Development of a risk management model – a design study at an oil company

Summary Master Thesis

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Relevance and purpose of the thesis

The purpose of this research is to contribute to the current risk management model (further explained in the section 'Theoretical background') by testing its applicability and executing the individual steps thereof. This is academically relevant as risk management initiatives have become more important than ever and a structured risk management process is required for managing a company's risks (Manuj & Mentzer, 2008; Craighead et al., 2007; Jüttner, Peck, & Christopher, 2003; Shaer & Goedhart, 2009; Tummala & Schoenherr, 2011). Until now, the current risk management research has rather focused on the theme's insurance, finance, economics, strategic management and international business management, while supply chain issues were neglected (Manuj & Mentzer, 2008). Furthermore, only a few studies were conducted in collaboration with a company although the results thereof can be highly advantageous (Sodhi et al., 2012; Tummala & Schoenherr, 2011; Manuj & Mentzer, 2008). Yet, this research is addressed at a supply chain issue at an oil company. To be more precise, the company experienced margin losses and reputational damages due to retail station stock outs which were caused by non-product availability incidents at the supplying tank storage. Hence, this research is not only focused at a supply chain issue, but also conducted in collaboration with a company. The petroleum supply chain is characterized as one of the most complex and advanced supply chains around the world (Kazemi & Szmerekovsky, 2015) The petroleum supply chain is divided in upstream and downstream operations: While the *upstream* segment is concerned with the exploration and extraction of crude oil, the *downstream* operations start at the refineries where the crude oil is processed into usable products such as gasoline, diesel, jet fuels, heating oil and petroleum-based products (e.g. plastics, asphalt, tires etc.) (Kramer, 2018; Kazemi & Szmerekovsky, 2015). Next to the refining, the downstream activities also include transport, storage, marketing and distribution of the petroleum products (Lima et al., 2016). Nevertheless, risk management in petroleum supply chains is understudied in the current literature (Lima et al., 2016). Thus, this research does not only fill gaps in regards to the general risk management model, but also contributes to the risk management literature in the (downstream) petroleum supply chain.

Theoretical background

In order to "manage global supply chain risks, companies need to follow a path from risk identification to strategies to deal with risks" (Manuj & Mentzer, 2008). In the literature, a general consensus exists in regards to the following five sequential steps in a risk management process (in this summary referred to as 'general risk management process'): risk identification, risk assessment, selection of a strategy, implementation of the strategy and risk monitoring. All steps are interactive and interdependent. (Giannakis & Papadopoulous, 2016; Manuj & Mentzer, 2008; Chapman, 2006; Kleindorfer & Saad, 2005). The focus of this research will be on the second and third step of the risk management process. The second step risk assessment (2^{nd} step) is aimed at determining the likelihood of occurrence and the potential impact of the risks identified in the first step (Chopra & Sodhi, 2014; Kneymeyer, Zinn, & Eroglu., 2009; Harland et al., 2003). Haimes (1999) and Manuj and Mentzer (2008) proposes to use historic (frequency) data in order to make assumptions about the probability of future occurrences. This however presumes that there is historical data available which is reliable and adequate (Manuj & Menzter, 2008). Furthermore, not all risks affect the company in the same way. Some risks are more severe than others - Ponomarov & Hocomb (2009) even alert that a disruption at one compartment might impact all other parts of the supply chain. Consequently, a potential risk's impact on other parts of the supply chain must be considered. Yet, research is rather limited in regards to characteristics that determine the impact of a disruption (Adenso-Diaz et al., 2012, Sodhi et al., 2012). A rare exception is Craighead's et al. (2007) *severity* of supply chain disruptions for estimating the impact of a risk. The severity is derived from the number of entities within a supply network whose ability to deliver and/or receive goods has been handicapped by an unplanned event (Craighead et al., 2007). According to this definition, severe disruptions impact more parties in the supply chain. The severity is ought to depend on the supply chain design characteristics *density, complexity* and *node criticality* (Craighead et al., 2007). Once the likelihood and impact of a disruption are determined, a risk profile map can sum up the results of the second step graphically (Cole & Kelly, 2015). In general, a company should especially focus on the more vulnerable risks to the supply chain (Manuj & Mentzer, 2008, Craighead et al., 2007). The third step is to choose a suitable strategy (3^{rd} step) to manage the risks. In order to pick a strategy, a company needs to understand the causes and effects thereof (Giannakis & Papadopoulos, 2016). An understanding is essential for generating strategies which redeem the cause. Otherwise, risk management strategies would be just best guesses (Lambert and Cooper, 2000). For understanding the causes and effects more thoroughly a failure mode effect analysis (FMEA) could be conducted (Stamatis, 2003). The FMEA aims at identifying and preventing problems before these reach the final customer. Once the risks with the highest priority are identified, risk management strategies come into place. These are intended to either decrease the probabilities of occurrence or limit the impacts (Sodhi et al., 2012). More generally, strategies can be aimed at avoiding the identified risks, or if not possible, at least control, share or retain them. Researchers have agreed upon the following five risk management strategies as illustrated in figure 1 (Giannakis & Papadopoulos, 2016; Jüttner et al., 2003; Miller, 1992).

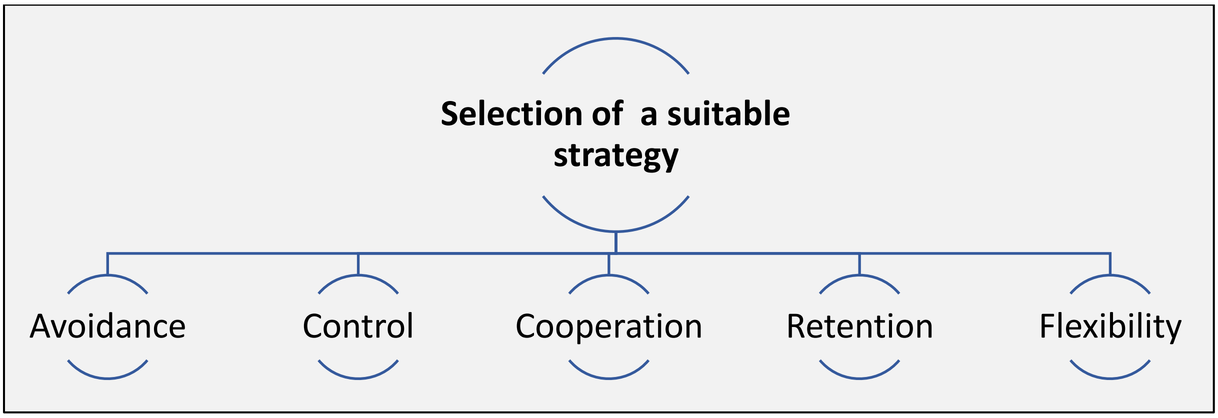

Figure 1: Selection of a suitable strategy (Own illustration)

Once the appropriate strategy has been selected, the strategy implementation (4th step) succeeds. The ultimate step risk monitoring (5th step) entails the constant monitoring of effects of the applied strategies, as well as the tracking of changes in regulations or operating policies and any change of the risk profile matrix due to the dynamics of supply chains. Once changes become apparent, new solutions should be proposed inheriting that the risk management process starts all over again (Wu & Blackhurst, 2009; Giannakis & Papadopoulos, 2016).

The research gap that is addressed

The literature review has not only demonstrated a need to test the general applicability of the risk management model in other industries, but also indicated that elaborations on the individual steps of the risk management model are desirable (Sodhi et al., 2012).

Heading in a similar direction, there is not extensive empirical work in this field although it would be advantageous (Sodhi et al., 2012; Chopra and Sodhi, 2004; Tummala and Schoenherr, 2011). Hence, future research should focus on testing the applicability in different companies and industries. This would also increase the number of empirical studies and might provide managers with more practical insights.

In regards to Craighead's et all. (2007) severity of disruption, it is proposed that by comparing the design characteristics (*density, complexity* and *node criticality)* between different supply chains, a disruption's impact in the relative supply chain can be estimated. Yet by comparing the characteristics, one can only derive whether a certain supply chain set-up is denser/looser, less/more complex or whether it includes more/fewer critical parties than another supply chain set-up. No guidelines were provided in terms of how to conclude whether the impact of a design characteristic is high, normal or low. Furthermore, the classification issue is further complicated when considering more than one variable for a design characteristic e.g. if for the *node criticality*, two variables are considered (such as the "sales volume" and the "number of customers"). In such a case, it is unknown how to define the overall *node criticality* of a supply chain.

Besides, heading in a similar direction, Craighead et al. (2007) did not discuss how an overall severity level can be derived. This is especially problematic if the variables *complexity*, *density* and *criticality* are not consistently higher or lower compared to other supply chain, but if e.g. the *complexity* of a chosen supply chain is high compared to other supply chains, but the analysed supply chain is *less dens*e and *critical* than the comparison group. Finally, it is not researched whether the design characteristics are all equally important or whether some characteristics are more determining than others for the determination of a disruption's impact. These gaps were considered in the research.

The approach taken, the methods of analysis

Normally, the risk management process commences with an identification of the risks (1st step) that are threatening the supply chain. In this case, the risks have been identified beforehand and non-product availability at the tank terminal has been prescribed as the interest of this research. In the thesis, the risk assessment (2nd step) and the selection of suitable risk management strategies (3rd step) are administered and applied to a company case as the current literature lacks empirical research. Hereby, the goal is to test the applicability and fill gaps in the literature. More specifically, it is conducted in the highly vulnerable, but understudied downstream segment of an oil company. Cigolini and Rossi (2010) and Omole et al. (2004) have suggested the usage of the general risk management model in the oil industry. Yet, they have preliminarily focused on the upstream petroleum supply chain which contains different activities than the downstream side of the petroleum supply chain.

More specifically, the identified risk will be assessed on a location's likelihood for a disruption and its impact in case of a disruption. The analysis on a location level is proposed by Cigolini and Rossi (2010). While the determination of the risk's likelihood will be conducted using historical data as recommended by Haimes (1999), Manuj and Mentzer (2008) and Cigolini and Rossi (2010), the impact assessment will be carried out by testing the applicability of Craighead's et al. (2007) severity of disruptions. Due to a fact that a company seldom has the (human) resources to focus on all locations simultaneously, the tank terminals are prioritized. This is done by generating a risk matrix as proposed by Cole & Kelly (2005). The risk matrix graphically depicts the results of the risk assessment. All tank terminals are assigned to a "box" based upon their likelihood and severity of disruption. Risky tank terminals are flagged and can easily be spotted (=highly likely, highly severe box). These are the tank terminals that should receive an increasing amount of attention since they are threating the retail station supply the most. After the highly likely, highly severe locations are identified, the causes for the disruptions at the riskiest tank terminals are identified based upon historical data. Thereafter, the essence of the failure mode effect analysis will be applied to prioritize the potential failures (= in this research "failures" is used interchangeably with "causes"). The FMEA assesses a cause predictability, probability and severity for prioritizing the cause. Those with the highest risk prioritization number (RPN) are to be considered first. Thereafter, successively those with a lower RPN are to be considered. In this research, also a company's influential power on the cause is analysed as it gives an indication of how a firm can currently influence a cause. Ultimately, for those causes with the highest priority, suitable risk management strategies are proposed.

While the fourth risk management step is the implementation of the selected strategies, the fifth step deals with the monitoring of risks. Both steps need to be executed in reality and could only be described theoretically in this paper. Yet, as the formulation of an implementation plan and the establishment of risk monitoring processes are rather extensive and usually require further arrangements with employees from the respective department and maybe even a detailed analysis and restructuring of IT systems, it is omitted in this research. These are important steps which should be analysed in further research projects.

In figure 2, the general risk management process is graphically depicted. All executed steps are marked in blue:

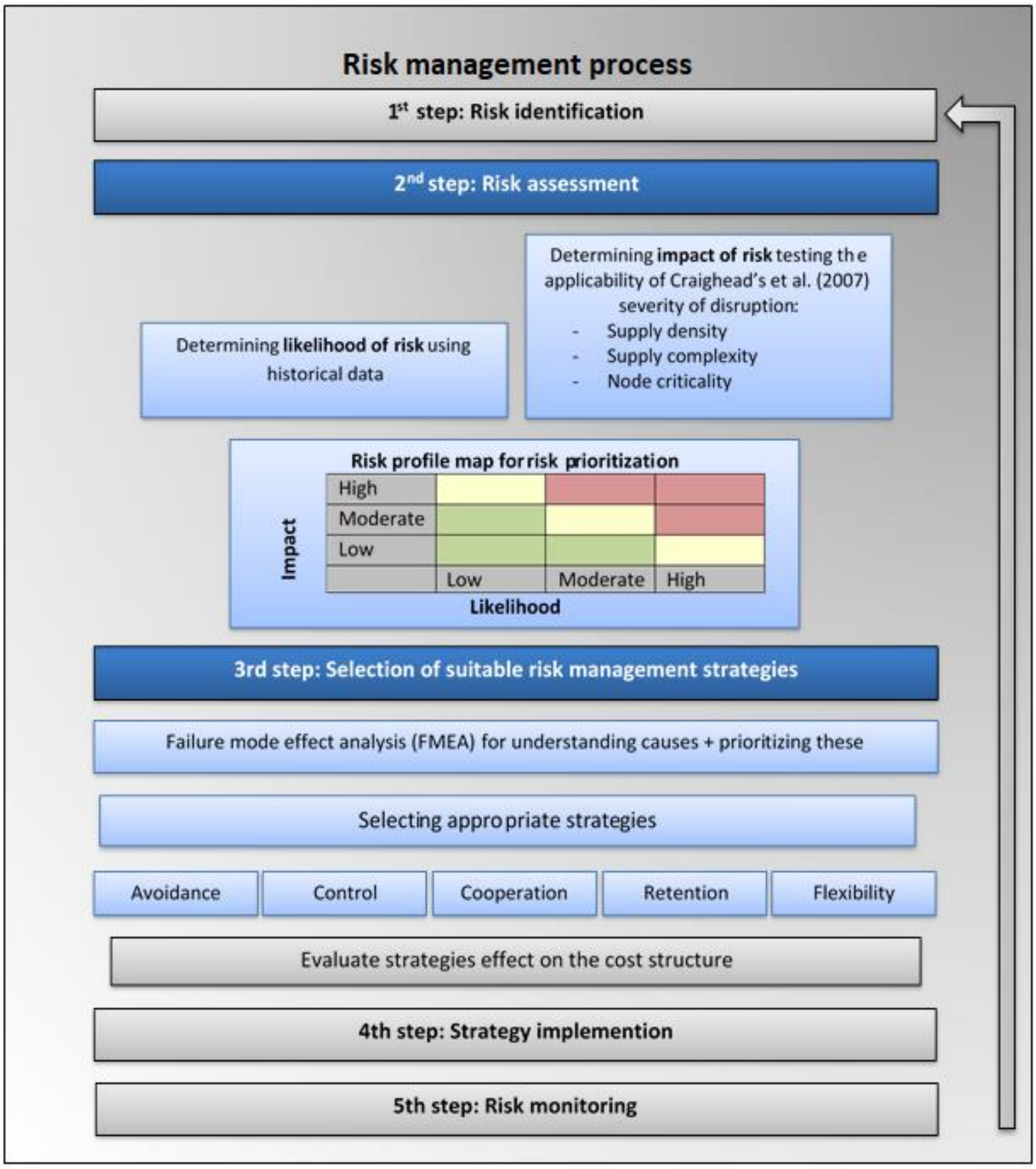

Figure 2: Risk management process (Own illustration)

Theoretical contributions

In regards to the theoretical contributions to the general risk management literature, this research has tested and confirmed the applicability of the above depicted risk management model in the understudied, but highly vulnerable downstream petroleum supply chain. In contrast to the vast majority of current literature which merely mention the steps of the risk management process, in this research the risk assessment, cause identification and prioritization and partially also the selection of suitable risk management strategies were discussed in lengths providing managers with practical insights.

Applying Craighead's et al. (2007) design characteristics for the impact analysis of the risk assessment has illustrated that the logic of the *node criticality*, *supply complexity* and *supply density* can also be applied to the downstream petroleum supply chain.

Furthermore, contributions to Craighead et al. (2007) severity were derived by not only proposing a method for considering more than one variable for a design characteristic, but also defining an overall impact level based upon the three design characteristics: Craighead et al. (2007) did not discuss how to deal with more than one variable for a design characteristic. In this research, it was tested by considering two variables for the design characteristic *node criticality* which was evaluated based upon *the number of retail station* and their *respective sales volume*. In this research, the variables were first considered and assessed one by one. Afterwards, the variables were confronted with each other and an overall impact based upon the *node criticality* was defined. In regards to the impact classification, Craighead et al. (2007) argues that a comparison of design characteristics between different supply chains gives an indication of the riskiness of a supply chain. This was indirectly done. However, by comparing the characteristics, one can only derive whether a certain supply chain set-up is denser/looser, less/more complex or whether it includes more/fewer critical parties than another supply chain set-up. No guidelines were provided in terms of how to conclude whether the impact of a design characteristics is high, normal or low. Therefore, in this research, the distribution of the variables was utilized for classifying the variables in different risk categories. This resembles one possible way for classifying variables in a category. Using this approach, nearby variables are summarized in a category. A lower and an upper threshold value were set whenever two values experienced a rather huge gap between them. For future studies, (although omitted in this research) a sensitivity analysis should be conducted. This assesses how robust the classification system is if the risks would have been put in other risk categories (Saltelli, 2003).

Practical contributions

Practical recommendations are granted to the oil company: By applying the second step of the risk management process (=risk assessment), all company tank terminals were assessed for their likelihood and potential impact of a disruption.

This provided the company with an overview of the overall riskiness (likelihood and severity of a disruption) of the respective tank terminals. The BP-supplied tank terminals are analysed in terms of their likelihood and severity of a potential truck loading disruption for the retail station supply. The risk assessment aims at identifying those tank terminals at which a disruption is highly likely and has highly severe consequences. These are the tank terminals that should receive an increasing amount of attention since they are threating the retail station supply the most. Hence, the causes for disruptions at these tank terminals were identified by means of historical data. In total, ten type of causes were determined. Due to the fact that managers seldom have the (human) resources to focus on all causes simultaneously, a failure mode and effect analysis (FMEA) was conducted for the purpose of prioritizing the causes. Here, system breakdowns, technical and logistical issues turned out as the three highest priority causes. Ultimately, for these three high priority causes, general initiatives aimed at improving the product availability at the tank terminals were derived and presented. An improvement thereof is desirable as the current situation has a negative impact on the supply reliability at the company's retail sites and causes huge margin losses.

Next to the risk management strategies, also an adaption of the process for documenting the disruptions at the tank terminal was proposed. This is highly recommendable since there are still a rather huge portion of the causes unknown (30%).

Discussion of the main findings

The results of this analysis are focused on and applied to an individual company. However, the framework and tools which were applied in the master thesis are to a great extent also applicable to other companies e.g. the defined approach for classifying Craighead's et al. (2007) design characteristics can also be used for other studies. In case of an oil company, even the same variables can be used to assess the likelihood and impact of a potential disruption.

The thesis resembles a step-by-step, practical-oriented potential way of how to conduct a risk assessment which could be consulted by managers.

Nevertheless, in future studies a sensitivity analysis should be conducted as it tests the robustness of the classification system if the risks would have been put in other risk categories and thereby enhance the credibility of the findings.

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