section of warehouse. The next round of the game the animals are processed into consumer portions, which you place in the outbound section of the warehouse. Now, the product is ready to be sold.

Outbound process
You sell the consumers portions to the supermarket. The average selling price is € 10 per 10 kg, which is the Minimum Order Quantity. Depending on your negotiation skills you may be able to sell for a higher price! The appropriate volume - specified in the contracts - is delivered to the supermarket.

Your Objective
In the trade-network described above, risks occur. Risk is defined as; "The potential for loss or diminished opportunity for gain caused by factors that can adversely affect the achievement of a company's objectives." **Your objective is to maximize profits**, by buying products from your supplier and selling it to your customer. The company with the most profit in the end wins the game. In order to sustain profits, you will have to **pro-actively manage risks**.

A history of Risks
In the meat supply chain, things are not what they used to be. Several diseases (Bovine Spongiform Encephalopathy ('crazy cow decease') from 1994 and Foot and Mouth Disease drove governments to export/import bans and mandatory preventive destruction of live animals and meat products at farms, importers, exporters, processing companies and supermarkets. End-customer demand decreased and the reputation of the meat sector diminished (besides the impact on human well-being in terms of deaths and sickness).

For the meat sector, it was a huge financial blow -*for all stakeholders*-. In addition to these '*high impact risks*', numerous recurrent '*low impact*' events such as accidents, equipment failure and Human Resource matters manifested recently.

To be able to internationally compete, operations have scaled-up massively and have become leaner. A European Commission supported research that has been performed in the 2000-2006 period to investigate all kinds of risks in the meat sector and to provide solutions for this strategic industry – which in several countries strongly contributes to the Gross Domestic Product. For instance, in the Netherlands, 27.000 people are employed in the meat-sector. The ultimate purpose of the European Commission[36], individual governments and the red meat industry is to create a *sustainable meat sector that is able to compete globally*, with –for instance- the Argentina and Russian competitors. Several risks occur in all supply chains, some are specific to the meat sector. In total, seven different categories of risks to the European meat industry were identified in the research;

[36] Source: Regulation (EC) No 178/2002 on 'the General Food Law'

	Risk category	Explanation
GENERIC	**Production**	Risk relating to the production process / value-added process
	IT & Communications	Risk relating to IT-systems and Communications
	Sites and Facilities	Risk relating to Sites and Facilities
MEAT CHAIN SPECIFIC	**Regulation & Legislation**	"Hazard Analysis and Critical Control Point (HACCP), is used to describe an internationally recognized way of managing food safety and protecting consumers. It is a requirement of EU food hygiene legislation that applies to all food business operators EU Regulation 852/2004 (Article 5) requires food business operators, including meat plant operators to implement and maintain hygiene procedures based on HACCP principles"
	Sickness	Several bacteria and viruses may lead to animal sickness resulting in dangerous meat products
	Hygiene / Sanitation	Poor hygiene and sanitation result in fines posed by Inspections from Government authorities.
	Unknown	Events that cannot be predicted in advance with reasonable certainty, against which you cannot deal with 'ex-ante'

All these risks have a certain financial impact, which is listed on the **event cards**. Event cards simulate 'risky events' that take place each month. After each month, (1 round in the game), two event cards are drawn from the deck.

How to manage risk?

As you are a newly assigned CEO, you thought you might need some help in this new environment (your previous job was CFO at an imploded investment bank). You choose to attend an interactive Supply Chain Risk Management workshop which involves a 'gaming simulation' at the top Enterprise Risk consultancy firm in the world. They advise you to *'put on your risk coloured glasses'* and helped you to identify risk management strategies in this new business environment. The workshop helped you to identify two risk management strategies to reduce 'Risk exposure' and to make your company 'Risk Intelligent':

- *Decrease vulnerability to risks (ex-ante risk management)*

You can invest in your company to decrease the vulnerability to risks. There are multiple categories of risk against which you can protect your company with '**controls'**. If you have made a profit through buying products from your supplier and selling it to your customer, you can invest (some of these) profits in order to decrease vulnerability. The prices of decreasing vulnerability and the categories of risk are displayed on the risk management overview. For instance, IT & Communications risks can be controlled ex-ante by installing virus scanners and having IT-security policies.

- *Increase resilience (ex-post risk management)*

You can also invest in increasing resilience. This is important if risks actually occur. "*The essence of resilience is the containment of disruption and recovery from it"*. You can invest in the level of resilience as clarified on the risk management overview. For instance, the IT & Communications risks can be controlled ex-post by using back-up systems that increase system redundancy.

Game round: steps of play

Each game round is characterized by sequential activities that must be performed. A game round consists of six phases, the production phase, the simulation, order, delivery, event and risk management phase. The phases are structured according to the following sequence;

1) **Production phase**. Products move from the inbound to the outbound section of the warehouse
2) **Simulation phase.** The end market (consumer) demand at supermarkets is simulated.
3) **Contract phase**. Products are ordered through the settlement of a contract. Contracts are filled in and are moved from buyer to supplier.
4) **Event phase.** Each month, 2 Event Cards are drawn from the deck.
5) **Delivery phase.** All companies deliver the products to their customers. Customers directly pay the supplier. The products are delivered according to the following sequence;

   First, the Supermarket delivers to the Consumer market
   Second, the processing company delivers to the Supermarket
   Third, the farming company delivers to the Processing Company
   Fourth, the breeding farm delivers to the Farming companies

6) **Risk management phase.** You have two options to manage risk; you can *reduce vulnerability* to risks or *improve resilience*.

Contracts

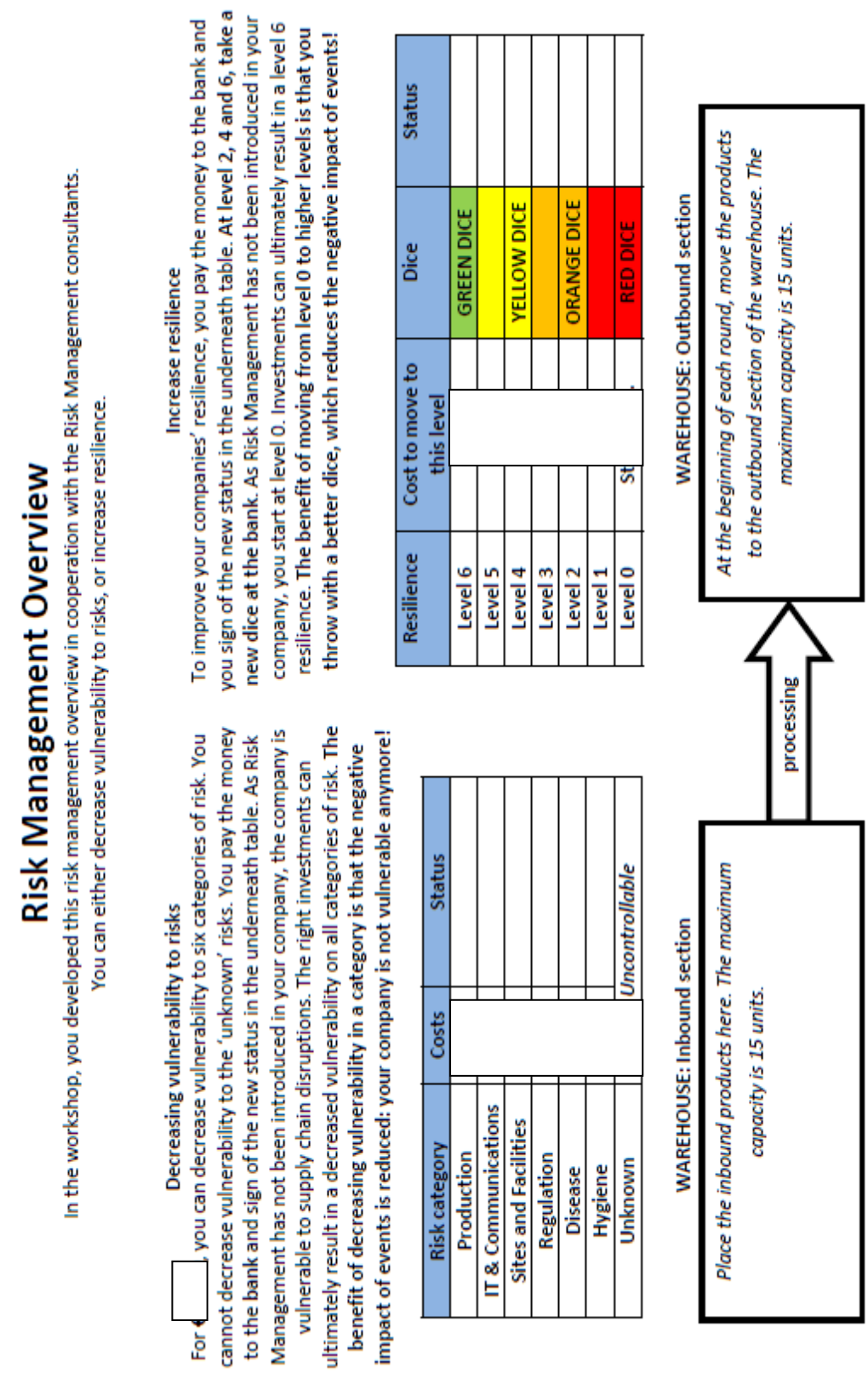
Buying and selling products can only be done by signing contracts. Contract forms are provided to you.

Rules

Since organizational changes are lengthy and difficult, you can only invest in 2 levels on the resilience meter and you may only decrease your companies' vulnerability to risks on 2 categories each month.

If the farm, processing company and the supermarket choose to collaborate to decrease vulnerability to a certain risk category, the costs for each company are reduced by 10%. So, each player invests € 10per risk category.

Appendix F: Risk Management Overview



NB: The risk management overview should be printed on an A3-page with 'landscape' orientation. It serves as the participants' game board. All game materials are located on the enclosed CD-Rom.

Appendix G: Interview outline and interview reports

In this appendix the interview outline and reports are presented. During the project, six formal interviews have been conducted. The interviews have been conducted to identify design requirements and to gain inspiration for the Supply Chain Risk Management Game. The interviews have been conducted at various stages during the design process (see 'dates' in Table 19). The interview questions (as presented below) were used to provide some structure during the conversations. For some interviews however, only one or two questions were needed to start discussion. Therefore, the interviews can be characterized as 'semi-structured'.

The interviewees were selected based on their availability and experience. The following interview outline has been used to provide some structure to the interviews and to start the discussion.

Interview outline

- Introduction
- Study & Thesis Topic
- Interviewee background
- Risk man. and/or Supply Chain experience

Interview questions

1) **What is your viewpoint on a serious game to educate people about supply chain risk management?**
2) **Do you see business opportunities / a business need for this game?**
3) **Considering this need, which topics/design needs should be taken into account?** - number of participants. – duration. - introduction – game session – debriefing – additional information/follow up? – location.
4) **Which models should be incorporated *(risk diagram / COSO-framework / (Model of Peck / Christopher*) in the game session?**
5) A result of the literature review is that managers are often not 'aware' of risks. Therefore I want to introduce people to the key concepts of Supply Chain Risk Management, make them more aware of risk and ultimately – to stimulate organizational learning. ***Do you follow this line of reasoning?***
6) **What are the most important risks experienced by Deloitte (and customers**)? (Relating to supply chains: reputation / geographic distances / product quality / disruptions risk / financial risks / IT-risks)
7) **What part of the risk management process should be incorporated in the game?** (identification/assessment/decision/risk strategy)
8) A basic difference between normal and supply chain risk management is that the organizations are dependent on each other in terms of risk management and the success of it. **What do you think that is unique to risk management in 'network companies'/supply chains?**
9) **If you can choose a supply chain, which can teach people about risk management, what type of industry would you choose to use in the game session? And, why?**

Examples: TNT / Apple (high-tech, high-risk) / Classic production chain: Corus / Heineken / Unilever / Proctor and Gamble / Pharmacy (high risk?) / Other suggestions:

Interview Report

During the project, six Deloitte employees have been interviewed. Each interview lasted 1 hour. The job title and dates of the interviewees are presented in Table 19.

Job Title	Date
Senior Consultant Supply Chain Strategy	20-10-2008
Consultant Supply Chain Strategy	24-10-2008
Consultant Enterprise Risk Services	5-12-2008
Director Enterprise Risk Services	9-2-2009
Manager Enterprise Risk Services	9-2-2009
Senior Manager Enterprise Risk Services	11-2-2009

Table 19: Interviewee: job title and date

The interview reports are (anonymously and in random order) presented below.

Interview Summary (#1)

- Goals of the game session should be determined together with the client
- The next step is to identify risks. Which risk do we see? Are that all risks? Different types of risk? (Internal, external, supply, demand, environmental)?
- Goal of the game session is training and a possibly a first step to risk management

Deloitte Workshops

- The usual approach to conduct a workshop is:
- Determine the goals → Risk identification → Impact/Chance → Top-risks → Control measures

Success factors:

- Determine which goals you want to accomplish.
- The workshop is a method, not a goal in itself.
- Create a safe environment.
- Create the right atmosphere.
- Conduct preparatory interviews (for instance 4, 6 or 8 interviews). Sometimes the interviews should be held with senior management to identify the topics that should be addressed in the workshops. These senior managers may not be present during the actual event.
- Create a recognizable environment: (make the concepts 'tangible', monitoring, variable rewards for risk management, repeatability).
- Identify the people that may drive change within the organization, so as to make sure the right people participate.
- The right people should play the game (risk unaware → risk aware).

Fail factors:

- Struggle between different departments, divisions or actors in the chain.
- No top management support.
- Not tangible, not recognizable enough for participants → people cannot 'feel' the role and scenario of the game.
- Bad atmosphere.

Models: 'Risk Intelligence map', model Harland, model Jüttner (for identification and classification).

(Dis) advantages of a workshop (based on experience with the 'Deloitte In Control-workshop'):

- It is difficult to play the game with multiple actors of the supply chain
- Silo's within organizations exist
- To what actor in the chain is the money allocated that is earned with Risk Management?

Important Remarks:

- Workshop is a method. What do you want to accomplish. What is the goal? (Rob: the goal is to introduce people to the 'key concepts' of SCRM).
- The action plan should be: 1) determine to goals of the workshop 2) goals versus risks 3) impact/chance list 4) top risks 5) control measures (risk management strategy)
- Most people know what their 'own' risks are, but the goals within the organization are misaligned.
- For Deloitte. A report is less interactive than a workshop. A workshop is less interactive that a gaming simulation.

Interview Summary (#2)

Market need

- The game is an easy accessible manner to introduce risk management in an organisation.
- The existing status of risk management in a company is important. If the current status of risk management in the organization is sufficient, the game does not 'add value'.

Silo-approach

- The game should focus on risks between actors/organizations, these are the real 'Supply Chain Risks'.
- Risks within organizations are dealt with through 'Enterprise Risk Management (ERM)'.
- Think of different departments: sourcing, distribution, legal etc.
    - → Key words are: risk allocation, management of interfaces, dependencies, collaboration and coordination.
- Supply Chain Risk Management enables to address and manage these topics.
- The reason to turn to Supply Chain Risk Management Practices is that risks are less expensive to mitigate early in the chain.
- Deloitte vision on risk management: 'An integral approach to guiding and controlling'.
- Risk management is to make sure the goals are accomplished, within a certain confidence level.

- Many people use the words 'value chain'. The reason to operate in a value chain is voluntary. You have to cooperate.

Important Remarks

- Aim at the 'management of interfaces'.
- About the Probability/impact framework → reducing change (preventive) or reduce impact (repressive)
- Almost nobody within organizations approach risk management in an integral manner.
- There are multiple persons dealing with risk, such as a 'compliance officer' or 'operations manager'.

Practical issues to take into account:

- If creating awareness is the specific goal: talk about specific risks to involve people, risks that are 'close to home'.
- MVO for example. Reputation risks are easy to model in a chain. Risks move downstream. Look up reputation risks in the 'Risk Intelligence map'.
- Workshop should be well-prepared.
- Information sources for the debriefing. 'Risk Intelligence Framework'. Knowledge is available (SAS70, TPA) to facilitate discussion about Risk Management.

Interview Summary (#3)

This interview focussed on the development and use of an existing Deloitte game about Risk Management: Risk & Control Game. See Appendix B: Evaluation of existing games for an evaluation of this game.

At what events has the game been used? On a business course for students and at a learning curriculum, the 'foundations training' in Prague.
In the game, how is the link between risks, control objectives and control activities been made?
Risks are identified through a brainstorm session. These risks are presented to the participants. The control objectives are formulated with the client. The control activities are selected by Deloitte.
In what way is this incorporated in the game? With excel. See excel files. This is confidential information, please do not use outside Deloitte!
How often has the game been tested?
Two times during preparation. During the development process, the game has been tested a number of times.
How long took the development process?
Two weeks, without any (desk) research.

What are the challenges presented to the players? Players have a difficult challenge. Limited time and budget. Information overload.

Important remarks:

- The knowledge level of participants and level of control measures should be properly linked. In the game, only one Risk Management Strategy can be applied: 'treat'.
- Use pictures to illustrate the concept of risk and interactivity.

Interview Summary (#4) – (answers in Dutch)

What is your viewpoint on a serious game to educate people about supply chain risks?
Spellen kunnen vaak een boodschap beter overbrengen dan traditionele leermethoden (boeken/college). Het is tastbaar, leerzaam doordat je fouten maakt (experiental learning!!). Hou het simpel! Je moet de kernpunten goed weten over te brengen. Een simpel spel kan meer leerwaarde hebben dan een complex spel. DOELGROEP: wat mij betreft hoef je niet direct een onderscheid te maken tussen studenten en klanten van Deloitte of Deloitte werknemers als doelgroep. Kijk maar naar de Beergame, dat wordt ook door iedereen gespeeld en is bovendien op zich een simpel spel met een kernachtige boodschap. Je zou het spel bijvoorbeeld op een seminar over risico's of supply chain management aan (potentiële) klanten kunnen meegeven.
Can a game be beneficial to inform the client organization about Deloitte at the start of a SCM project?
Nee, dat zie ik niet als meerwaarde.
What are the most important risks (supply chain issues) experienced by Deloitte (and customers) *at the supply chain group*?
Bedrijven denken vaak dat ze uniek zijn, en dat risico's voor het bedrijf daarom ook uniek zijn. In werkelijkheid is dit vaak niet zo. De problemen waar ze mee te maken hebben zijn voor veel bedrijven hetzelfde.
Is it more valuable to Deloitte (&customers) to have a Game about generic risks or about some more specific risks?
Omdat de risico's vaak hetzelfde zijn en omdat je een bepaalde kernboodschap wilt overbrengen, is een spel op een algemeen niveau het best. Een spel gebaseerd op een specifiek risico is wat minder interessant voor mensen die geen affiniteit hebben met die keten. Het duurzaamheidvraagstuk is wel interessant, maar met de huidige economie is het ook vaak het eerst waar bedrijven op bezuinigen. Het is voor (grote) bedrijven een verplichting geworden om iets te doen aan Sustainability.
Can I base the game on a specific 'case' of Deloitte?
Ja dat kan, als dat nodig is. Informatie is er genoeg. Je moet wel oppassen met het kiezen van een 'case' die je gaat simuleren in een spel. Want bijvoorbeeld een bedrijf als Ahold of Wal-Mart (power-balance) heeft zo veel invloed op de keten, dat de verdeling van risico's ook niet in balans is. Zulke bedrijven hebben zoveel macht, dat leveranciers en soms klanten (automobielindustrie) geen keuze hebben. Als ze niet aan voorwaarden voldoen, dan worden ze zonder pardon aan de kant geschoven. Dit heeft te maken met competitie in de markt (bijv. monopolie, dan ook verstoorde balans).

What part of the risk management process should be incorporated in the game? (analysis/evaluation/control). Suggestion: every round players analyze, evaluate and act on a risk that manifest at the start of the round.
Lijkt me een goed idee. Wat je kan proberen is om de eerste aantal ronden de risico-evaluatie door spelers individueel te laten uitvoeren. Waarna ze in een later stadium de risicoanalyse met meerde

partijen kunnen maken, en risico's kunnen delen. Foute en goede beslissingen volgen dan. Je kan bijvoorbeeld een risico beoordelen als 'klein' en er vervolgens niet aan doen.

To what extend can I build on the SCRAM-model of Carsten Treur and use it?
Ja, je hoeft het wiel niet opnieuw uit te vinden.
Are there current 'supply chain games' at Consulting?
Het spel ketensynchronisatie (presentatie nog per mail).
If the goal of the game is training / educating on the subject of risk awareness, how much time and how many players should I focus on?
5 tot 6 spelers, maximaal een dagdeel.
Which roles do you think are important to incorporate in the game?
Meerdere partijen zijn zeker nodig om een supply chain situatie na te bootsen. Producent. Leverancier. Transporteur. Overheid. Concurrent. Je wilt een 360graden view. Door mensen andere rollen te laten aannemen, kun je leren van de keuzen voor andere.

Important remarks:

- Einddoel van het spel. Er moet iets te winnen zijn. Wanneer heeft de keten gewonnen? Bijvoorbeeld de meest efficiënte keten. Er moet ook geld weg kunnen stromen uit het spel (door ongedekte risico's bijv.). Ook moet er geld kunnen instromen in het spel (door winst van het bedrijf.)
- De dynamiek in het spel vooral op risicoaspecten houden. Dus niet allerlei andere (rand)zaken toevoegen, dat frustreert de spelbeleving.
- Acties van overheid hebben vaak implicaties voor gehele keten.
- Over kaarten; De overheid zou je kunnen meenemen met een aantal kaarten (random element).
- Certificering van leveranciers (risico voor producent, maar kosten worden betaald door leverancier; optie: samenwerken door deel te betalen 50/50.

Interview Summary (#5)

What is your viewpoint on a serious game to educate people about supply chain risks?
You have to determine the target group; students or Deloitte's clients. It is a good idea to involve people from different organizations in the game, to share knowledge on the topic. We experience the problem that even in the same organization people are not aware of each other decisions. It is a good idea to have a game-session with several organizations, to share knowledge and to exchange ideas.
Can a game be beneficial to inform the client organization about Deloitte at the start of a SCM project?
Sometimes we experience some resistance from employees in the client organization when starting a SCM-improvement program, but I don't think that happens often.

What are the most important risks (supply chain issues) experienced by Deloitte (and customers) *at the supply chain group*?
Not meeting demand. It is necessary to define a supply chain risk in a way that is useful to your game. A more broad definition can also involve social and environmental issues (see ERS-leaflet).

Is it more valuable to Deloitte (&customers) to have a Game about generic risks or about some more specific risks?
A game can serve as an opportunity to share knowledge within a group of representatives from different organizations and Deloitte professionals. It is an opportunity to show expertise. The game should start discussion.
Can I base the game on a specific 'case' of Deloitte?
Yes, you can. We have some well-documented cases on '*kx*' (search name: Mark Tusveld). The sustainability issues (green supply chain) are very relevant to our practices. But, choosing a specific case brings several problems; 1. Not being able to play the game with different people (from another sector/industry), and (2) ff they are from the sector/industry, they may not find the game 'real' enough. The sustainability issues are so generic they are relevant for different organizations and their supply chains.
What part of the risk management process should be incorporated in the game? (Analysis/evaluation/control). Suggestion: every round players analyze, evaluate and act on a risk that represented itself in the beginning of the round.
Seems to be a good idea if you can do that every round.
To what extend can I build on the SCRAM-model of Carsten Treur and use it?
As a student here, you can use it. Environmental issues (social, sustainability, health & safety) are not taken into account in this model, but they should be, if you focus on the sustainability issue. Customers more and more ask for advice on dealing with sustainability issues on their logistics operations. The issue is very relevant for Deloitte's practice. Furthermore, globalization and its risk are major issues of our clients.
Are there current 'supply chain games' at Consulting?
Yes, but I don't know where you can find it. Ask Mark v/d Boom, he acted as a game-facilitator I believe. We are going to play an online game: www.freshconnection.nl
If the goal of the game is training / educating on the subject of risk awareness, how much time and how many players should I focus on?
4 to 10 people. I a workshop setting, the duration may be half a day.

Important remarks:

- Customers should be able to discuss the risks as perceived by them. A game in which the outcome is pre-stated can be unsatisfactory. Suggestion: in the evaluation phase, the link from game to reality must be made.
- Game topic: globalization or sustainability

Interview Summary (#6)

- Risk management is costly to improve.
- Risk is intangible, but must be incorporated.
- Risk management silo's have improved: SOX, Tabaksblat.
- Bottom-up vs. top down = see 'Risk Intelligence', in practice these things do not come together.
- Audience, middle-management, **what is take-away (message)?**

- Learning opportunities: - 1. **Professional services firm**, for example senior consultants, to see across the organizational matrix. 2. **Companies**, Accounting, sourcing, marketing……different functions have different perspectives on Supply Chain Management.
- SILO'S → Coordination game
- Do not use the word game, but 'interactive learning'.
- Use classic production chain. People are familiarized.
- Geographic & Reputation risks are important for customers (= brand protection)
- Look at Risk Link, see links (by e-mail).

Appendix H: Facilitator Guide

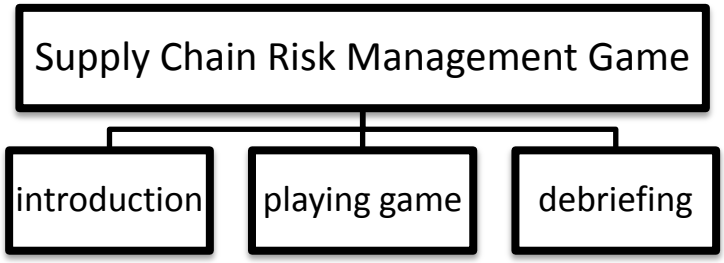
In this guide, all things you need and know in order to facilitate the Supply Chain Risk Management Game are discussed. It may take up to eight hours to prepare yourself as a facilitator, depending on your pre-knowledge and the availability of all game materials.

Pre-knowledge Facilitator

You should have a basic understanding of Supply Chain Management and/or Risk Management. Furthermore, experience in facilitating serious games is beneficial. If you do not have any knowledge and/or experience about these subjects, you should (at least) read Chapter 4 of this report. For the remainder of this guide, it is expected that the reader is familiar with these subjects and terminology. Useful reading material is 'Supply Chain Risk Management: vulnerability and resilience in logistics (Waters, 2008: ISBN: 978-0-7494-4854-7). Available for Deloitte employees through 'books 24x7'.

Elements of the Supply Chain Risk Management Game

The Supply Chain Risk Management Game consists of three elements, the introduction, playing the game and the debriefing.



During the actual game session, you should introduce participants to the game, facilitate the game itself and debrief the game. The workflow of the facilitator is presented in the underneath table. It includes the facilitator tasks, sub-tasks, duration and guidelines.

Facilitator tasks	Sub-tasks	Duration	Guidelines
Prepare the game session	print out and construct all game materials read and understand the player manuals, the risk management overview and the contract forms.	+/- 8 hrs. (if all materials are present)	See this facilitator guide.
Present the introduction	prepare the introduction. present slide number 1 -9 of the introduction presentation	15 min.	See 'comments' in presentation. See this facilitator guide.
Hand out the game materials to the participants	hand out the player manual, risk management overview, contract forms, play money, event cards and dices to the participants.	5 min.	See this facilitator guide.
Play the game: round 1	put slide 10 on of the introduction presentation in the first game round. See if participants understand their tasks and help where necessary. THE GAME STARTS IN THE SIMULATION PHASE. (all supermarkets take an envelope)	10 min.	Slide number 10 and the comments
Play the game: round 2	put slide 11 on of the introduction presentation in the first game round. See if participants understand their tasks and help where necessary.	10 min.	Slide number 11 and the comments

More rounds	See if participants understand their tasks and help where necessary.	10 minutes per round	
Present the debriefing	prepare the debriefing present the debriefing (presentation)	15 min.	See 'comments' in the presentation. See this facilitator guide.

Learning goals and process of change

The main learning goal of the game can be summarized as '*to facilitate learning about the key concepts of Supply Chain Risk Management*'.

The main learning goal is separated into six (sub) learning goals. These are: *participants of the game session reach (a further) understanding about…*

1) the theoretical background of Supply Chain Risk Management;
2) different types of risk (internal, supply, demand & external risk);
3) the risk management approach in a network situation;
4) risk management strategies;
5) the need for collaboration and coordination in supply networks;
6) the need to manage risk pro-active instead of passive.

The result of reaching these six learning goals is that people develop a 'holistic perspective on Supply Chain Risks and the subsequent management issues'.

Game materials

In your role as a game facilitator, you should make sure you have all the materials to play and to facilitate the game. If you do not have all game materials, you can easily construct and print out all materials in approximately four hours. All game materials are located on a CD-ROM enclosed to this report. The amount of game materials needed depends on the number of participants. **You need:**

1) **The introduction to the game session** (PowerPoint ™ 2007 presentation. File name: 'introduction_supply chain risk management game.pptx')
2) **The game materials**
   - 1 'Player manual' for each player (appendix G)
   - 1 'Risk management overview' for each player (appendix H)
   - 10 'contract forms' for each player (appendix F)
   - The 'resilience' dices. One set for three participants (Table 8)
   - The event cards. One set for max. 12 participants (Appendix I)
   - Play money (notes of €10, €10, €10, €10 and €10)
   - 10 small plastic chips for three participants
3) **The debriefing of the game session** (PowerPoint ™ 2007) presentation. File name: 'debriefing_supply chain risk management game.pptx')

To conduct the game session, you also need a **computer** with (PowerPoint ™ 2007 installed) and a **beamer** and a **projection screen**.

Flexible use of the Supply Chain Risk Management Game

The game is designed and developed for 'adaptability' and is thus suited for flexible use, in terms of the number of participants and the duration and content of the introduction and debriefing.

1. Participants

In the simplest form, a game session is conducted with three participants: 1 farm, 1 processing company and 1 supermarket. All roles can be multiplied so there can be 6, 9, 12, 15 or 18 or even more participants. If the game session is conducted with six or more participants, the participants can compete against each other. Preferably, play the game with at least six participants. In addition to the competition element, this offers more a more dynamic learning environment (compared to only 3 participants) and better reflects the 'reference system', because participants can switch suppliers and choose between 'single', 'dual' or 'multi-sourcing'. There is also a greater incentive to bargain on prices and more discussion and interaction between participants can be expected. Above 15 participants, it is expected that two or more game facilitators are needed.

2. Introduction

The introduction consists of 11 slides. Slide number 1 till 9 are presented before the actual game play starts. Slide number 10 and 11 can be used during the simulation game, and help the participants and the facilitator to remind in which phase of the game round the game is at and which actions they should take. In the comments underneath the slides, the role of the facilitator is explained for each slide. You are free to adapt, add and remove slides, if that better serves the target audience's needs. Example: for students, the theoretical background may be interesting (slide #4). For use at Deloitte clients, this sheet may be removed and some information regarding the Clients processes and risks may be incorporated (slide #3). General guidelines for presenting to an audience apply.

3. Debriefing

The debriefing consists of 9 slides. Slide number 1 and 2 are also used in the introduction. To stimulate learning effects, ask the questions in the 'comments' to the participants. At slide #3, participants reflect on the strategy they have chosen in the game. Then the winner is announced (slide #4). Slide number 6 & 7 are only relevant for use at Deloitte clients and must be adapted to the clients' situation. The debriefing ends with some questions and a word of thanks. In the comments underneath the slides, the role of the facilitator is explained for each slide. You are free to adapt, add and remove slides, if that better serves the target audience's needs.

The debriefing should ensure that the learning objectives (as on page 1 of the facilitator guide) are reached. In order to maximize effectiveness of the debriefing, extensively prepare the debriefing and take time to discuss the questions (see comments).

During the game, participants choose different strategies. 'Risk averse' people tend to invest their starting capital in risk mitigation strategies. 'Risk taking' people tend to limit the investments. The rationale of participants for these choices must be expressed by participants in order to stimulate discussion about risk management, relating to the processes incorporated in the game. Different perspectives on risk can be discussed. About the rationale, typical statements participants make are: "I only invested in increasing 'resilience' because it is uncertain which categories apply to my company and which (financial) consequences these risks have". Or, "I only invested in decreasing vulnerability because it offers full protection regarding some categories". Most people tend to invest in both options.

These typical arguments provide a chance to relate the game to the real-life system: what strategy / approach do participants choose if they were actually responsible Supply Chain Risk Management in real-life. Participants also have the option to collaborate in order to decrease vulnerability. Collaboration (or the lack of it) as observed in the game, provides a starting point for discussion. It is difficult to point out exactly what will happen in a game session, because it is human behaviour and thus difficult to predict. Game-guru's report that gamers can –to some extent- create their own game.

Rules and processes in the game

The rules and processes in the game are described in the player manual (see Appendix E: Player Manual). You have to make sure the phases of the game round are strictly followed and that the participants follow the rules. To help with these tasks, the processes (phase) of the game round are presented in the introduction presentation (slide 11 till 18). You have to observe the participants behaviour to make sure the rules are followed.

Embedding the Supply Chain Risk Management Game in a learning context

The game can be used in a learning context. If used in a Supply Chain Management learning context, one can best start with the normal curriculum and then (in the end) have a game session with the scholars. In this way they can first familiarize with Supply Chain Management and then 'learn and understand' more about Supply Chain Risk Management (SCRM). SCRM is regarded as a special topic of supply chain management.

If used in a Risk Management (RM) learning context, one can best start with the normal curriculum and then (in the end) have a game session with the participants. In this way they can first familiarize with Risk Management and then 'learn and understand' more about Supply Chain Risk Management. SCRM is regarded as a special topic of risk management.

Possible areas for implementation

The SCRMG can be used:
For recruitment purposes. At the start of a Supply Chain (Risk) Management improvement program.
For internal or external training programmes.

Complementary learning modules

If the game is used at Deloitte clients, complementary learning modules may be beneficial for the client's organization. Relevant Service Offerings are presented in slide 7 of the debriefing (risk awareness training, risk management workshop).

Spatial game setting

The spatial game setting is visualized in the following table, that clarifies the top-view on the spatial game setting for nine participants. The consumer market, breeding farm and bank are played by the game facilitator or a participant of the session (for instance, in case of 10 people).

<table>
<tr><td colspan="3">Breeding Farm (1 table)</td><td rowspan="5">bank</td></tr>
<tr><td>Farm 1</td><td>Farm 2</td><td>Farm 3</td></tr>
<tr><td>Processing company 1</td><td>Processing company 2</td><td>Processing company 2</td></tr>
<tr><td>Supermarket 1</td><td>Supermarket 2</td><td>Supermarket 3</td></tr>
<tr><td colspan="3">Consumer market (1 table)</td></tr>
</table>

Figure 29: Spatial game setting

Starting up the game

After the presentation of the introduction, all participants get their game materials. Each player gets 20 contract forms, a player manual, a risk management overview, € 20.300 in different notes, a red dice, and 10 units in the outbound section of the warehouse.

The game starts in phase 2, as presented in the introduction presentation. When the actual playtime begins, the introduction presentation should be used to remind you (and all participants) in which phase the game is at.

First game round
The game facilitator explains before the first round begins what will happen in the first game round. This explanation should be very practical. The presentation clarifies the exact steps.

Breeding Farm
Each game round, in the delivery phase, each farm may buy an unlimited amount of calves (plastic units) from the breeding farm for the fixed price of € 100 per unit. The money is paid directly to the breeding farm. The breeding farm is 'risk averse' and only signs contracts if all risks are allocated to the buyer.

Consumer market
Each game round, each supermarket may sell (max.) **10**ton meat (**10**units of **10**kg / unit) to the consumer market for the fixed price of € **10**per unit. The money is directly paid by the game facilitator. The end market demand is simulated by taking envelopes.

Bank
The bank only accepts money. Participants pay money to the bank and sign of the new status of vulnerability and resilience on the risk management overview. At Resilience level 2, 4 and 6, participants get a new resilience dice at the bank. The process is clarified on each participants 'risk management overview'.

Important remarks: (1) do not announce the last game round! (2) if the participants are bi-lingual, determine the language participants use in the game session (i.e. Dutch or English).

Appendix I: Event Cards

In this appendix the event cards are presented.

Print instructions

1) Print this document. The size of cards is L= 8,0 cm W= 6,5 cm
2) Print the front of the event cards multiple times on medium heavy paper (+-120 gram / A4-page). (The front of the cards is presented on the last page of this document)
3) Cut out the event cards with a scissor or cutter
4) Combine the front and back of the cards with glue, staples or plastic sleeves.

Information sources used for the design, development and construction of the event cards are:

- Production: SCRAM-model (Treur 2008)
- Regulation: http://www.food.gov.uk/foodindustry/meat/haccpmeatplants
- IT & Communications: SCRAM-model (Treur 2008)
- Other categories: www.meatandmeal.nl, imagination and personal communication with Deloitte interns.

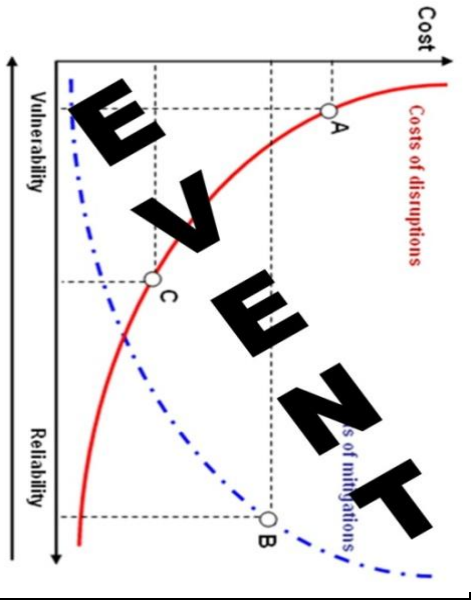
The event cards are based on what *could* occur in real-life.

no significant event occurs **Consequence: Nothing**	**Production** *A new colleague has experience in fixing production machines. You save money on maintenance costs* **Consequence: a one-time saving of € 10**	**Production** *Personnel training standard is insufficient* **Consequence: pay € 10 * Dice for a workshop**
Production *Visibility of production processes must improve in order to prevent "knowledge leakages" if personnel stops working. All processes must be documented.* **Consequence: pay: € 10 * Dice**	**Production** *There are complaints concerning the quality of the final product.* *You decide to improve quality control processes.* **Consequence: pay € 10 * Dice**	**IT & Communications** *The newly hired office cleaner prefers to fix computers instead of cleaning toilets.* *You cancel the order for a new desktop computer.* **Consequence: One time € 10 saving**
IT & Communications *A 12 year old Japanese girl adapted the Russian computer virus (#31WDKA))' into a major IT-security threat that enters IT-systems through hacking the printers. You need to purchase new IT-hardware and software updates* **Consequence: pay € 10 * Dice**	**IT & Communications** *Critical failure of IT & Communication systems* **Consequence: pay € 10 * Dice to fix it**	**IT & Communications** *Electricity network outage due to overproduction of energy by the newly build sea-located wind-mill farm. This results in a system crash.* **Consequence: pay € 10 * Dice for new IT-hardware**

Sites and Facilities *Precautionary measures are done by employees to prevent long term breakdown of assets at sites and facilities* **Consequence: One-time € 10saving on maintenance costs**	**Sites and Facilities** *All sites and facilities need a evacuation plan* **Consequence: Pay € 10* Dice**	**Sites and Facilities** *Precautionary measures are needed to prevent long term breakdown of assets at sites and facilities.* **Consequence: Pay € 10* Dice**
Sites and Facilities *Central heating boiler needs maintenance* **Consequence: Pay € 10* Dice**	**Regulation** *Hazard Analysis and Critical Control Point (HACCP), is used to describe an internationally recognized way of managing food safety and protecting consumers. It is a requirement of EU food hygiene legislation that applies to all food business operators.* **Consequence: pay € 10* Dice for HACCP process & procedure checks by External Auditors**	**Regulation** *Hazard Analysis and Critical Control Point (HACCP), is used to describe an internationally recognised way of managing food safety and protecting consumers. It is a requirement of EU food hygiene legislation that applies to all food business operators.* **Consequence: HACCP procedures increase integrity of process & control measures:** **You have a one-time € 10cost-saving**
Regulation *Hazard Analysis and Critical Control Point (HACCP), is used to describe an internationally recognized way of managing food safety and protecting consumers. It is a requirement of EU food hygiene legislation that applies to all food business operators.* **Consequence: Government inspections reveal incompliance with HACCP process and procedures:** **Pay a fine of € 10* Dice.**	**Regulation** *Hazard Analysis and Critical Control Point (HACCP), is used to describe an internationally recognised way of managing food safety and protecting consumers. It is a requirement of EU food hygiene legislation that applies to all food business operators.* You must implement HACCP modules. **Consequence: pay € 10* Dice**	**Disease** *Quality assurance inspections reveal insufficient 'disease alertness' and insufficient control measures* **Consequence: Provide a quality assurance report: costs € 10* Dice**

Disease *High concentrate of dioxins discovered in red meat products! The government requires mandatory dioxins – testing* **Consequence: Pay € 10* Dice**	**Disease** *Following the outbreak of BSE, the government asks all actors in the agri-food chain to improve risk management systems and actions* **Consequence: pay € 10* Dice for a microbiological risk assessment**	**Disease** *Outbreak of Food and Mouth Disease! Discovered at the farm, processing company and supermarket level* **Consequence: Destroy 0 units of your inventory**
Unknown *Outbreak of an Unknown Disease! Discovered at the farm, processing company and supermarket level* **Consequence: Destroy 0 units of your inventory**	**Unknown** *A fraudulent employee transferred money to his personal bank-account in the Bahamas.* **Consequence: Pay € 0**	**Unknown** *Traces of dioxin found in your product, maybe originating from polluted feed from a (foreign) Low Cost feed supplier.* **Consequence: Destroy 0 units of your inventory**
Unknown *You get € 500 through government subsidies.* **Consequence: A one-time saving of € 0**	**Unknown** *Water leakage* **Consequence: Pay € 0 * Dice to the plumber**	**Unknown** *An employee stumbled over the pavement at the entrance and twisted her knee.* **Consequence: Pay € 0 * Dice to hire a temporary worker**

Unknown *One of your employees has become sick, stating she is bullied by colleagues and 'the company' did nothing to prevent this. Your HR-department fired her. She took it to court, where she lost.* **Consequence: Pay € 10 * Dice to your lawyer**	**Unknown** *Small water leakage at night resulted in water damage!* **Consequence: Destroy 10 units of your inventory**	**Unknown** *Smoke damage due to a fire in your warehouse!* **Consequence: Destroy 10 unit of your inventory**
Unknown *Nationwide labour strike against Mass lay-offs in the automotive sector due to the financial/credit crisis! You have to employ temporary workers for 1 day to continue operations.* **Consequence: Pay € 10 * Dice**	**Unknown** *Your accountant discovered a duplicate payment from FY2008.* **Consequence: Get € 10 through a return payment**	
Hygiene *Inspections from government officials (VWA) reveal insufficient hygiene in your warehouse.* You are fined by government authorities. **Consequence: Pay € 10 * Dice**	**Hygiene** *In order to store your products according to the right conditions, you must treat the warehouse with a high-tech anti-bacteria protecting varnish.* **Consequence: Pay € 10 * Dice**	

Hygiene *Employee HACCP training* **Consequence: Pay € 10 * Dice**	**Hygiene** *Yearly warehouse and equipment cleaning operation* **Consequence: Pay € 10 * Dice**	**Hygiene** *Government subsidy for biodynamic operations. Your company uses chlorine free cleaning products.* **Consequence: A one-time € 10 subsidy**
The picture on the right is the front of the 'event cards'.		

Appendix J: Complete List of Design Requirements

In this appendix the complete list of requirements for the Supply Chain Risk Management Game is presented. Multiple data sources have been used to construct the list of requirements. By constructing this list, **design sub-objective 1** is fulfilled (see Chapter 2).

For readability purposes, a colour scheme is used to label the requirements. Green = Need to have. Yellow = Nice to have. Turquoise = add-on.

	Supply Chain Risk Management (source §4.1 & §4.2)
1	SCRMG incorporates Normal Accident Theory (§4.1.1)
2	SCRMG is about a global supply chain network (§4.1.1)
3	SCRMG influences risk related beliefs (§4.1.2)
4	SCRMG increases risk awareness (§4.1.2)
5	SCRMG incorporates High Reliability Theory (§4.1.2)
6	SCRMG incorporates Transaction Cost Analysis: 1) coordination costs & 2) transaction risk (§4.1.3)
7	SCRMG incorporates competition (§4.1.4)
8	SCRMG incorporates Utility Theory (§4.1.4)
9	SCRMG incorporates Agency Theory (§4.1.4)
10	SCRMG incorporates Portfolio Theory (§4.1.4)
11	Risk sources have Supply Chain Risk consequences, but can be mitigated by Supply Chain Risk Mitigating Strategies (§4.2.1)
12	SCRMG incorporates a definition of Supply Chain Risk Management (§4.2.1)
13	SCRMG incorporates supply, demand, process, control and environmental risk (§4.2.2)
14	SCRMG incorporates risk at different levels (§4.2.2)
15	In the SCRMG, risk management is a continuous effort (§4.2.2)
16	SCRMG incorporates risk identification (§4.2.3)
17	SCRMG incorporates risk estimation (§4.2.3)
18	SCRMG incorporates risk evaluation (§4.2.3)
19	SCRMG incorporates 'vulnerability' (§4.2.3 & §4.2.5)
20	SCRMG incorporates 'resilience' (§4.2.3 & §4.2.5)
21	Participants experience limited visibility (§4.2.3)
22	Participants can behave opportunistically (§4.2.3)
23	SCRMG incorporates different risk management strategies (§4.2.4)
24	SCRMG incorporates different levels of risk (§4.2.4)
25	SCRMG incorporates different risk factors (§4.2.4)
26	Participants can integrate risk management in the supply chain (§4.2.5)
27	SCRMG incorporates risk management strategies that can be implemented by a single actor (§4.2.5)
28	SCRMG incorporates risk management strategies that can be implemented by multiple actors (§4.2.5)
29	SCRMG incorporates cost of disruptions (§4.2.5)
30	SCRMG incorporates costs of mitigations (§4.2.5)
31	Participants must trade-off the costs of disruptions versus the costs of mitigations (§4.2.5)
32	Participants have limited information about probability (adapted from Waters 2008)
33	Participants have limited information about impact (adapted from Waters 2008)
34	Participants have limited budgets (adapted from Waters 2008)
35	Participants have limited time to take decisions (adapted from Waters 2008)
	Gaming (source: interviews and other sources)
36	Game session should facilitate interaction

37	Participants should know how they can 'win' the game
38	The game session must have a powerful message (through simplicity)
39	Game must be fun
40	Game should reflect reality, "a real-life context (van Dam 2007, p. 9)" This implies a need to focus on relevant and understandable risks, in order to 'light the fire' & start discussion.
41	Game outcomes should be based on luck
42	Game outcomes should be based on strategy
43	Participants should experience a 'game flow'
44	Participants of the game have a low pre-knowledge level
Practical / Design Constraints	
45	The game session can be attended by 4-10 people (source: interviews Deloitte)
46	Total duration of a game session should not exceed 4 hours (source: interviews Deloitte)
47	SCRMG should be designed in eight weeks (Design Constraint)
48	SCRMG should be inexpensive to develop (max € 500) (Design Constraint)
49	The game is non-computer aided to stimulate player-player interaction and discussion
Deloitte (source: interviews)	
50	The game session should be used in a organization where SCRM is under-developed and/or not applied sufficiently
51	Training employees by means of a game session can add-value when an organization starts to use Supply Chain Risk Management practices
52	The game session should be tailored to specific issues and needs, therefore the game must be customizable and adaptable to the requirements of a specific target group
53	The game session should be prepared together with Client's management team (information sources: interviews, year report, website)
54	The client can provide input for their specific requirements of the game session.
55	After the game session, discussion with client on the basis of Risk Intelligence framework (Appendix A: Risk Intelligence Framework) takes place. Knowledge is available and does not have to be developed.
56	TPA & SAS70 are relevant Service Offerings to discuss.

Table 20: Complete list of design requirements

Appendix I: Scientific Article

In this appendix a scientific article about 'Supply Chain Disruption Risk Management' will be provided. The article can be read by participants before or after a game session.

Supply Chain Disruption Risk Management: an introduction

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Abstract

"There are two broad categories of risk affecting supply chain design and management: (1) risk arising from the problems of coordinating supply and demand, and (2) risk arising from disruptions to normal activities (Kleindorfer & Saad 2005)". This paper is concerned with the second category of risks, which may arise from different risk sources. The goal of this paper is to introduce the reader to three topics of Supply Chain Disruption Risk Management: risk sources, risk diagram, and risk management and strategy. The paper provides a definition of Supply Chain Disruption Risk Management. We then describe two perspectives on supply chain risk sources. Examples of supply chain disruptions are presented in the risk diagram, according to the quantitative definition of risk: 'probability * impact'. Risk management strategies are identified and separated in either *active* or *passive* management approaches. The paper finally elaborates on the concept of risk allocation and the strategic trade-off between the costs of disruptions and the costs of mitigations. Based on the literature review - two suggestions for future work are provided.

Keywords: Supply Chain Risk Management; Disruption; Vulnerability; Resilience; Networks.

1. Introduction

Risk relating to supply chains can be read about on a daily basis in newspapers. Mattel (the manufacturer of Barbie toys) recently had problems with its Chinese manufacturers which caused "The recall of nearly 20 million Chinese-made toys". Amongst other problems, "Chinese firms used lead-based paint, which is prohibited in the United States (Merle & Mui, 2007)".

Another example of supply chain risks are disasters. "*A major supplier to Nokia (the cell phone manufacturer) is Philips NV, which produces the major semiconductors for Nokia phones at its plant in Albuquerque, New Mexico. On March 17th, 2000, a line of thunderstorms rolled through the city, and the furnace in the plant was hit by lightning and caught fire (Handfield et al., 2006)*." Philips NV was also a *key supplier* to Nokia's direct competitor Ericsson. Nokia responded quickly to the decrease of production capacity at one of its key suppliers and pro-actively managed the disruption. At Ericsson, the 'incident' was handled as "one technician talking to another (Sheffi, 2005; p. 8)", and was not 'on top of mind' at Senior Management. In the meantime, Nokia demanded all spare production capacity of Philips' other plants. The unavailability of semiconductors to produce high-end handsets resulted in a huge financial blow. "At the end of the first disruption-affected quarter, Ericsson reported losses of between US$430 and 570 million owing to a lack of parts *(ibid.)*".

Zsidisin (2003, p. 217) reports that "*there is little understanding of what risk means within a supply management context, although a few scholars have begun to address the issue*". The above mentioned disruption risks stress the importance of appropriate management. Supply Chain Risks and subsequent management issues are the focus of the research area of Supply Chain Risk Management.

"*There are two broad categories of risk affecting supply chain design and management:*
(1) risks arising from the problems of coordinating supply and demand, and
(2) risk arising from disruptions to normal activities (Kleindorfer & Saad, 2005; p. 1)".

This paper is concerned with the second category of risks: '*risk arising from disruptions to normal activities'* in Supply Chains: 'Supply Chain Disruption Risk Management' (SCDRM). Companies should turn to SCDRM-practices because "*supply chain disruption announcements are associated with an abnormal decrease in shareholder value of 10.28%* (Hendricks & Singhal, 2003; 2008)".

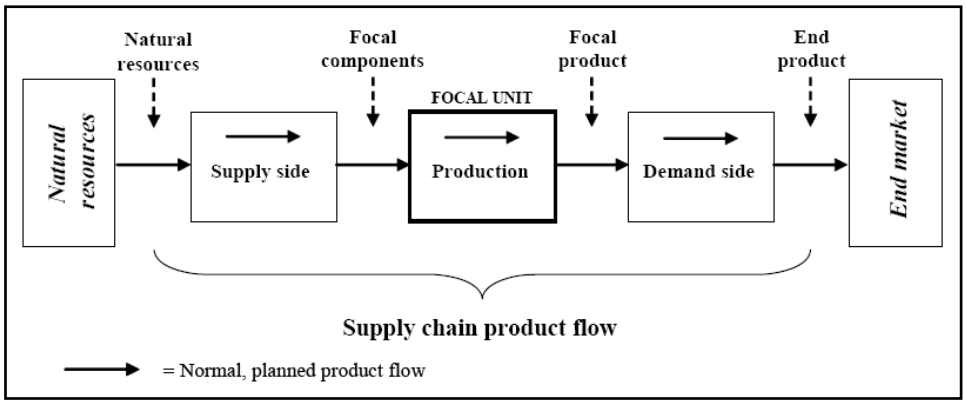

Figure 30: Supply chain network structure model (Paulsson, 2004; p. 344)

To illustrate our focus on *disruptions* within a supply chain context, a conceptual supply chain is presented in Figure 1.

Disruptions disturb the 'normal, planned product flow' and can thus result in a mismatch between supply and demand. From the perspective of the 'focal unit', the product flow can be disturbed at the supply or demand side.

The topic has been introduced and the focus towards *disruptions* is stipulated. The goal of this paper is to introduce to reader to selected subjects of Supply Chain Disruption Risk Management and to provide suggestions for future work. A literature review has been conducted to fulfill this goal. Most selected literature are from authoritative sources: members of the International Supply Chain Risk Management Network (2008).

For this goal, this paper has four objectives:

- To provide a definition of Supply Chain Disruption Risk Management.
- To provide multiple perspectives on the sources of supply chain risks.
- To provide examples of disruptions in a risk diagram.
- To summarize and provide an overview of risk management strategies.

Structure
The next section provides a definition of Supply Chain Disruption Risk Management. This is followed by an elaboration on two different perspectives on supply chain risk sources. Next, several examples of supply chain disruptions are presented in a risk diagram. Then, risk management and strategies are discussed. The final section builds upon the first five sections. In the final section conclusions are formulated and two suggestions for future work are provided.

3. Definition of Supply Chain Disruption Risk Management

Several definitions Supply Chain Risk Management are suggested in literature. To our knowledge, these definitions do not make the distinction between the broad categories of risk as proposed by Kleindorfer and Saad (2005). In this section a definition of Supply Chain Disruption Risk Management will be proposed, based on existing definitions of Supply Chain Risk Management and the key concepts of 'vulnerability' and 'resilience'.

Waters (2008, p. 76) defines Supply Chain Risk Management (SCRM) as; "*Supply chain risk management is the process of systematically identifying, analyzing and dealing with risks to supply chains*". The second part of this definition is further specified by Tang (2006, p. 2), who incorporates the goal and methods of SCRM into the definition and defines SCRM as: "*The management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity*." According to this definition, collaboration and coordination are the tools that the supply chain partners have to use in order to 'deal' with supply chain disruption risks. Jüttner (2005, p. 123) incorporates the goal of SCRM and defines SCRM; "*the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole*."

Hammant and Braithwaite (2007, p. 98) argue that identifying and addressing risks starts with the

"*intrinsic vulnerability of the supply chain (its exposure to risks) and its resilience to the various risks that it may encounter (ability to ride the shocks)*".

If these statements are combined, Supply Chain Disruption Risk Management is defined as;

Supply Chain Disruption Risk Management is the process of systematically identifying, analyzing and dealing with disruption risks to supply chains, through coordination or collaboration among the supply chain partners, by decreasing supply chain vulnerability and increasing supply chain resilience, so as to ensure profitability and continuity for the whole supply chain.

From a business perspective, the reason to turn to Risk Management practices is to 'ensure profitability and continuity for the whole supply chain' – this implies that an *economic* and *supply chain wide perspective* on the subject is adopted. There are multiple dimensions of loss; "financial, performance, physical, psychological, social and time loss (Harland *et al*., 2003; p. 52-53)". This paper is only concerned with *financial* aspects of SCDRM. The performance of the supply chain can be viewed from a single or multi-actor perspective. "Rather than competing *firm versus firm*, today's organizations are battling *supply chain versus supply chain* (Ketchen Jr. & Hult, 2007; p. 1)." Therefore, a Supply Chain Wide perspective is adopted. The next section describes multiple perspectives on the sources of supply chain risk.

4. Supply Chain Risk Sources

The basis constructs of SCRM are visualized in Figure 2 (Jüttner, Peck and Christopher, 2003; p. 121). The consequences of the 'risk sources' are influenced by (1) the supply chain and the (2) 'supply chain risk mitigating strategies'. An important notion is that the consequences of the risk sources can be reduced by Supply Chain Risk Mitigating Strategies.

In order to properly identify a phenomenon, one needs a classification / structuring model. Two models are discussed that provide a framework which can support the structuring of identified risks.

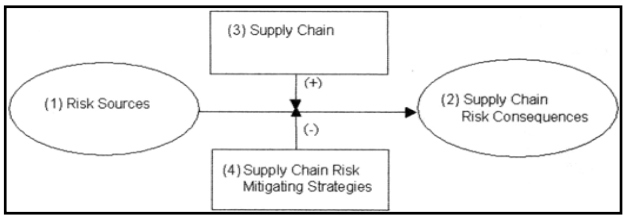

Figure 31: Basic constructs of Supply Chain Risk Management (Jüttner, Peck & Christopher, 2003; p. 121)

There are basically two kinds of risk to a supply chain; internal risks and external risks (Waters, 2008; p. 8; Christopher, 2003; p. 14). "Internal risks are [...] more widespread in their effects. These are the risk to operations that managers can control – such as delays and breakdowns – and there are traditional ways of dealing with them." External risks however, are uncontrollable. "External risks come from outside the supply chain, such as earthquakes, hurricanes, industrial action, wars, terrorist attacks, outbreaks of disease, price rises, shortage of raw materials etc." Risks can be internal to the supply chain as a whole, but external to an individual organization in that chain (for instance, for the *focal unit* – see Figure 1).

When further specifying risks, Waters (2008, p. 177) distinguishes another type of risk, 'supply chain risk'. *"Each member of a supply chain is vulnerable to its own risk (internal risk), risks to other members of the supply chain (supply chain risks) and risks that arise from interaction between the supply chain and its environment (external risks).*" These different categories of risk are termed 'supply chain risk sources'. "Supply chain risk sources are any variables which cannot be predicted with certainty and from which disruptions can emerge (Jüttner, 2005; p. 122)". Supply chain risk sources of a supply network are visualized in Figure 3. As visualized in Figure 3, Jüttner (2005) separates the internal risks into two categories, 'process' and 'control' risks and states that the internal risks either work as an '*amplifier'* or as an '*absorber'*, referring to either sufficient or insufficient management of these risks. Christopher and Lee (2004, p. 3) also refer to this (amplification / absorption) effect; they termed it 'chaos risks'. "*The complexity and uncertainty within a supply chain can also increase the 'chaos' risks within the supply chain. These chaos effects result from overreactions, unnecessary interventions, second guessing, mistrust, and distorted information throughout a supply chain (ibid.)*".

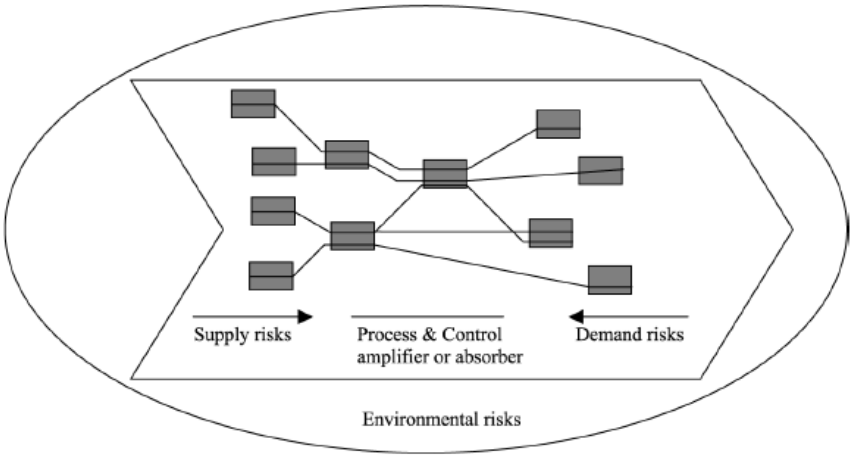

Figure 32: Supply Chain Risk Sources (Jüttner, 2005; p. 123)

The impact of a supply risk is reduced if proper control mechanisms are put in place by a supply chain partner. On the other hand, if insufficient control mechanisms are put in place, then a supply risk is amplified and can have a severe impact on the companies' and supply chain performance. Following our definition of SCDRM as stated above, the performance is specified as '*profitability and continuity for the whole supply chain*'.

In Table 1, the supply chain risk sources (supply, process, control, demand and environmental risks) are defined (see also Figure 3). The definitions are taken over from Jüttner (2005), who investigated and compared the different supply risk sources and their categories based on consultation of relevant scientific literature and extensive empirical research. Jüttner (2005) adopts a "supply chain orientation" and notes that the pathway of supply and demand risks is not limited between two members of the supply chain; "*Supply and demand risks describe the direction of potential disruptive effects (from supplier of raw materials to the end consumer or vice versa) and are not restricted to dyadic relationships between two directly related vendor and customer organizations (ibid.)*".

A different model of SCRM is proposed by Peck (2005, p. 218), it distinguishes risks manifesting at four different horizontal levels (see Figure 4). The model has similarities with the model of Jüttner (2005 – see Figure 3): both models incorporate *'the environment'.*

The difference in these two models is that Jüttner (2005) takes a *vertical* view on risks (Figure 3) and distinguishes five types of supply chain risk sources, where Peck (2005) distinguishes four *horizontal* layers of risk (Figure 4). Jüttner (2005) takes the actors as the unit of analysis in the conceptual model. Peck (2005) takes the technical system as the unit of analysis.

Supply Chain Risk Source	Definition
Supply Risk	Supply risk is the uncertainty associated with supplier activities and in general supplier relationships
Demand Risk	Demand risk is any risk associated with the outbound logistics flows and product demand
Process Risk	Processes can either amplify or absorb the effect of risks in the supply chain and refer to the design and implementation of processes within and between the entities in the supply chain
Control Risk	Supply chain control mechanisms like decision rules and policies regarding order quantities, batch sizes and safety stocks can either amplify or absorb risk effects
Environmental Risk	Environmental risk sources comprise any external uncertainties arising from the supply chain

Table 21: Definition of Supply Chain Risk Sources (Jüttner, 2005)

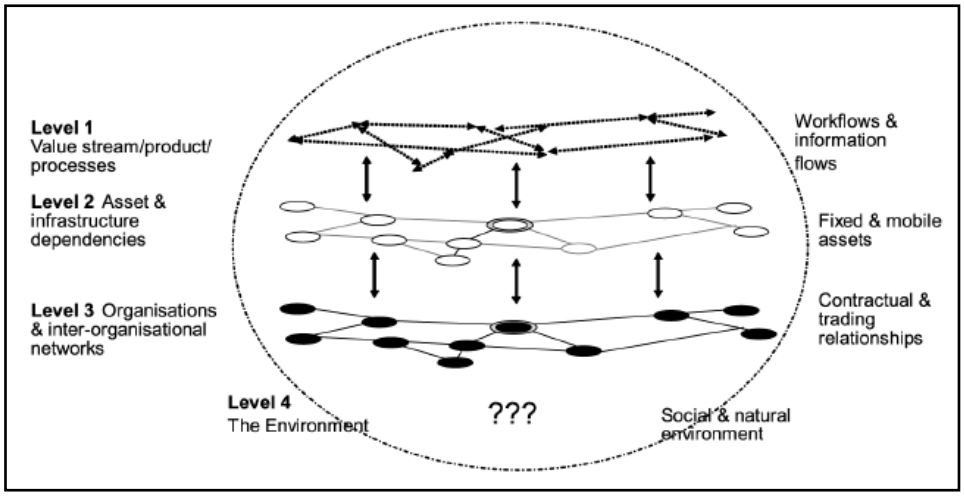

Figure 33: An integrative model of a supply chain as an adaptive system (Peck, 2005; p. 218)

Already in 2001, Lazzarini, Chaddad and Cook introduced the concept of 'netchain analysis' and report that the *horizontal* view refers to Network Analysis (NA) and the *vertical* view refers to Supply Chain Analysis (SCA). "*A netchain is a set of networks comprised of horizontal ties between firms within a particular industry or group, which are sequentially arranged based on vertical ties between firms in different layers (ibid.)*".

Netchain analysis combines horizontal and vertical interdependencies: "*Supply chain analysis suggests vertical interdependencies. Unlike SCA, NA is not particularly concerned with vertically organized ties, but rather with horizontal relationships between firms belonging to a particular industry or group (ibid.)*".

The supply chain risk sources overlap, an *external* (environmental) risk can result into a supply or demand risk, which then becomes *internal* to the supply chain. In the model of Peck (2005), an environmental risk at level 4 can result in a risk at level 3, 2 and/or 1. Hence, the time dimension influences risk: an environmental risk can become –in terms of Jüttner (2005)- a 'supply', 'process', 'control', or 'demand' risk in the future.

The supply chain risk sources and two different models are discussed. These models can be used to map, indentify, and categorize risk. The concept of 'netchain analysis' provides a starting point to integrate both a *horizontal* and *vertical* view on sources of supply chain risk. The next section elaborates on a widely used tool that supports supply chain risk analysis: the 'risk diagram'.

5. Risk diagram

"Once risks are identified, their impact and probability must be assessed (Blackhurst et al., 2008)". The risk diagram is a tool to conduct a 'risk likelihood/impact analysis' and "can be helpful in this respect (Hallikas et al., 2004)", it is a tool to support supply chain risk analysis (Jüttner, 2005). When the risks are identified, either with brainstorming techniques or more formal methods, the identified risks can be evaluated in a 'risk diagram' according their impact and probability. The quantitative definition of supply chain risks is then expressed as: Supply Chain Risk = Probability * Impact/severity of the event (Knemeyer *et al.*, 2008; Harland *et al.*, 2003).

The risk diagram with several examples of disruptions to normal activities is presented in Figure 5.

In the risk diagram, the impact ranges from 'none' till 'catastrophic' and the probability ranges from 'none' till 'very high'. Basically, two important questions are answered in the risk diagram. The first question is: *How likely is it that an event will occur?* "The likelihood of an event occurring depends partly on the extent of the *exposure* to risk and partly on the likelihood of a trigger that will *realise* the risk (Harland *et al.*, 2003)".

The second question addressed by the risk diagram is; 'What is the significance of the consequences and losses (impact)?' The significance of the consequences depends on the companies' resilience to disruption risks. Resilience is defined by Peck (2005, p. 211) as "the ability of a system to return

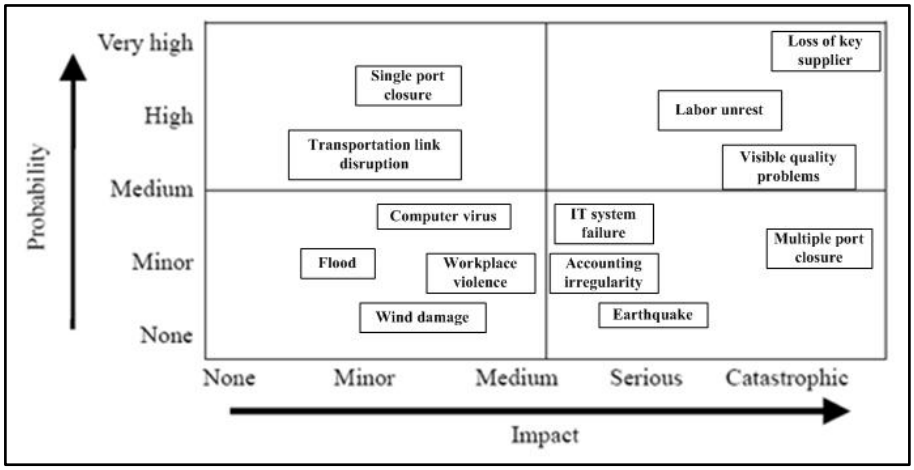

Figure 34: Risk Diagram (Blackhurst *et al.*, 2008; p. 53; Hallikas *et al.*, 2004; examples from Sheffi, 2005; p. 32)

to its original [or desired] state after being disturbed". Vulnerability is defined as : "exposure to serious disturbance, arising from risks within the supply chain as well as risks external to the supply chain (Peck, 2006)". The reliability of the supply chain can thus by described as a function of vulnerability and resilience.

Several problems arise when the risks are addressed in the "semi-quantitative assessment (Hallikas *et al*., 2004; p. 53)" when dealing with *supply chain disruptions to normal activities*. Two main problems are 1) data about the probability of occurrence is required and 2) data about the impact is required. Especially in a supply chain / network situation, both probability and impact are difficult to address.

Actors are 'reciprocal' dependent on each other in a supply chain/network (Lazzarini *et al.*, 2001; Thompson, 1967), in order to ensure 'profitability and continuity for the whole supply chain'. This dependency and (possible) "*goal incongruence* (Jüttner, 2005)" require a soft approach to asses risk. In an (extreme) soft view, risk is seen as a "social construct (de Bruijn & Ten Heuvelhof, 2004)".

The risk diagram can be used to conduct a risk likelihood/impact analysis and to communicate about risks within a single organization or across the supply chain. Risk management and strategies are discussed in the next section.

6. Risk Management and Strategy

"An effective disruption-management strategy is a necessary component of a firm's overall supply chain strategy (Tomlin, 2006; p. 655)". There is a need to integrate risk management along the supply chain. As Christopher and Peck (2004) put it; "Risk management requires a new focus on managing and mitigating risk which extends beyond the four walls of a plant".

6.1 Integration

Waters (2008, p. 86) suggests five levels of integration for Supply Chain Risk Management, based on the following rationale; "*a risk might appear within an individual organization, but the links between organizations automatically transmit its effects to other members of the chain […] the reliability of the whole supply chain depends on its weakest link […] so, all members of a chain should work together for their mutual benefit, reducing the overall vulnerability*". According to Kouvelis *et al*. (2006, p. 37), "integration is the essential theme of supply chain management". The five levels of integration are (Waters, 2008);

- Level 1. No significant risk management is done anywhere in the supply chain.
- Level 2. Some basic risk management is done within the separate activities of logistics within some organizations.
- Level 3. Risk management is done for the broad logistics function, but is contained within separate organizations.
- Level 4. Risk management is extended and coordinated along the supply chain to include first-tier suppliers and customers.

- Level 5. Risk management is extended to the broader supply chain.

The move from low to higher levels of integration is by Deloitte (2006) referred to as a development towards 'risk maturity / risk intelligence'. Most companies still operate at level 2 or 3 and few companies seem to have reached higher levels (Waters, 2008). According to Jüttner (2005, p. 139), "*the concept of SCRM is still in its infancy, and understanding of SCRM is patchy, both in terms of its key issues and its implementation*". Therefore, it is not surprising that companies are still at lower levels of integration, which is confirmed by research of Aberdeen Group (2006) and McKinsey (2006).

6.2 General risk management strategies

'Risk management systems and actions' are identified by Paulsson (2007, p. 344) as "of special significance from a *disruption risk point of view*". Four high level strategies can be used to manage risk. These include: transferring risk, reducing risk, accepting risk and subdividing risk into individual levels for further analysis (Hallikas *et al.*, 2004). According to Jüttner *et al.* (2003), the reducing strategy can be subdivided into *avoidance*, *control*, *cooperation* and *flexibility* strategies. Adopting the view of Jüttner *et al.* (*ibid.*) -that cooperation is a risk reducing strategy- the following 'Supply Chain Risk Management decision tree' is constructed (Figure 6).

The decision illustrated in the tree is the decision to *actively* or to *passively* manage risk[37]. Another categorization is "preventive" (ex-ante) or "interceptive" (ex-post) management (Gaonkar and Viswanadham, 2007). From a managerial perspective, the two categories of *active* and *passive* management seem useful. In similar lines, Waters (2008) argues that managers need to manage risk *pro-active* instead of *passive*. Several distinct high-level Supply Chain Risk Management Strategies are presented in the decision tree (Figure 6). The next subsection will

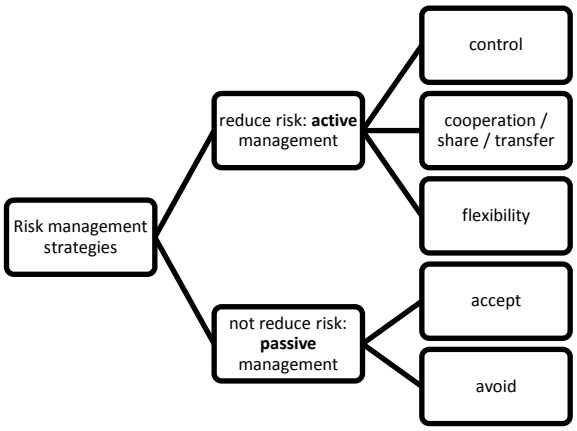

Figure 35: Supply Chain Risk Management decision tree

discuss a key concept in Supply Chain Risk Management: 'risk transferring'.

6.3 Risk transferring

Transferring risk in a network is explained as follows (Hallikas *et al*. 2004): *"The network relationships often include transferring risks from one company to another. This may reduce the total risk if the company taking the risk can cope with it better than the company transferring it."* In contrary, sometimes risks are transferred to actors that are in worse positions to cope with risks. Following our definition of SCDRM, this stipulates the need for 'collaboration and coordination', so as to ensure the right allocation of risks: "benefit and risk sharing (Harland *et al.* 2003, p. 60)".

"In any economic exchange, people have to agree on how to divide costs, benefits and risks (Williamson, 1985)". The economically best possible manner to manage risks is by the actor for which the costs of mitigation are the lowest. The costs of disruptions increase when risks 'fire' further down the supply chain, because the product is closed to the final customer. In addition to the exponential increase in mitigation costs, the 'focal company' is often blamed for the behaviour of their direct and indirect suppliers, the so-called 'reputation risks'[38].

Both the financial importance of reputation risks and fact that costs tend to increase when

[37] In this view, avoiding risk is a *passive* risk management strategy. Further, 'cooperation', 'share' and 'transfer' are placed in same leaf of the tree, because of the characteristic that these strategies require multiple actors.

[38] *"A Fortune 25 chief executive officer is worried that he might see his company's name on the cover of the New York Times because a small unknown fourth tier supplier of trucking services in a low cost country is using child labor at no pay* (Cavinato, 2004; p. 383)."

disruptions occur lower in the chain (thus closer to the end market), requires appropriate 'management of the interfaces', which is essentially based on the proposition that the individual companies, actors or systems are difficult to manage, because of the complexity and the specialist knowledge one needs. Therefore, one could focus on the management of the interface between these companies, actors or systems. For SCRM, this means, the coordination of outbound and inbound logistics, transportation and communication between the chain members and all other processes. Furthermore, -*from a supply chain wide orientation*- risk should be managed as quickly as possible, because of the increasing marginal costs of disruptions. From a single actor perspective, it can be beneficial to transfer risks to the downstream partner: opportunistic behaviour.

Eliminating risk can be achieved by stopping with the business activity; however, this is not always a reasonable option, especially if logistics/supply chain activities are an integral part of the business activities. To accept risk is not a 'good decision' according to Tomlin (2006); "Firms that passively accept the risk of disruptions leave themselves open to the danger of severe financial and market-share loss". No supply chain is totally risk free; there is always 'inherent risk'. In other words -*contrary to desires*- "there is no such thing as zero-risk (Harland *et al.*, 2003; p. 54)."

6.4 Trade-off: Cost of Disruptions versus Cost of Mitigations

The economic trade-off between taking (accepting) and reducing (proactively managing) risk is visualized in a model of Husdal (2007). A 'rational' decision maker will reduce (mitigate) risks till the costs of disruptions are lower than the costs of mitigation, this point is the intersection in Figure 7. Companies which are on the left side of the intersection should turn to SCDRM practices.

Husdal (2007) explains the economic rationale of the figure in the following way: "*it could be said that the marginal cost of disruptions initially will fall sharply while the marginal cost of countermeasures will only rise slightly. The more countermeasures that are put in place, the less extra benefit is achieved for each marginal investment in reliability. This is in line with the traditional way of thinking in contingency*

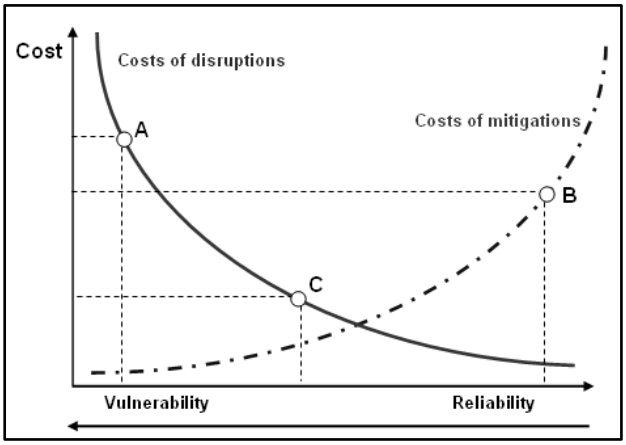

Figure 36: Cost of disruptions and cost of mitigations (Husdal, 2007)

planning, that it often only takes small changes or investments to make a considerable impact. Full and 100% reliability however is very costly, due to the unpredictable manner of the potential disruptions."

Next to the development to more integration, SCRM should increase resilience, which reduces the impact of an event. According to Sheffi (2005), "the essence of resilience is the containment of disruption and recovery from it." Sheffi (*ibid.*) explains the link between 'company culture' and resilience. "*Culture contributes to resilience by endowing employees with a set of principles regarding the proper response when the unexpected does occur, and when the formal organization's policy does not cover the situation at hand or is too slow to react*."

The general steps and strategies for mitigating risk are not directly applicable to each individual company. The risk management process must be tailored to the specific situation of an organizations supply chain, its business goals, products and "risk appetite (Committee of Sponsoring Organizations of the Treadway Commission (COSO), 2004)". There is "no one size fits all solution (Kleindorfer & Saad, 2005)".

In our perspective towards the management of disruption risk in supply chains, organizations should choose the appropriate risk management strategy on the basis of four important factors: (1) costs, (2) the decrease in vulnerability, (3) the increase in resilience and (4) the 'risk appetite'. The 'risk appetite' of organizations reflects the organizational perspective and culture towards risk taking. As Harland *et al.* (2003, p. 54) report:

"businesses and individuals trade-off risks and benefits every day, performing some form of balancing of risk and reward. The way that they make these trade-offs depends on what are deemed to be acceptable levels of risk, the size of the benefit and the attitude of the organisation to risk taking".

7. Conclusions

Insufficient management of 'disruptions to normal activities' can have severe negative financial consequences. Two broad categories of risk arise from problems in coordinating supply and demand and 'disruptions to normal activities'. Following this distinction, Supply Chain Disruption Risk Management can be defined as: "*the process of systematically identifying, analyzing and dealing with disruption risks to supply chains, through coordination or collaboration among the supply chain partners, by decreasing supply chain vulnerability and increasing supply chain resilience, so as to ensure profitability and continuity for the whole supply chain.*

A *horizontal* or *vertical* view on supply chain risk sources can be adopted. 'Netchain analysis' suggests that both the Network Analysis (horizontal view) and Supply Chain Analysis (vertical view) can be combined. The risk diagram is a tool to support supply chain risk analysis. In a risk diagram, risks can be visualized according to the quantitative definition of risk: 'probability * impact'.

Integration is the essential theme in Supply Chain Management. Companies still operate at lower levels of integration, which is confirmed by empirical research. It has been argued that general risk management strategies can be separated in *passive* or *active* strategies. Based on these distinct categories, five lower level Supply Chain Risk Management strategies can be distinguished: control, cooperation, flexibility (*active*), accept and avoid (*passive*). There is, however, 'no one size fits all solution'. Supply Chain Risk Management strategies should be chosen on the basis of: (1) costs (2) the decrease in vulnerability (3) the increase in resilience, and (4) the organizations' 'risk appetite'.

The reliability of a supply chain is a function of its vulnerability and resilience. Risk is transferred in a supply chain / network situation, this implies the need to include the costs of disruptions and the costs of mitigations for all actors when managing disruptions to normal activities. Further, -from a supply chain wide economic perspective- risk should be allocated to the actor for which the costs of mitigations are the lowest.

Based on the arguments provided in this paper, two suggestions for future work are formulated.

1) The development of a model that incorporates both a *horizontal* and *vertical* view on Supply Chain Risk Sources. Such a model provides a starting point to further understand the complexity of Supply Chain Risks and would visualize how risk arising from different sources is transferred throughout the network, between different actors and layers. The model should incorporate multiple levels of risk in the network (Network Analysis) and multiple supply chain risk sources (Supply Chain Analysis): a direction towards a model to support 'Netchain Risk Analysis'.

2) The development of a more comprehensive model to present the costs of disruptions versus the cost of mitigations. In the model of Husdal (2007) 'resilience' is excluded. In this paper it has been argued that the reliability of a supply chain depends on both its 'intrinsic vulnerability to risks' and the 'ability to ride the shocks'. A conceptual model of the strategic cost-risk trade-off may advance cost effective mitigation practices. Such a model must include the costs of disruptions and mitigations for multiple actors. This may yield an optimal co-investment level, as actors are reciprocal dependent on each other in a network situation.

Limitations

An economic and supply chain wide perspective on the subject has been adopted. This automatically excludes other types of risk and solutions from a single company perspective. Furthermore, the rationale throughout this paper is based on theoretical considerations. No directly applicable method or tool to support Supply Chain Disruption Risk Management has been proposed. However, it is believed the suggestions for future work may support the development of practical tools or methods that organizations can use to pro-actively manage disruptions risks.

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