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Master thesis

Supplier risk analysis of Company X: An application of risk analysis for non-metal components suppliers

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Abstract

Purpose

This paper aims to provide a solution for Company X so they are able to determine the level of risk of their critical non-metal component suppliers. Multiple studies about supply risk and managing this in an effective way have been written. Yet, this paper will provide a tailor-made solution specifically for Company X

Design/methodology/approach

The business problem solving methodology van Aken et al. have been used during this study. Several interviews with employees of Company X have been conducted to find out what the most common supplier risk sources at Company X are. Business documentation has also been used to define the most critical material groups of Company X. Furthermore, a project group and several focus groups provided feedback about the progress of the study and provided also information about the most important aspects of the critical suppliers of Company X.

Findings

To measure the level of risk of the critical non-metal components suppliers of Company X a self-assessment model has been developed. This self-assessment model consists of five risk subjects which are quality, logistics, financial, knowhow and environment & safety.

Research limitations/implications

The research findings are mostly subjective of nature and are specifically for the situation of Company X.

Practical implications

The paper provides a self-assessment model to measure the level of risk of suppliers. It is specifically made for Company X, but the research approach can also be adapted by other firms.

Originality/value

The research has provided a new model to measure the level of risk of suppliers.

Keywords

Supply risk, supplier management, risk management, supplier evaluation

Acknowledgements

Hereby, I would like to present my master thesis about the application of risk analysis for non-metal components suppliers of Company X. The aim of this thesis was on one hand completing the Master of Science in Business Administration at the University of Twente and on the other hand solving a business problem of Company X.

Apart from the efforts I have made to successfully write this thesis, the success of this thesis depends also on the efforts of others. Therefore, I want to thank a number of people who have made a contribution during my graduation period.

First of all, I want to thank my supervisor's dr. Schiele and dr. Hoffmann for their guidance and valuable comments during this period.

I would also like to thank all the employees of Company X who have cooperated during this period. Their contribution was of great importance during the research period of this thesis. Especially, I want to thank Mr. X and Mr. Y for the opportunity they gave me to join their team and their valuable guidance during the last six months.

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Zutphen, 14 July 2018

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1. Introduction: An introduction towards Company X and their need for an effective supplier risk evaluation model

1.1 Risk management in Company X' supply chain gains more importance due to a shift of in-house production to outsourcing

The consequences of a shift from in-house production towards outsourcing and therefore, also the growth in globalisation has led to the fact that firms nowadays are greatly dependent on their suppliers. Drivers of outsourcing and globalisation are focussing on core competencies, increasing shareholder value, cost reduction and quality improvements.[1] This shift does not lead only to advantages, as outsourcing increases the complexity of products/services and globalisation increases the possibilities of risk in a supply chain.[2] Therefore, greater dependency on suppliers is not only positive and it "increases the need to effectively manage suppliers".[3] Nowadays the challenge of the buying firm is to manage and mitigate risks by creating a more resilient supply chain.[4] As effective supply chain processes are influencing many value-added activities which increase customer satisfaction.[5]

Also for Company X it is important to have an effective supplier management procedure and to handle supply risk in the best possible way. This in order to fulfil the customer's wishes and stay ahead in a competitive market. Multiple studies have provided information about supplier management[6] and supplier risks[7] and also models have been made to handle this in an effective way. This research will provide a model, based on the literature and conducted field research, which Company X can use to identify risks at their suppliers, as well an action plan will be developed with steps to take after certain risks occur. As mentioned, extended research is performed in the field of supplier management and supplier risks. This thesis will made a contribute to the academic literature in the form of extending the literature with a new specific application of measuring risks of suppliers with the form of a self-assessment model. Note should be made that this research will mostly provide recommendations and implementations

[1] See Heikkilä and Cordon (2002), p. 183; See Kaya (2011), p. 168; See Kakabadse and Kakabadse (2005), p. 183; Meixell and Gargeya (2005), p. 533.
[2] Harland et al. (2003), p. 51.
[3] Kannan and Tan (2002), p. 11.
[4] See Christopher and Peck (2004), p. 1.
[5] See Hallikas and Lintukangas (2016), p. 487.
[6] See Hallikas et al (2005); See Chou and Chang (2008); See Kannan et al. (2013); See Hudnurkar (2016)
[7] See Blackhurst et al. (2008); Hoffmann et al. (2013)

actions specifically for Company X Nevertheless, it is possible for other companies, or for other studies, to follow the research methods which have been followed during this research and to use the specific outcomes.

1.2 Company X leading position as integrated copper group in Europe and largest copper recycler worldwide

Company X is the leading integral copper group and the biggest copper recycler worldwide. It produces high-purity, high-quality copper from copper concentrates and recycling materials and processes it into intermediate products such as rod, strip and wire. Each year the Company X groups produces more than one million ton of marketable copper products. More than 6.400 employees in over twenty countries work for Company X. The headquarter of Company is stationed in X.[8]

This research will be executed for Company X production site in X. Company X is part of the Company group. The main job in X is the production of thin brass and copper strip, which is mainly used in the automotive- and electronica industries. The produced copper and brass strip is mainly used for engine cooling, stamping, deep drawing, cable wrap and brazing foil. The finished products are worldwide exported to more than 400 customers divided in 70 countries. Since the customers are first- or second tier suppliers of the automotive industry Company X is certificated by the norms of ISO9001, ISO14001 and IATF-16949. The site in X consists of about 300 employees, which produces about 48.000 ton a year of products ready for shipment all over the world.[9] Company X is part of the business unit FRP. This business unit has also production sites in W, Y and Z. These production sites are comparable to each other, as they are producing the same copper and brass items and therefore, are operating in the same markets. As these sites are producing the same items, these sites also need the same materials and components to produce these items. In fact, Company X and Company Y are purchasing some materials at the same suppliers.

Company X consists of two separate procurement departments. One department focusses on the purchase of raw materials, which are used to produce the final product of Company X The main task of the other procurement department is to take care of the purchase of non-

[8] Company X, About us (2018)
[9] Company X, About us (2018)

metal components. This can be categorised by facility buying, MRO-components (maintenance, repair and operations) and packaging materials. The research of this thesis will be performed for the procurement department of non-metal components. The procurement department of non-metal components consists of three employees and is under the responsibility of the director finance & control. The procurement manager is responsible for the daily management of the department, where an assistant-buyer is responsible for the purchase of MRO-components and a buyer is responsible for facility buying. This is done according to the corporate procurement policy and the local procurement policy of Company X[10]

1.3 Determining critical suppliers and developing a supplier risk scoring model as goals of this thesis

To fulfil the demands and wishes of the customers of Company X it is important that the primary production process proceeds smoothly. Therefore, it is important that the machine park is maximum available for production and that the finished products are conform the requirements of the customer. The availability of non-metal components, like pallets, tubes, lubricants, oils, rolls or mechanical parts are in this case extremely important. These non-metal components are needed through the whole process and at the moment of failure in the machine park it is necessary that problems can be fixed in a short time to keep maximum production. Besides the availability of the non-metal components, the quality of these materials is also important. As these materials could have impact on the quality of the finished product of Company X

At the moment there is no supplier risk analysis at Company X and Company X want to gain more insight in which their critical suppliers are in the supply chain of non-metal components.

So the goal of this research is to provide Company X insight in their critical suppliers in the non-metal components supply chain. Therefore, a scoring model will be developed which Company X can use to determine the level of risk of a certain supplier. This will provide Company X with information about their risky suppliers and this information can be used to take action in order to avoid problems in the supply chain.

[10] Meeting procurement manager Company X, 15-11-2017.

Therefore, the main question for this research is as follows:

‘’How can Company X determine on a regular basis the risk of suppliers of critical non-metal components and which actions can be taken to deal with these risks?‘’

The main question will be answered using several sub questions:

1. What are the critical non-metal components of Company X?
2. What kind of supplier risks occurs at Company X at the moment?
3. How should those supplier risks be measured?
4. If a critical supplier is determined which steps should be taken?

During the research some restrictions were given by Company X Chapter 4.4 explains more in detail why these restrictions are given. The restrictions are the following:

- The solution to measure the risks of suppliers should be cost free
- The solution to measure the risks of suppliers should be in the form of a self-assessment model
- The self-assessment model should mostly consist of closed questions which can be answered with rating criteria

2. Literature: Supply risk models based on risk sources, risk measurement and risk mitigation strategies

2.1 Greater dependency on suppliers ask for effective management of suppliers using the following methods: classification, selection, evaluation and development

Hence, firms have to cooperate and interact with their suppliers in order to maximise the productivity and lower the cost. Managing suppliers is extremely important and therefore, purchasing departments are using several methods to do so, such as supplier selection, supplier coordination, supplier evaluation and supplier development.[11] This chapter will elaborate four steps of the supplier management process, which are supplier classification, supplier selection, supplier evaluation and supplier development. The choice for these four steps is based on the research question and the sub questions of this research. Studies about supplier classification, selecting, evaluating and developing can provide information which can be relevant for answering the research question and sub questions of this research.

There is not one way of dealing with all suppliers and therefore, "effective supplier management requires distinct practices for different supplier".[12] Because different suppliers require different practices, firms are classifying their suppliers to manage them accordingly.[13] Three approaches of supplier classification are widely known, the process method, portfolio method and the involvement method.[14] The portfolio method will be explained more in detail, as this method will be used in chapter 4.3. Kraljic was the first to introduce the comprehensive portfolio approach. Two variables, profit impact and supply risk, are the basis for classifying all materials a firm purchases. Based on the profit impact and the supply risk of the supplier the product or component is placed in one of the four quadrants. The quadrant with low profit impact and low supply risk is characterised by items with low value which can be purchased at a lot of suppliers and therefore, these items are non-critical. For items with a high profit impact and low supply risk the buying company has a lot of power. Bottleneck items are the ones with low profit impact and a high level of supply risk. These items are hard to purchase

[11] See Chou and Chang (2008), p. 2241.
[12] Hallikas et al (2005), p. 73.
[13] See Hudnurkar et al. (2016), p. 623.
[14] See Rezaei and Ortt (2012), p. 4594.

and therefore, the supplier has more power than the buyer. The last quadrant are items with a high profit impact and a high supply risk. These items are often purchased at one supplier and a good relationship between the buyer and supplier is the most important in this case. For each of these quadrants a different strategy can be used to deal with the supplier in the best way possible.[15]

As companies are more dependent on their suppliers, the supplier selecting process has become one of the most important and critical issue of a company.[16] Poor decisions in this process can have direct and indirect consequences on a firm's performance.[17] During the supplier selection process multiple criteria are consulted which are qualitative as well as quantitative. Most of the time a trade-off has to be made between conflicting criteria in order to find the most suitable supplier.[18] One way of selecting suitable suppliers is by performing an evaluation. Supplier evaluation comes back in two phases of the supply management process. First of all, in the supplier selection process. As evaluations are made of potential suppliers to see if they meet the requirements and to select the preferred ones. Secondly, evaluations are made on a regular basis to check the performance of the suppliers and check whether the current suppliers still meet the requirements.[19] Multiple studies have been performed on the topic of supplier selection and evaluation and several models and tools have been developed for this purpose. Therefore, organisations are able to develop or choose a method for supplier selection and evaluation based on those studies. However, during this process specific requirements of an organisation has to be taken in mind. Most of the time the models can be copied one-on-one and therefore, model flexibility and a different application of the model are needed.[20]

Supplier development is the last step in the supplier management process and can be defined as the activities which a buying firm undertakes to increase the performance of its suppliers.[21] Typically, supplier development activities are performed to bridge the gap between the performance of the supplier and the expectations of the buyer.[22] Therefore, this

[15] See Kraljic (1983), p. 112.
[16] See Kannan et al. (2013), p. 355.
[17] See González et al. (2004), p. 492.
[18] See Ghodsypour and O'Brien (1998), p. 199.
[19] See Osiro et al. (2014), p. 96.
[20] See Govindan et al. (2015), p. 66.
[21] See Krause et al. (1998), p. 40.
[22] See Dunn and Young (2004), p. 20.

step follows after the supplier evaluation is done, because in the evaluation phase a gap can be discovered.

The four steps which are explained in this chapter will be used as input for the supplier management process of Company X, which is stated in chapter 5.4. Also the portfolio method will be used in chapter 4.3 of this research. Chapter 2.8 will give additional information about supplier development and activities which can be performed.

2.2 The probability of an incident of inbound supply, due by an individual supplier or the supply market, that has a negative impact on the customer demands can be seen as supply risk

Recently the risk of supply chain disruptions is receiving increased attention. The firm's inability to match demand and supply can be seen as an indication of supply chain disruptions.[23] First of all it is reasonable to elaborate the term supply chain as it will be mainly used within this research. According to La Londe and Masters a supply chain is a set of firms that pass materials forward. In a supply chain different independent firms are working together on the manufacturing of a product, so finally the final product will be delivered at the end user in the supply chain. Raw material and component producers, product assemblers, wholesalers, retailers and transportation companies can all be seen as members of a supply chain.[24]

To adequately research the different sources of supplier risk it is important to describe what risk in general is and how it occurs in a supply chain. Therefore, the definition of Harland et al. helps to understand what risk is as they define it as follows "Risk can be broadly defined as a chance of danger, damage, loss, injury or any other undesired consequences."[25] Yates and Stone broke down risk in three essential elements, namely losses, the significance of those losses and the uncertainty associated with those losses.[26] Mitchell contributed on that study and stated that there are two main aspects in the risk concept, these aspects are the probability of loss and the impact of loss to the individual or the organization. Therefore,

[23] See Hendricks and Singhal (2005), p. 35.
[24] See La Londe and Masters (1994), p. 38.
[25] Harland et al. (2003), p. 52.
[26] See Yates and Stone (1992), p. 23.

Mitchell developed a formula to assess the level of risk by multiplying the probability of loss with the significance of the loss for an event. $Risk_{n} = P(loss_{n}) \times L(loss_{n})$.[27]

The last years the total costs in the supply chain has been decreased due to concepts such as just-in-time production, zero inventory and reductions in the number of distribution facilities. This change has also a side effect, which is an increase of the number of risks that occur in the supply chain. In a best possible scenario suppliers plan and manage their tasks in the supply chain accordingly and disruptions never occur. However, in the real world, problems and disruptions do occur.[28]

The problems and disruptions which occur within the supply chain can be described as supply chain risks. The definition of Zsidisin et al. helps to better understand the concept of supply risk, as it is stated as follows "the potential occurrence of an incident associated with inbound supply from individual supplier failures or the supply market, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety".[29] In this definition the two concepts of risk, the probability and the impact of loss, are clearly mentioned.[30] The definition of Manuj and Mentzer on supply risks gives a deeper understanding of the risks which occur due to failures from individual suppliers or the supply market, as it is formulated as follows "Disruptions of supply, inventory, schedules, and technology access; price escalation; quality issues; technology uncertainty; product complexity; frequency of material design changes".[31]

In chapter 1.1 it is mentioned that Company X needs to handle supply risk in the best possible way to achieve customers' demands. Therefore, the definition of supply chain risk by Zsidisin will be used during this research, as this definition also refers to meeting customers' demands. This definition covers therefore, the intention of Company X to set up an effective supply risk management model. Furthermore, the formula of Mitchell will be used in the development part of the model, chapter 5.

[27] See Mitchell (1995), p. 116.
[28] See Lee (2008), p. 99.
[29] Zsidisin (2003), p. 222.
[30] Zsidisin et al. (2004), p. 397.
[31] Manuj and Mentzer (2008a), p. 138.

2.3 Identifying risks, measuring risks and mitigation strategies are the basis of the supply risk management process

With the knowhow why supplier management and supply chain risk are gaining more attention, now the risk management process will be elaborated further in detail. Firms need to respond to those new situations in the supply chain through active management of their suppliers, which includes risk management as well.[32] The risk management process is mostly divided into three or four steps.[33] Kleindorfer and Saad developed a framework for risk management which consists of three main tasks. The first task is to specify the risk sources, then a risk assessment takes place to determine the risk and the last task is to take actions in order to mitigate the risk.[34] Harland et al. and Hallikas et al. are using the following four stages, risk identification, risk assessment, risk management actions and risk monitoring.[35] A framework for supplier risk management of Ritchie and Brindley and Matook et al., consists of five stages.[36]

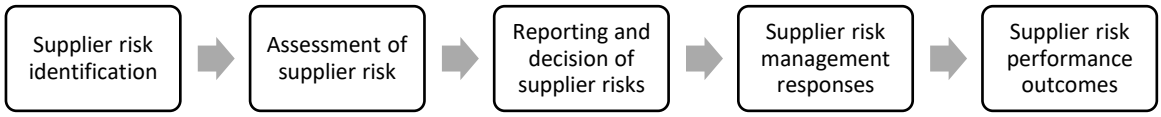

Figure 1. Framework of supplier risk management.
Source: Figure invented by the author. Based on Ritchie and Brindley (2007), p. 308.

Three steps are all coming back in the studies mentioned above, which are risk identification, risk assessment and risk actions/responses. This is also mentioned in the study of Hoffmann, which proposed a risk management system based on the following three elements: (1) selection of relevant risk sources; (2) monitoring through risk indicators; and (3) risk mitigation strategies.[37] Therefore, the three steps of Hoffmann will be leading in this research, as those steps also refer to three sub questions in this thesis.

The first step of supplier risk management is risk identification, by determining the potential risks in the supply chain.[38] A well-known study in risk management is conducted by Hallikas et al. and risk identification is seen as a fundamental phase in the risk management process. According to Hallikas et al. a decision-maker or a group of decision makers become

[32] See Matook et al. (2009), p. 242.
[33] See Lavastre et al. (2012), p. 829-830.
[34] See Kleindorfer and Saad (2005), p. 54.
[35] See Harland et al. (2003), p. 56.; See Hallikas et al. (2004), p. 52.
[36] See Ritchie and Brindley (2007), p. 308; See Matook et al. (2009), p. 246.
[37] See Hoffmann (2011), p. 54-55.
[38] See Tummula and Schoenherr (2011), p. 476.

aware of the events or phenomena which cause uncertainty by identifying the risks in a company. So recognising future uncertainties is the main focus of risk identification, whereas the next steps should be to manage these uncertainties in a proactive way. Risk sources are not the same for every company and therefore, it is necessary that risk sources are identified for a specific company. Risks sources from comparable companies, like companies which are in the same sector, can be used as input, as there could be common risk sources.[39] A procedure of risk identification which can be followed is based on the study of Wu et al. First of all, a set of risk factors is composed, based on the review of supply risk literature. Then a prototype classification system for supplier based risk is prepared and validated in the field with the use of interviews. Finally, the literature review and the industry interviews are the input of the several risk factors, which can be divided in certain risk categories.[40] Because environments and organisations changes, risks should be identified continuously. Risk identification is a continuous process, which should be carried out from time to time to see if current risks are identified.[41]

If certain risks are identified the next step is the assessment of these risks. Therefore, risk measurement factors should be developed for assessing and monitoring the respective risks. These measurement factors make it possible to measure the probability of occurrence of a particular risk. With the use of supply risk assessment tools companies are able to obtain and communicate potential supply risk issues. The assessment of risks helps companies to focus on essential risks and it helps also for the choice of strategies. A tool for risk assessment is created by Hallikas et al. where qualitative analysis of risks is measured in a quantitative way. The probability of an event, in this case an identified risk factor, and the effect of an event are multiplied in this tool and so the level of risk is composed.[42]

The last step of the risk management process is taking actions to mitigate the risk which are determined. This step is according to Manuj and Mentzer important as "By understanding the variety and interconnectedness of supply chain risks, managers can tailor balanced, effective risk-reduction strategies for their companies."[43] There are two types of actions firms can take to respond to supply chain risks. Firms can take actions in advance, so before the

[39] See Hallikas et al. (2004), p. 52.
[40] See Wu et al. (2006), p. 353.
[41] See Tchankova (2002), p. 293.
[42] See Hallikas et al. (2002), p. 53.
[43] Manuj and Mentzer (2008b), p. 193.

disruption has occurred, which can be seen as mitigation tactics. Contingency tactics on the other hand are the actions a firm takes when a certain disruption occurs. Firms can choose multiple tactics at one time and combining tactics can be an appropriate strategy for managing supply risks.[44] The next chapters will elaborate the three steps of the risk management process in further detail.

The three steps of supplier risk management by Hoffmann are coming back in the rest of this research. These steps are the basis of this research, as these steps are answering the sub questions of this research. The risk identification procedure of Wu et al. is used in this research, as the input for the risk sources is based on literature review and findings out of interviews. The interviews are held with employees of Company X, which will be explained in the methodology part chapter 3.2.1, whereas the results will be mentioned in chapter 4.2. Furthermore, figure 2 shows the implementation steps of a risk management model, which is created by Schiele. This model shows possible steps which can help to create a risk management system. A few steps out this model are used during this research. First of all, the core suppliers and essential products within an organisation should be determined. The suppliers on the short list are seen as important suppliers and therefore, those suppliers should be evaluated. This step is also taken in this research, chapter 4.1 and 5.1 are showing the results of the critical suppliers of Company X The next steps include designing a detailed process, selecting risk indicators to measure the level of risk at suppliers and checking for possible software support to do so. Also this step has been taken, as the risk indicators of Company X have been defined in chapter 4.2 and 5.2. If the results of the evaluation of the supplier indicate a certain level of risk, then an on-site audit could be performed. For Company X different actions steps are proposed if there is a certain level of risk measured, which will be explained in chapter 5.4.[45]

[44] See Tomlin (2006), p. 640.
[45] Information retrieved from: PowerPoint Supplier Risk Management, Schiele, 2017, p. 137.

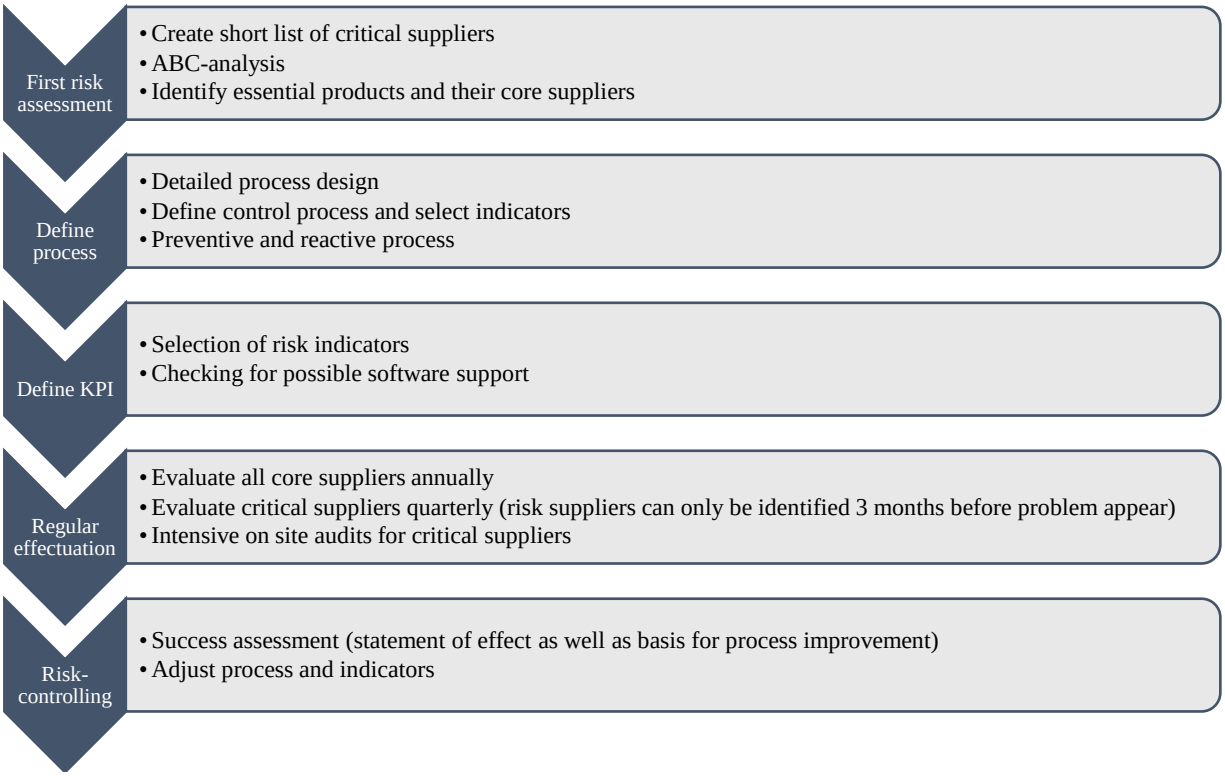

Figure 2. Implementation steps of a risk management system.
Source: Figure invented by the author. Based on PowerPoint Supplier Risk Management, Schiele, 2017, p. 137.

2.4 External risks and internal risks seen as the two main categories of supply risk

The basis of a good working supply risk management process begins with the understanding of what kinds of different risks sources in a supply chain occur. Several studies have been carried out in this field and therefore, information about risks types and sources in a supply chain are available. Supply chain risk is mostly classified in two or three categories. Two mainly seen categories of risks are internal and external risks[46] or operational and disruption risks.[47] Internal or operational risks refer to uncertainties arising from problems of coordinating supply and demand. External or disruptions risks can be considered as natural and man-made disasters such as earthquakes, floods or terrorist attacks. Most of the time the impact of external or disruption risks is much bigger than the impact of internal or operational

[46] See Wu et al. (2006), p. 352; See Trkman and McCormack (2009), p. 249; See Kumar et al. (2010), p. 3718; See Olson and Wu (2011), p. 402.
[47] See Tang (2006), p. 453; See Ravindran et al. (2010), p. 409.

risks.[48] External or disruption risks can affect all the organisations in a supply chain, as an internal or operational risk only affect one or several organisations in a supply chain.[49] Other studies divided risk sources in three categories, namely operational/organisational risk (e.g. process and control risks), network risk (e.g. demand and supply risk) and environmental risk (e.g. natural disasters and war).[50] One of the latest studies about supply risk management made a distinction of risk categories, which can also be subdivided under the internal/operational and external/disruption risks. The model of Hoffmann et al. consists of four risk categories and will be further explained in detail, as this is one of the most comprehensive risk models in the current literature.[51]

The risk categories in the study of Hoffmann et al. are environmental risks, financial risks, operational risks and strategic risks. Environmental risks are exogenous incidents like natural disasters, economic downturns, terrorism or political instability. [52] These kinds of risks are affecting each market player equally and those risks cannot be directly influenced by firms themselves. Therefore, a distinction is made between environmental risks on one side and financial, operational and strategic risks on the other side. In contrast to environmental risks the other three categories of risks affect not an entire market, but only one player. These risks arise within the buyer-supplier relationship.[53]

Financial supply risks appear when a supplier faces liquidity issues or bankruptcy.[54] The financial situation of a firm can determine the long-term relationship with the manufacturer. Financial stability is namely one of the aspects for a long-term relationship between buyer and supplier.[55] A way of determining if the financial situation of a supplier is stable can be done by analysing the supplier's financial structure, with for instance information out of the supplier's balance sheet. Another method is analysing the payment behaviour of a supplier towards their suppliers. [56]

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[48] See Tang (2006), p. 453.
[49] See Olson and Wu (2010), p. 695.
[50] See Jüttner et al. (2003), p. 201-202; See Christopher and Peck (2004), p. 4-5; See Jüttner (2005), p. 122-123; See Lin and Zhou (2011), p. 164-165; See Lockamy III and McCormack (2012), p. 318-320.
[51] See Hoffmann et al. (2013), p. 204.
[52] See Chopra and Sodhi (2004), p. 54; See Schoenherr et al. (2008), p. 105; See Hoffmann et al. (2013), p. 204; See Samvedi et al. (2013), p. 2435.
[53] See Hoffmann et al. (2013), p. 204.
[54] See Tang and Musa (2011), p. 27; See Hoffmann et al. (2013), p. 204
[55] See Chan and Kumar (2007), p. 422.
[56] See Chan and Kumar (2007), p. 422; See Hoffmann et al. (2013), p. 208.

A supplier can also face competence issues and this can be seen as an operational risk. In that case the supplier is willing, but unable to achieve a particular desired performance which is desired by the buyer.[57] Operational risks which are most common seen in literature are quality issues and poor delivery performance.[58]

The last type of risk is a customer-specific risk. A strategic risk occurs when the customer is not attractive enough for the supplier. In that case the supplier is able to achieve the desired performance of the buyer, but is not eager to do so. Those kind of strategic risks are likely to occur, when the customer is not accounted as a preferred customer to the supplier.[59] "When the supplier is more satisfied with particular customers than with others, the former will be awarded preferred customer status and enjoy the associated benefits".[60] Being the preferred customer creates advantages for the buyer, such as getting the best people, machines and ideas from the supplier. So being a preferred customer is beneficial for the buyer, as the supplier offers the buyer preferential resource allocation.[61]

The categories discussed in the study of Hoffmann give firms the ability to select risk sources, risk indicators and risk mitigation strategies based on the four risk sources.[62] For Company X the operational and financial risks are the most important and these risks will also be used in the risk assessment model which has been developed. The environmental and strategic risks are not taken into account in the risk assessment model. In chapter 4.4 and chapter 5 more details are given about why the operational and financial risk categories are taken into account into the risk assessment model and why the environmental and strategic risks are left out.

2.5 Buying firms using measurement tools to monitor risk sources of their suppliers on an ongoing basis

The second step of the risk management process is the risk assessment phase. As the risk sources are identified, companies should determine a way to assess these risk sources in the

[57] See Hoffmann (2011), p. 52.
[58] See Zsidisin (2003), p. 221; See Cucchiella and Gastaldi (2006), p. 706; Blackhurst et al. (2008), p. 149; Kull and Talluri (2008), p. 410; Zsidisin et al. (2008), p. 409.
[59] See Hoffmann et al. (2011), p. 52.
[60] Hüttinger et al. (2012), p. 1194-1195.
[61] See Steinle and Schiele (2008), p. 11.
[62] See Hoffmann (2011), p. 54.

supply chain. Monitoring the risk in a supply chain can provide companies an early warning signal when risk levels are rising. This gives companies the opportunity to react to those rising risk levels by applying their risk mitigation strategies. To monitor the risk sources on an ongoing basis companies should use certain measurement tools.[63]

The study of Hoffmann provides several risk measurement factors which can be used to assess supply risk. The risk measurement factors were retrieved by organising a world-café workshop with several participants from different companies. The result of this workshop was a list of 22 risk measurement factors. With these measurement factors the four risk sources discussed in chapter 2.4 can be monitored, which can help companies by early identifying these risks.[64] Possible measurement factors are nation reports or industry reports (environmental risks), payment behaviour of supplier to their suppliers (financial risks), development of buyer's supplier assessment over time (operational risks) and change in own turnover at supplier (strategic risks).[65] Therefore, this study contributes to the development of an integrated and practically applicable supply risk management model.[66]

A study conducted by Blackhurst et al. created a risk analysis methodology which analyses and monitors supplier risk levels over time in the automotive industry. The risk assessment and monitoring system is based on the analysis of supply chain risk literature and findings out of interviews from automotive manufacturers to identify risks in the supply base. With these findings a framework of risk factors is created and a multi-criteria scoring procedure is developed which calculates supplier risk indices.[67] As mentioned, this risk assessment model focuses on the automotive industry, but could also be applicable in other industries. Other firms which adopt this method should only define risk categories based upon their own needs and industry type. Therefore, the first step in the risk assessment model of Blackhurst et al. is to create categories of risks. This study provides also a great contribution towards predictive risk analysis. The auto manufacturers wanted to change their reactive supply risk management towards a proactive approach. Therefore, the risk ratings must be tracked over time, so trends could be monitored. For example, if a supplier risk level is still on an acceptable level, but the

[63] See Hoffmann (2011), p. 97.
[64] See Hoffmann et al. (2013), p. 203-204.
[65] See Hoffmann et al. (2013), p. 208.
[66] See Hoffmann et al. (2013), p. 207.
[67] See Blackhurst et al. (2008), p. 143.

time-based data shows a trend towards an unacceptable risk level, then proactive risk mitigation strategies could be used, before the real risk occurs.[68]

During the research period at Company X the proposed idea of risk measurement was with the risk categories and measurement factors out of the study of Hoffmann et al. This idea was presented to some employees of Company X and had not the support of them, this will be further explained in chapter 4.4. The study of Blackhurst et al. has a lot of comparability's with this research, as for the development of the risk assessment model for Company X also literature findings as interview findings are used. The study of Blackhurst et al. created a model with multi-criteria scoring method, which is also used in the risk assessment model of Company X In chapter 5 the risk assessment model of Company X is displayed in detail.

2.6 Several risk mitigation strategies used to take, diminish, counteract or eliminate risks

As a certain level of supplier risk is measured the next step should be to response to this risk in an appropriate way. Therefore, several risk strategies are developed in order to take, diminish, counteract or eliminate the risk.[69] These strategies are developed to deal with risk situations in a way so it has a minimal impact on the business.[70] Risk mitigation strategies can be either proactive or reactive. A mitigation strategy which is used when an undesired event occurs can be seen as reactive. Diminishing or eliminating future risk sources can be seen as a proactive mitigation strategy.[71]

A study conducted by Miller distinguishes five generic strategies companies undertake in order to mitigate risk.[72] These mitigation strategies can be adapted in supply chain contexts, which are avoidance, control, co-operation, imitation and flexibility. If risks occur due to problems in a specific market or geographical area a strategy can be to drop specific products, suppliers or geographical markets and to avoid the risks that can occur. Controlling risks can be done by increasing the stockpiling, the use of buffer inventory, vertical integration or excess capacity in production, storage or transport. Another way of risk mitigation is to co-operate with other organisations and create joint agreements, such as sharing risk-related

[68] See Blackhurst et al. (2008), p. 156-158
[69] See Hallikas et al. (2004), p. 52; See Schoenherr et al. (2008), p. 101.
[70] See Norrman and Jansson (2004), p. 437.
[71] See Hoffmann et al. (2013), p. 203.
[72] See Miller (1992), p. 321.

information or preparing supply chain continuity plans. By the imitation strategy a company follows the industry leader, so if the industrial leader discovers a certain level of risk and takes some actions, like changing from supplier or market, other companies can copy these actions. The last risk mitigation strategy focuses on flexibility, where postponement, multiple sourcing and local sourcing are well used examples.[73] Multiple sourcing can help a company to reduce various types of risk, as shortages or natural disasters, due to the fact that the risk is divided over several suppliers.[74]

Also a study conducted by Chopra and Sodhi focuses on supply risk management and several risk mitigation strategies are composed. "Unfortunately, there is no silver-bullet strategy for protecting organizational supply chains. Instead, managers need to know which mitigation strategy works best against a given risk".[75] Table 1 shows mitigation strategies and the effects on risk sources. As table 1 indicates some of the mitigation strategies also have a counter effect on the risk sources. Adding capacity can avoid delays, but on the other side the chance of capacity risks increases.[76]

Mitigation strategy	Disruptions	Delays	Forecast risk	Procurement risk	Receivables risk	Capacity risk	Inventory risk
Add capacity		↓↓		↓		↑↑	↓
Add inventory	↓	↓↓		↓		↓	↑↑
Have redundant suppliers	↓↓			↓		↑	↓
Increase responsiveness		↓↓	↓↓				↓↓
Increase flexibility		↓		↓		↓↓	↓
Aggregate or pool demand			↓↓			↓↓	↓↓
Increase capability		↓					↓
Have more customer accounts					↓		

↑ Increases risk
↑↑ Greatly increases risk
↓ Decreases risk
↓↓ Greatly decreases risk

Table 1. Mitigation strategies.
Source: Table invented by the author, based on Chopra and Sodhi (2004), p. 55.

[73] Jüttner et al. (2003), p. 206-207.
[74] See Namdar et al. (2017), p. 6.
[75] Chopra and Sodhi (2004), p. 55.
[76] See Chopra and Sodhi (2004), p. 55.

In a study conducted by Zsidisin et al. nine companies are examined on the usage of supply risk management models and how to handle certain risks. Looking at the results, the most used risk mitigation strategy is multiple sourcing, especially for strategic parts. The results indicated also other ways to reduce risks in the supply chain, like supplier development, forming alliance relationships, let suppliers develop risk mitigation plans, maintaining common platforms for products and establishing industry standards. Also buffer activities, like holding safety stock, is a well seen mitigation strategy.[77]

Several mitigation strategies have been discussed, which can be helpful for Company X Yet, one of the mitigation strategies will be further explained in the following chapter, which is supplier development. Supplier development is one of the four steps of the developed risk management process of Company X and therefore, additional information of this step will be given.

2.7 Buying firm carries out direct or indirect supplier development activities with the intention to improve supplier's performance or capabilities

As the previous chapter elaborate several risk mitigation strategies, this chapter will dive deeper into one of them, namely supplier development. As mentioned in chapter 2.1 supplier development is a step in the supplier management process of Company X, which will be further explained in chapter 5.4. This chapter will explain what supplier development is and what kind of activities companies can take to improve the performances of suppliers and therefore, decrease the level of risk.

Extended research in the field of supplier development has been conducted, especially by Krause. Therefore, the definitions out of the articles of Krause are used to describe supplier development. So according to the articles of Krause supplier development can be described as all the activities and efforts performed by a buying firm with the intention to improve the performance or capabilities of its suppliers.[78] "Hence, ultimately, the buying firm will reap benefits from its supplier development efforts".[79] Supplier development activities are mostly performed after the supplier evaluation process is completed. The supplier evaluation results provides valuable insights in weaknesses of the supplier, and therefore a good starting point

[77] See Zsidisin et al. (2000), p. 195.
[78] See Krause and Ellram (1997a), p. 21; See Krause (1999), p. 206.
[79] Li et al. (2007), p. 231.

for supplier development activities.[80] Supplier development activities are mainly categorised as direct or indirect[81], as well as internalised or externalised.[82]

By a direct supplier development program, the buying firm plays an active role and makes a transaction-specific investment, like dedicating personnel or capital resources to the supplier. Indirect supplier development programs focusses on encouraging suppliers to make performance improvements with limited resources or no resources at all from the buying firm.[83] An internalised supplier development program is characterised by the direct investments of the buying firm's resources in the supplier. Whereby an externalised supplier development program is characterised by the fact that no direct investments of the buying firm is done. With little involvement the buying firm wants to encourage the suppliers to improve their performances.[84] Besides the mentioned distinctions of supplier development activities, Sánchez-Rodriguez et al. grouped supplier development activities into three sets of practices, namely basic-, moderate- and advanced supplier development. These groups are formed based on the level of firm involvement and implementation complexity, such as skill, time and resources required. Basic supplier development activities require the most limited involvement of the firm and also minimal investments of the firm's resources, and therefore these activities are most likely to be implemented first. The moderate- and advanced supplier development activities are characterised by respectively moderate and high levels of buyer involvement and requires also more resources of the buying firm in the form of personnel, time and capital.[85]

Besides that, supplier development activities can be categorised based on the involvement and investments of the buying firm, there can also a distinction be made in the approach of supplier development. This can be classified as either reactive or strategic. By a reactive approach supplier development activities are carried out after poor supplier performances, for instance when a supplier does not perform according to the requirements. The actions taken are to eliminate existing deficiencies and improve the performance. The strategic approach is more proactive, as it tries to improve supplier performance before problems actually occur.[86]

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[80] See Hahn et al. (1990), p, 5.
[81] See Monczka et al. (1993), p. 50; See Wagner (2006), p. 557.
[82] See Krause et al. (2000), p. 35.
[83] See Monczka et al. (1993), p. 50; See Wagner (2006), p. 557.
[84] See Krause et al. (2000), p. 35-36.
[85] See Sánchez-Rodriguez et al. (2005), p. 290-291.
[86] See Krause et al. (1998), p. 45.

As mentioned before, extended research in the field of supplier development has been conducted and many supplier development activities are mentioned by these researchers. Table 2 shows a list of supplier development activities with a short explanation and a classification if the supplier development activity is direct or indirect. In chapter 5.4 the supplier development activities of Company X are mentioned, which are based on the list below.

Supplier development activity	**Explanation**	**Direct/Indirect**
Competitive pressure[87]	Usage of multiple suppliers for a purchased item in order to create competition among the suppliers	Indirect
Part standardisation[88]	Part standardisation by sourcing from a limited number of suppliers to eliminate differences in the production of similar parts	Indirect
Ad-hoc assessment of supplier[89]	Ad-hoc evaluation of the performances of a supplier with no standard procedure	Indirect
Formal assessment of supplier[90]	Formal evaluation of the performances of a supplier with a standard procedure and guidelines	Indirect
Feedback of evaluation[91]	Communicating the evaluation results as feedback to the supplier	Indirect
Supplier certification programme[92]	A programme which obligate suppliers to get a quality certificate	Indirect
Request to improve performance[93]	Communicating to the supplier that improvement of performance is necessary	Indirect
Supplier awards[94]	Recognising the performance of the supplier in the form of a supplier award	Indirect
Establishing trust[95]	Investing in the buyer-supplier relationship to create a level of trust from the buyer	Indirect
Collaborative communication[96]	Bi-directional, timely and frequent communication between buyer and supplier about objectives, capabilities and needs	Indirect
Promises of benefits[97]	Promising the supplier current or future	Direct

[87] See Krause and Ellram (1997b), p. 48; See Krause et al. (2000), p. 36.
[88] See Handfield et al. (2000), p. 46; See Sánchez-Rodriguez et al. (2005), p. 291.
[89] See Krause and Ellram (1997b), p. 48; See Trent and Monczka (1999), p. 931-932; See Krause et al. (2000), p. 36.
[90] See Krause and Ellram (1997b), p. 48; See Trent and Monczka (1999), p. 931-932; See Krause et al. (2000), p. 36.
[91] See Krause and Ellram (1997b), p. 48; See Krause et al. (2000), p. 36.
[92] See Krause and Ellram (1997b), p. 48; See Trent and Monczka (1999), p. 934.
[93] See Krause and Ellram (1997b), p. 48; See Li et al. (2007), p. 232.
[94] See Krause and Ellram (1997b), p. 48; See Trent and Monczka (1999), p. 933.
[95] See Li et al. (2007), p. 232; See Govindan et al. (2010), p. 56.
[96] See Modi and Mabert (2007), p. 55.
[97] See Krause and Ellram (1997b), p. 48; See Humphreys et al. (2004), p. 133.

	benefits, like higher volume order or future business considerations, as a reward for improvements	
Site visit[98]	Visiting the site of the supplier to help supplier improve its performance	Direct
Inviting supplier's personnel[99]	Inviting the supplier's personnel in order to create more awareness of how their product is used	Direct
Training/education of supplier's personnel[100]	Giving training/education to the supplier's personnel	Direct
Investment in supplier[101]	Investing in the operations, like equipment and tools, of the supplier	Direct
Early Supplier Involvement[102]	Early involvement of suppliers in the product and process design, to receive benefits from supplier's capabilities	Direct

Table 2 – Supplier development activities.
Source: Table invented by the author.

2.8 Risk management important aspect of ISO9001:2015 and IATF-16949:2016 standards

As mentioned before, Company X is certificated according to ISO9001:2015 (Quality management standard), ISO14001:2015 (Environmental management standard) and IATF-16949:2016 (Automotive quality management standard). These certifications are important, because Company X is a supplier of the automotive industry. Customers of Company X wants to get a certain assurance about the delivered quality. The ISO9001:2015 and IATF-16949:2016 standards gives this assurance towards the customers. Risk management is one of the aspects within the ISO9001:2015 and IATF-16949:2016 standards and therefore, this chapter will provide information about the criteria of risk management in the ISO9001:2015 and IATF-16949:2016 standards.

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies.[103] ISO standards are becoming a more important phenomenon, given the quite impressive growth and diffusion of registrations.[104] In 1995 less than 200.000 companies were certificated according to the ISO9001 standard. The amount of certificated

[98] See Krause and Ellram (1997b), p. 48.
[99] See Krause and Ellram (1997b), p. 48.
[100] See Krause and Ellram (1997b), p. 48; See Trent and Monczka (1999), p. 935; See Krause et al. (2000), p. 37.
[101] See Krause and Ellram (1997b), p. 48; See Li et al. (2007), p. 232.
[102] See Trent and Monczka (1999), p. 936-937; See Lin et al. (2005), p. 363.
[103] Information retrieved from: ISO 9001:2015, p. 7.
[104] See Sampaio (2009), p. 38.

companies according to the ISO9001 has risen to more than 1.100.000 in 2010.[105] A literature review by Tarí et al. determined the benefits derived from implementing the ISO9001 standard. Improved efficiency, improved customer satisfaction and improvements in relations with employees are the most frequently seen benefits from the ISO9001 standard.[106]

As mentioned before risk management is an aspect within the ISO9001:2015 and IATF-16949:2016 standards, and according to those standards organisations should plan actions to address risks and opportunities. These actions to address risk and opportunities should be proportionate to the potential impact on the conformity of products and services. According to the ISO9001:2015 standard "Options to address risks can include avoiding risk, taking risk in order to pursue an opportunity, eliminating the risk source, changing the likelihood or consequences, sharing the risk, or retaining risk by informed decision".[107] In the IATF-16949:2016 standard supplier monitoring is an important aspect. Organisations are required to evaluate the performance of their suppliers, as it is stated as follows "The organization shall have a documented process and criteria to evaluate supplier performance in order to ensure conformity of externally provided products, processes, and services to internal and external customer requirement".[108] The IATF developed the Automotive Quality Management System Document (MAQMSR) which can be used by organisations for the purpose of supplier monitoring. This document consists of a number of clauses of the IATF-16949:2016 standard. Organisations can use this document to evaluate and develop the quality management system of sub-tier suppliers in accordance with the IATF-16949:2016 standard. [109] This document is a sort of a summary of the whole IATF-19649 standard. It points out the most important aspects of this IATF-16949 standard, so companies can use this to check whether they apply to these aspects. The goal of this document is as mentioned evaluating and developing the quality standards of suppliers. The IATF-16949 standard will be used in this research during the development process, see chapter 5.2.

[105] See Heras-Saizarbitoria and Boiral (2013), p. 47.
[106] See Tarí et al. (2012), p. 302.
[107] Information retrieved from: ISO 9001:2015, p. 27.
[108] Information retrieved from: International Automotive Task Force (IATF-16949:2016), p. 37.
[109] Information retrieved from: International Automotive Task Force (MAQMSR), p. 1.

2.9 Conclusion

This chapter will give an overview of the most important aspects which are stated in the several chapters above. The most attention will be given to those aspects which will be used at a later stage during this research. The first chapter described that supplier management is becoming more important, because firms have to cooperate with their suppliers to maximise productivity. Four methods of supplier management are explained which are supplier classification, selection, evaluation and development. The focus is one these four methods, as they will be used in the supplier management process of Company X which has been developed and is stated in chapter 5.4.

Chapter 2.2 gives an overview of what risk and especially supply chain risk is. The formula of Mitchell, $Risk_n = P(loss_n) \times L(loss_n)$[110], describes what risk in a general way is and this formula will be used during this research by determining the critical material groups of Company X in chapter 5. The definition of Zsidisin will be used during this research to describe supply chain risk and this definition is as follows: "the potential occurrence of an incident associated with inbound supply from individual supplier failures or the supply market, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety".[111] This definition touches the core of this research, developing a risk evaluation model so Company X can handle supply risk in the best possible way to achieve customers' demands.

The risk management steps which will be followed during this research are based on the literature of Hoffmann and are the following; (1) selection of relevant risk sources; (2) monitoring through risk indicators; and (3) risk mitigation strategies.[112] These steps are comparable with the sub question 2, 3 and 4 which are mentioned in chapter 1.3. The first step, selection of relevant risk sources, is discussed in chapter 2.4. There are two main categories of supply risks, which are external and internal risks. External or disruption risks can affect all the organisations in a supply chain, as an internal or operational risk only affect one or several organisations in a supply chain.[113] The four risk sources of Hoffmann are taken into account during this research. These four risk sources are environmental, operational,

[110] See Mitchell (1995), p. 116.
[111] Zsidisin (2003), p. 222.
[112] See Hoffmann (2011), p. 54-55.
[113] See Olson and Wu (2010), p. 695.

financial and strategic risk. Two of these risk sources, operational and financial risks, are used in the developed risk evaluation model.

If the risk sources are known these sources should be measured. The study of Hoffmann provided, based on the four risk sources, a couple of measurement factors which can be used to assess the level of supply risk of a certain supplier. As mentioned before, only two of the risk sources of this study will be used in the developed risk evaluation model. Also a proposal has been made to measure the level of supply risk of suppliers with the measurement factors. This idea was not supported by the project group of Company X, see chapter 4.4. Therefore, the study of Blackhurst et al. provided a better way of measuring supply risk for Company X In the study of Blackhurst et al. a multi-scoring risk evaluation model has been developed based on literature studies and interview findings. This has also been done during this research, where the risk evaluation model of Company X is stated in chapter 5.

The last step of risk management is selecting risk mitigation strategies in order to react to discovered risks in an appropriate way. Chapter 2.6 have given information about risk mitigation and which strategies could be used. For Company X the strategy of supplier development has been chosen as the risk mitigation action. Supplier development is the last step in the supplier management process of Company X and with this step certain actions should be performed to counter the discovered risk at a supplier. Table 2 in chapter 2.7 gives an overview of the supplier development activities which could be performed. In chapter 5.4 the chosen supplier development activities of Company X are mentioned.

The ISO9001, ISO14001 and the IATF-16949 standards are important for Company X as the organisation is certified according those standards. Information out of these standards have been used during the development of the risk evaluation model of Company X in chapter 5.

3. Methodology: Interviews, business documentation and project- and focus groups key methods for obtaining information

3.1 Methodology of business problem solving followed during this project

The aim of this research is to develop a risk evaluation model for Company X This is typically an example of a business problem-solving project and therefore, the theory of van Aken, Berends and van der Bij, problem solving in organizations, has been followed during this thesis. The theory of business problem-solving focusses on the performance improvement of a business system, department or company on one or more criteria. Most of the time the objective of a business problem-solving project is to make an operational business process more efficient or effective.[114] For this project at Company X the final objective is to develop a new evaluation model to assess the level of risk of suppliers. Therefore, the goal is to increase the efficiency and effectiveness of discovering risks at current, and possibly also new, suppliers of Company X By doing that, it could be possible for the procurement department to take actions towards certain risks which have been discovered at suppliers. This can have a positive effect on the whole organisation, as it can lead to improvements of suppliers' performances.

The theory of business problem-solving typically consists of two parts, on the one hand it is theory-based and on the other hand it is design-focused. Business problem-solving projects are basically following the regulative cycle, see figure 3. This cycle has also been followed during this project. The first step of this cycle is problem definition. This step has been taken at the very beginning of this project and is translated into a research proposal. The aim of this research proposal was to identify the problem and to get an idea of the deliverable solution, whereby a clear structure of the research has been described. As mentioned in chapter 1.3 the deliverable solution should be a scoring model which Company X can use to identify the level of risk of their suppliers. The analysis and diagnosis part of this project consists of the literature study and the field research which has been conducted. The results of those two information sources have been analysed to get a clear view of the problem and the solution

[114] See Van Aken et al. (2007), p 7.

which has to be designed and implemented. The plan of action consisted of a few steps to come to the solution for Company X First of all, based on the analysis of the literature review a number of solutions for a design of supplier risk evaluation model came up. One solution has been chosen, supported by the results of the field research, and specifically designed upon the context of the problem and requirements of Company X Most of the time when the solution design is finished, the project owner has left the company by then.[115] In this case the project owner still worked at the company and could also work on the intervention and evaluation steps. During these steps it became clear that the current procedures of Company X should be adjusted. The current procedures of Company X were adjusted based on the delivered supplier risk evaluation model and new procedures has been made. This will be further explained in chapter 5.4. Also the evaluation part is executed by the project owner, whereas the supplier risk evaluation model is tested on a test group of different suppliers. The aim of the evaluation phase was to test the model and see what still has to be done to improve and realise the full potential of the new model. [116]

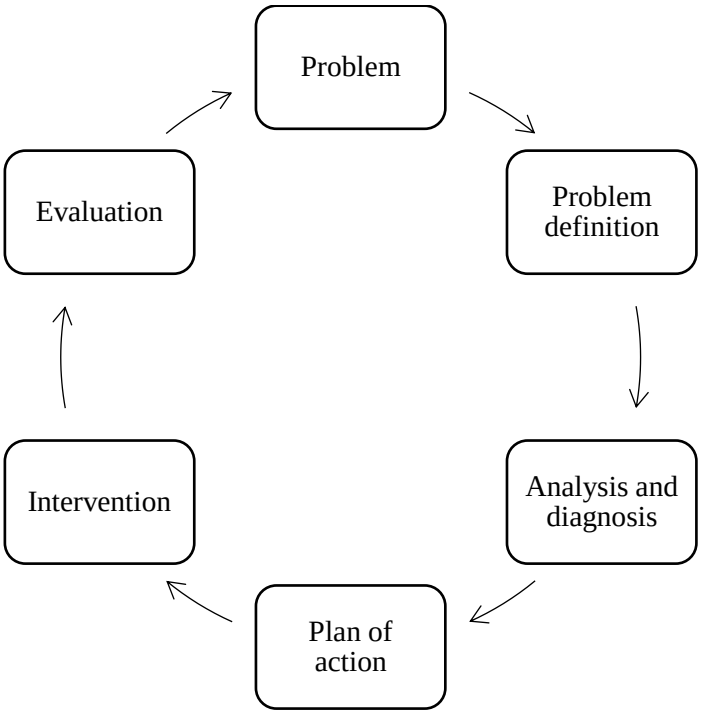

Figure 3. The regulative cycle.
Source: Figure invented by the author. Based on van Aken et al. (2007), p. 13.

[115] See van Aken et al. (2007), p. 14.
[116] See van Aken et al. (2007), p. 13-14.

So to conclude, the business theory of business problem-solving of van Aken et al. has been used during this research. The research proposal with the problem definition was the starting point of this research. Based on literature review and field research findings an action plan has been developed and the best solution for Company X have been chosen. This solution basically consist of two deliverables, which are the risk evaluation model and the risk management process. During the evaluation part the risk evaluation model has been tested and adjustments have been made to improve the model.

3.2 Three different approaches of qualitative research used to gather information about the problem and the possible solution

The research method which has been used during this thesis was qualitative of nature. "Qualitative analysis means making sense of relevant data gathered from sources such as interviews, on-site observations, and documents and then responsibly presenting what the data reveal".[117] In this project three different ways of qualitative research have been conducted. First of all, interviews with employees of Company X and Company Y has been conducted. Secondly, existing documentation of Company X, Company Y and Company Z has been used as a source of information. Thirdly, several focus groups have made a contribution to this research.

3.2.1 Semi-structured interviews based on three segments developed by Galletta[118]

To develop a model which assesses the risk of a certain supplier of Company X, information has been retrieved from interviews with employees of Company X The aim of the interviews was to get information about potential critical suppliers at Company X and what the most common supplier risk sources are according to the employees of Company X Another goal was to retrieve information about evaluation criteria of suppliers and risk mitigation steps. Also an interview have been held with two employees of Company Y. As mentioned in chapter 1.2 Company Y is part of the same business unit as Company X Therefore, the aim of the interview at Company Y was to get information about the supplier risk evaluation method they have in place. Also information of the risk sources, assessment method and mitigation

[117] Caudle (2015), p. 417.
[118] See Galletta (2013), p. 46-52

actions of Company Y can be valuable input for this research, as it maybe could be used at Company X as well.

The interviews which have been held with the employees of Company X and Company Y were semi-structured. With the semi-structured approach, a list of specific questions has been asked, but there was also sufficient room to ask for additional information. The list with questions used during the interviews can be found in Appendix I and II. During the interviews the interviewer had a dual role, as the interviewer aimed at getting clear and unbiased answers to the research question and had to manage the interview. The interviewer has created an open and pleasant atmosphere so the informant could speak freely and provides the right information. First of all the interviewer introduced the project and its background, gave the objectives of the interview and told how the interview would contribute to the project.[119] The interview protocol is based on three segments developed by Galletta. These segments are formulated as the opening segment, middle segment and concluding segment. The structure of these segments are moving from very open-ended questions focused on concrete experiences to more specific and theory-driven questions.[120] Figure 4 shows the three segments and their corresponding values.

1. Opening segment	2. Middle segment	3. Concluding segment
• 1.1 Establish a level of comfort and ensure understanding of participant rights	• 2.1 Attend to nuances in the narrative thus far	• 3.1 Pose questions that may reflect theoretical considerations - offer participant opportunity to explore opening narrative in relation to theory-driven questions
• 1.2 Move into broad questions that create openings for participants to begin to speak from her or his experience	• 2.2 Shift into questions that are more specific as they relate to your research question	• 3.2 Where possible, return to those stories and metaphors in need of further exploration
• 1.3 When necessary, probe for clarification	• 2.3 Loop back, when appropriate, to participant's narrative material as it connects with specific questions	• 3.3 Look for opportunities to explore contradictions
• 1.4 Mentally note meaningful junctures in participant's story to which you'll return later in the interview for greater exploration and depth	• 2.4 Explore further participant's responses noted as meaningful in the opening narrative	• 3.4 Work toward a sense of wrapping up and indicating to participant the interview is nearing completion
• 1.5 Support the flow of the narrative with probes that guide its direction as it relates to your research topic	• 2.5 Extend your probes beyond clarification to meaning making on the part of the participant toward the research topic	• 3.5 Ask participant for additional thoughts or final points
		• 3.6 Thank participant and emphasize his or her contribution to the research

Figure 4. Three segments for the interview protocol.
Source: Figure invented by the author. Based on Galletta (2013), p. 47, 50, 52.

[119] See van Aken et al. (2007), p. 135.
[120] See Galletta (2013), p. 46.

In the opening segment of the interview the goal was to create a level of comfort for the participant, so the participant should speak freely and provides the right information. The purpose of the interview and the research was stated and the participant was asked for permission to audiotape the interview. Furthermore, the questions in this part were broadly defined so the participants would speak according to their own experiences. In the middle segment questions were defined to pursue the topic of this research in more depth with the participant. These questions were much more specific and were more suited in the middle segment, where a certain degree of trust was established. The questions asked in this part were based on the research question and the sub questions, which are stated in chapter 1.3. Question about the following aspects have been asked at Company Y; differentiation of material groups, problems with specific material groups, supplier risk sources, assessment of supplier risk sources and actions to reduce risks. The questions asked to the employees of Company X were in almost in the same trend. Also in this case questions about material groups, problems with specific material groups, problems/risks of suppliers and on what aspects suppliers should be assessed were asked.

In the concluding segment questions were defined which reflects theoretical considerations. In this part there was also space to return to those stories and metaphors which needed further exploration. At the end of the interview the participant was asked for any additional thoughts or final points. Finally, the value of the participant's contribution to the interview was clearly expressed and the participant was thanked for his or her participation.[121]

Table 3 shows the participants of the interviews. The respondents have been chosen based on input and expertise of the procurement manager of Company X

Case	Function	Interview date
1.	Purchasing Manager Company Y Student Company Y (thesis on risk management)	08-12-2017
2.	Technical Planner	14-12-2017
3.	Manager Warehouse	14-12-2017
4.	Quality Manager	19-12-2017
5.	Quality Engineer (OPEX)	20-12-2017
6.	Production Manager	03-01-2018
7.	Team Leader	03-01-2018
8.	Manager Maintenance & Engineering	04-01-2018
9.	Group Leader Maintenance	11-01-2018

Table 3. Interview participants.
Source: Table invented by the author.

[121] See Galletta (2013), p. 46-52.

The employees of Company X will only mentioned the things they know or have experienced. So for the questions about problems with specific material groups, problems/risks of suppliers and on what aspects suppliers should be assessed the employees only answered what they have experienced. For instance, the employees will not mention risk they are not familiar with, but do exist. This is the blind spot of the employees.

The semi-structured interviews have been held to collect information regarding important material groups, risk sources, risk assessment methods and actions which can be taken to reduce risks. As can be seen these subjects are comparable with the research question and sub questions of this research. The goal of the interview at Company Y was to see what kind of risk management method they had in place and to get information about their risk sources, assessment method and risk mitigation actions. The information retrieved from the employees of Company X is a first step in determining which material groups and which risk sources are the most important for Company X The results of the interviews are stated in chapter 4.1, 4.2 and 4.3.

3.2.2 Business documentation used to determine critical material groups of Company X

Besides interviews with the employees, also company documents have been used as source of information. Company documentation can give additional information, which employees have partly or completely forgotten. Another advantage is that company documentation is often a more reliable source compared to the opinion of an employee.[122] By the start of the project a lot of company documentation and specifically procurement documents, like the procurement policy and the procurement procedures, have been read to get a better understanding of the company values and the role of the procurement department within the company. At a later stage during the research the company documentation has been used for two specific purposes.

To distinguish critical suppliers from non-critical suppliers, deviation reports and G8D reports of Company X have been used. A deviation report is made up by an employee of Company X if a quality, logistical or service problem have occurred caused by the supplier. It can be that the quality of the delivered product or services is not good or that the delivery date

[122] See van Aken et al. (2007), p. 136.

has been far exceeded. A G8D report is made up if a deviation have occurred and a quick solution should to be proposed to fix this. These documents are for each supplier individually and digitally saved in a folder. The number of deviation reports and G8D reports are for each supplier mentioned in table 13, appendix IV. This method gives a clear view of the suppliers with the most problems and therefore, can be seen as valuable input for the determination of the critical material groups of Company X One pitfall of this method should be mentioned, as the deviation/G8D reports only will show the deviations which are filled in by the employees. So deviations which are not filled in or passed through, but have taken place, are not taken into account. Also problems which did not yet occur are not taken into account, the so called latent risks are not visible with this method.

Also documented information of Company Y and Company Z has been used to gain insights into this topic. Documentation about the key supplier of Company Y and Company Z was available. For each key supplier the respective material group was mentioned. As Company X is comparable to these two sites, this information can be also valuable for the determination of the critical material groups.

As mentioned before, also the procurement policy and the procurement procedures have been read to gain a good overview of the role of the procurement department. In a later stadium these documents have been used in the intervention step, whereas a new procedure has been developed for the designed supplier risk evaluation model. As mentioned in chapter 3.1 new procedures have to be made based on the developed risk evaluation model. Information of the old procedures was used as basis to develop the new ones.

Both matters of company documentation were very useful and have made a good contribution to this project. The information retrieved from the deviation/G8D reports and the documentation of Company Y and Company Z has been useful for the determination of the critical material groups of Company X In chapter 4.1.2 the results of the both methods for defining the critical material groups are mentioned.

3.2.3 Project- and focus groups plays an important role in the design phase of the project

The first step of this qualitative research was conducting interviews with employees of Company X Those interviews have been conducted with individuals, whereas also interviews

have been conducted with more respondents at the same time. This can be considered as a group method for organisational analysis with so called focus groups. Group methods are a very common way to gather knowledge and to discuss what is going on in an organisational context.[123] Two forms of group methods have been used during the research period.

First of all, a project group was formed with internal stakeholders of the project. Project groups are according to Steyaert and Bouwen "created explicitly as an intervention device to decide upon and implement the intended changes".[124] With this idea in mind the project group was composed and the group consisted of the following persons:

- Project owner (author);
- Manager procurement;
- Director finance and control;
- Manager metal procurement;
- Manager quality assurance

The procurement manager and the metal procurement manager were part of this group, because of the knowledge and expertise in procurement processes. Also the deliverable solution will be for the procurement department and therefore, it is important that the manager of this department could give feedback on the solution. The solution should fit in the perspective of the procurement department and the procurement manager is the right person to judge this. Thereby, it could be possible that the solution is also useful for the metal procurement department. The manager quality assurance has received a lot of knowledge and expertise in the field of supplier evaluation and supplier development. This person is also responsible for the audit process of the IATF-16949 and knows exactly of what aspects the supplier risk evaluation model should consist based on this standard. In the organisation structure the director finance and control is the responsible person for the procurement department, therefore this person was also part of this project group.

Frequently meetings have been scheduled with this project group to discuss the progress of the project. Those meetings mostly started with a presentation of the project owner to show the latest results and the progress of the project. After the presentation a discussion was started so everybody could give their opinion about the current situation and how to go on. This

[123] See Steyaert and Bouwen (2004), p. 140.
[124] Steyaert and Bouwen (2004), p. 142.

provided the project owner with feedback and directions which way to go with the project. The project owner did take notes during these meetings and these notes were turned into action points.

Also different focus groups have been formed and meetings with these focus groups have been held. Focus groups are often used to simply and quickly gather information from several people simultaneously. Another advantage of focus groups is that not only the researcher is asking the questions, but that the respondents are also encouraged to talk to each other, asking questions and commenting on the experiences and points of view of the other respondents.[125] These focus groups have made a contribution in the design part of this research. The developed risk evaluation model measures the performance of a supplier based on five subjects, which are quality, logistics, financial, knowhow and environment & safety. The scores on each of these subjects are evaluated based on the developed norm for the respective subject. For Company X seven critical material groups have been defined and for each of these groups different norms have been established. This norm has been established based on the input of the participants in the different focus groups. For each critical material group, respondents have been invited for a meeting. These respondents could be seen as experts in the particular material group, as they are working with the products/services the suppliers are delivering and should have the most knowhow of it within the company. Therefore, the goal of these meetings was to gather information of several people simultaneously about the most important aspects of the products in the particular material group and the core values those particular suppliers should have. The respondents have been informed in advance about the purpose of the meeting and what their contribution towards the project would be. These meetings were semi-structured, as there was a certain guideline, but there was also room for additional information. The guideline consisted of the five subjects (quality, logistics, financial, knowhow and environment & safety) of the supplier risk evaluation model. The respondents were asked to give their opinion about how important each of these subjects are for their particular material group.

So two types of groups have made a contribution towards this research. First of all, the project group have provided the project owner with valuable feedback on the research. The information of the focus groups have made a contribution to the risk evaluation model, as it is

[125] See Kitzinger (1995), p. 299.

possible to evaluate the supplier's score with the requested norm. Chapter 5.3 provides more information about these norms and how this works in practice.

3.3 Interviews recorded, transcribed and analysed with the framework analysis approach

After all the qualitative data was collected, it needed to be analysed. First off all, the information of the interviews has been analysed. All the interviews have been recorded and afterwards transcribed. The denaturalised transcription method has been used, so details of the interviewee like stuttering, whispers or pauses were not mentioned in the transcription. Denaturalised transcription focuses on the informational content of the interview, whereas naturalised transcription focuses more on intricacies of the spoken language.[126] When the transcripts of the interviews were finished the framework analysis approach was used to analyse the data of the interviews.[127] With this approach a chart has been created with two types of headings. On the horizontal axes the case numbers of the participants were shown and on the vertical axes the main questions of the interviews were mentioned. For each participant the answer(s) on the question were mentioned in the chart. So in a quick overview the answers of all the respondents to each question were easily available. Behind each answer a number has been placed, which refers to the line of the interview transcript, so the quote of the participant was easily retrievable.

The conversations during the group meetings have not been recorded and therefore, also not transcribed. The main reason was lack of time, as transcribing interviews or group meetings is very time consuming. During the meetings with the project group notes were taken and these notes were later on turned in to action points for the project owner. Notes were also taken during the meetings with the focus groups. These notes were translated into a document and send to the respondents of the focus groups, so the respondents could check if the information they provided was translated correctly. If not the respondents were asked to give their comments, so the project owner could change this in the documents.

[126] See Oliver et al. (2005), p. 3-4.
[127] See Lacey and Luff (2001), p. 13.

3.4 Research phase evaluated with the following criteria: controllability, reliability, validity and recognition of results

In a production company one of the central goals is to meet the quality criteria for the goods produced. These quality criteria could be the width, strength or thickness of the product. Quality criteria are also important for business problem-solving projects, as these projects could also be evaluated on several criteria. Criteria business problem-solving projects are mostly evaluated on are research-oriented criteria.[128] The research phase of this project have been evaluated on the criteria controllability, reliability, validity and recognition of results.

Van Aken et al. describes controllability as "a prerequisite for the evaluation of validity and reliability".[129] The results of the research should be controllable and therefore, researchers should reveal the way how the study is executed. This chapter has revealed the way how this research was conducted, by revealing which data collection methods were used, what questions were asked and how the data was analysed. So the descriptions about the methodology gives other researchers the possibility to replicate this research and it is possible to check if this will lead to the same outcomes.[130]

The second quality criterion is reliability, which is the overall consistency of a measure. Something is unreliable if you cannot depend on it, like a car that occasionally fails to start or a person who does not keep it promises. Van Aken et al. describes four potential sources of biases, which are the researcher, the instrument, the respondents and the situation. Those four sources can harm the reliability of the research. The researcher can have a huge impact on the reliability of the research results. According to Goldman the biases of a researcher can be hot or cold. The influence of the interest, motivations and emotions of a researcher towards the research results are hot biases. In some cases, researchers want to please some parties in an organisation and shape their conclusions to do so. The researcher of this research was completely new at Company X and therefore, no relationship existed with employees of Company X So the researcher had no intention to handle in such a way to please any party based on interest, emotions or motivations. Cold biases are the subjective influences of the researcher and are cognitive of origin. An example of a cold bias is that researchers pays more attention to evidence which confirms their beliefs than to the evidence which do not confirm

[128] See van Aken et al. (2007), p. 155.
[129] Van Aken et al. (2007), p. 157.
[130] See van Aken et al. (2007), p. 157.

their beliefs. It is difficult to counteract this bias, but a few options to decrease the chance of this bias were used in this research. Standardisation of data collection was used so the researcher had at least a sort of fixed way to conduct the interviews. Also multiple sources of evidence were used, so if evidence was found in multiple sources it is logical that the researcher focuses on those results.[131] The multiple sources of evidence increase the reliability, as using only one research instrument can yield unreliable results. This approach is called triangulation and have a positive influence on biases, as the used instruments are completing and correcting each other. Also in this research multiple sources of evidence are used, like literature findings, interviews, focus groups and business documents.[132] Also respondents can cause biases, as the question arise if the chosen respondent will provide the same answers as another respondent. At this research different respondents where used in the interview phase as well as in the phase with the focus groups. The respondents participating in the interviews were chosen based on their function. In this phase it was important to get a good overview of the perspective of this research topic within the whole company. Therefore, participants were chosen wide across the company, from different departments. At a later stadium, the phase with the focus groups, the participants were chosen based on their knowhow about a specific topic and the participants were mostly of the same department. It should be also taken into account that the respondents only can answer questions based on their knowhow. So for instance, by the questions about the risk sources of suppliers a respondent only mentions those risk sources he or she knows or have experienced.[133] The last source of unreliability focus on the circumstances of the research. Different research circumstances can lead to different research results. The researcher tried to create the same circumstances for all the interviews. The interviews were always held at the office of the interviewee where no one else was around, so the interviewee would speak freely. Furthermore, the setup of the meetings with the several focus groups were also the same. As the meetings were always in the same conference room, with the same structure and presentation. In this way the researcher tried create the same circumstances within all the research methods.[134]

[131] See Goldman (1999), p. 230.
[132] See van Aken et al. (2007), p. 160.
[133] See van Aken et al. (2007), p. 161.
[134] See van Aken et al. (2007), p. 162.

The third criterion to evaluate the research results is validity. “Validity refers to the relationship between a research result or conclusion and the way it has been generated”.[135] One way of checking this relationship is done by checking if the measuring instrument also measures what was intended, the so called construct validity. In one case, within this research a measurement instrument did not completely cover all the intended concepts and therefore, additional measurement instruments were used. This was the case by determining the critical material groups of Company X With the results out of the interviews with the employees of Company X this question could not be answered. Therefore, additional research has been carried out by making use of business documentation of Company X, as mentioned in chapter 3.2.2.

The last quality criterion is very important in applied research, the recognition of results. This refers to the level of agreement of the problem owners towards the research results. So do the members of Company X recognise the outcomes of the research. This has been checked multiple times during this research. First of all, several times during the research meetings were planned with the project group to present and discuss the results so far. Also at the end of the research a meeting was planned with the project group to present and discuss the final results with the members. According to van Aken et al. this approach increases the chance that the members of an organisation recognise the results.[136]

3.5 Conclusion

This chapter will provide an overall conclusion of the methodology part of this research. In chronological order the steps taken during the research phase will be repeated. During this research the theory of business problem-solving has been followed. After the problem definition and the research questions were formulated, a literature study have been conducted, see chapter 2. The first field research was conducted shortly after, which were the interviews with employees of Company X and Company Y. The aim of these semi-structured interviews was to get information about the most important material groups and the most common risk sources at Company X, ways to assess supplier risks and actions to take if certain risks are discovered. With these interviews a lot of usable information have been retrieved. Yet, two

[135] Van Aken et al. (2007), p. 163.
[136] See van Aken et al. (2007), p. 167.

additional research methods have been used to get an answer on the question what the most important material groups of Company X are. This has been done, because this question could not be answered with only the results of the interviews. Business documentation, in the form of deviation/G8D reports and documentation of Company Y and Company Z have been analysed to get an answer on this question.

After the interviews results were analysed a meeting with the project group was scheduled. During this meeting the first results were presented and a solution proposal, a supplier risk evaluation model, has been pitched. The project group has provided the project owner during these frequent meetings with valuable feedback and directions for the project. This will be discussed more in detail in chapter 4.4.

Also focus groups were formed during this research. These focus groups have made a contribution to the solution of this project. Their information have been used as input for the established norm of the risk evaluation model.

4. Results: Business documentation and insights of employees of Company X useful for determination of critical material groups and risk sources

4.1 Three research approaches conducted to determine critical suppliers at Company X

4.1.1 Results of the interviews with employees of Company X shows a broad view of critical suppliers

To determine which suppliers should be evaluated with the supplier risk model, interviews with different employees of Company X have been held to gain insight into which materials are the most important for the production process of Company X As mentioned in chapter 3.2.1 the semi-structured interviews were held with 9 employees of Company X One aspect within these interviews was about the material groups of Company X The interviewee was asked which of the material groups causes the most problems and were the most important for Company X With this approach the project owner tried to discover which of the 38 material groups of Company X are the most important and the most critical. The results of those interviews are presented in table 4 and will be explained more in detail later on. Table 12, which can be found in Appendix III, shows the material groups of Company X

Case	Important material groups	Explanation/Quotes
2. Interviewee: Technical planner	• All materials are kind of important • Spare parts • Special made materials	• Hard to say which material group is more problematic • Spare part not available, no maintenance • Special made materials more critical than normal materials
3. Interviewee: Manager warehouse	• Hard to make a distinction • Spare parts	• Cannot really make a distinction in which material group is more important • Spare part important for possible shutdown of machines • Spare part more important than for instance a roll of tape
4. Interviewee: Quality manager	• Measurement equipment • Materials which are in direct contact with the final product	• Measuring quality of final product and there is a problem with the equipment than this problem gets through to the customer • Anything that is in direct contact with the material is an issue for me
5. Interviewee:	• Materials which are in direct contact with the final product	• If material comes into contact with final product, there is a possibility

Quality engineer (OPEX)	• Chemicals, measurement equipment, packaging, it-service, machine parts, chemicals lab, lubricant and oils, • Transport (to customers) • Materials that are dependent for the production process	that it affects the workability at the customer • Material groups I mentioned are in my opinion important • Currently a big problem is damage of the final product due to transport • A critical supplier delivers something that is dependent for the production process, so the customer will get good material on the right time.
6. Interviewee: Production manager	• Safety, casting, chemicals lab, machine parts, lifting equipment, bearings, flange and fittings, data communication, measurement, packaging, chemicals • External companies and hired staff • Materials for continuity of production	• Material groups I mentioned are in my opinion important for the production • Companies which support us with activities or staff which we hire are also important • A critical supplier is someone who delivers materials or auxiliary materials which are needed for the continuous production process
7. Interviewee: Team leader	• Packaging • Materials which are in direct contact with the final product	• Packaging is for me important, otherwise I cannot produce • Important material if it is in direct contact with the final product, like pallets
8. Interviewee: Manager maintenance & engineering	• Special made materials • Hired staff • ABC-analysis and availability	• Parts which are specially made for us based on our drawings, these materials must be of good quality • Specialised staff members which you hire to do maintenance activities are very important, otherwise machines cannot be repaired • ABC-analysis interesting in commercial point of view and availability of materials for production process
9. Interviewee: Group leader maintenance	• Spare parts and materials which are machine related • Special made materials	• Those materials I mentioned are in my opinion important, so the materials to run the machines • Biggest problems with the materials which are specially made for us

Table 4. Results of important material groups.
Source: Table invented by the author.

The results on the question which of the 38 material groups are the most important for Company X are very broad. Based on the results it is difficult to pick out some of the material groups. Yet, the results give an insight in some important aspects. As several employees mentioned that special made materials are more important or more problematic than normal materials. Special made materials can be described as materials which are specially made for the production process of Company X and therefore, not available at other suppliers. These

special made products are based on drawings which Company X provides to the supplier. Also three employees mentioned that materials which are directly in contact with the final product are important, because this can affect the final product in a negative way, which can lead to insufficient products or customer complains. Materials such as oils, rolls or pallets and boxes are in direct contact with the final product and if these materials have insufficiencies it could harm the final product. Another result out of the interview is that hired staff and transport (in this case the transport of the final product towards the customers) are also mentioned as an important material group. Two respondents mentioned that hired staff that do maintenance activities or support Company X in another way are important as they are important in case machines have to be repaired. A decent level of knowhow to provide these services in the right way is necessary. Therefore, not only materials suppliers, but also suppliers who provide services at Company X can be seen as a possible supplier group to evaluate.

4.1.2 Additional research into material groups provides new insights

As the interviews with the employees of Company X give a broad overview of the important material groups, additional research has been carried out. First of all, a list has been drawn up with suppliers and the number of deviation and G8D reports per supplier. A deviation report is made up if a supplier delivers materials with quality problems, delivers materials too late or provides a bad service. A G8D report is made up if a deviation have occurred and a quick solution should to be proposed to fix this. From this perspective an analysis is carried out to see which suppliers are performing bad based on the deviation reports. The list of the suppliers and the number of deviation/G8D reports can be found in Appendix IV, table 7. Further analysis is done based on the findings of the suppliers with deviation reports. For each supplier with a deviation report, it was examined in which material group they belong. A list has been drawn up with the material groups of Company X and the number of deviations of each group, based on the findings above. The list of material groups and the number of deviations can be found in Appendix V, table 14.

An analysis was performed based on the results of the two lists. There where ten suppliers with three or more deviation reports. Three of these suppliers are delivering packaging materials at Company X, whereas two packaging suppliers are even the number one and two of the list. Another specific outcome is that two of these suppliers are delivering rolls at

Company X The other five suppliers in the top ten of the list are delivering broader materials, such as spare parts for machines. Also mechanical service providers are part of the top ten. The material group with the most deviations is the group machine and spare parts, followed by mechanical services and machine parts. The material groups rolls and packaging are respectively number four and five. This analysis provides additional insights in the problems there are with different suppliers and also shows which material groups are problematic. Two comments should be made for this analysis, as it is known that the employees of Company X are not fully consistent in filling in the deviation reports. Secondly, some of the material groups of Company X are broadly defined. Especially the group machine and spare parts, so based on this analysis it is hard to say which product or material is really critical in that particular group.

Besides the analysis based on the deviations of the suppliers and the material groups, also an analysis of the material groups of Company Y and Company Z has been performed. As mentioned in chapter 1.2 these two sites are part of the same business unit where Company X is also part of. Documents of both sites were available which contained information about their key suppliers and in which material group these suppliers belongs to. Table 15 in Appendix VI shows the material groups where the key suppliers of Company Y and Company Z are fitting in. After each material group of Company Y and Company Z the respective material group of Company X is mentioned. Packaging and rolls suppliers are seen as key suppliers by Company Y and Company Z, whereas these suppliers of these material groups are also scoring high regarding deviation reports at Company X So the findings out of the documents of Company Y and Company Z give additional insights in their opinion towards key suppliers and important material groups. This can be helpful in the definition of critical material groups of Company X, as the three production sites are comparable to each other.

4.2 Quality and delivery performance main risk sources at Company X

As mentioned in chapter 3.2.1 question about risk sources at Company X have been asked during the interviews with the employees. Even as questions on what aspects suppliers should be evaluated and which actions should be taken if a certain risk is determined at a supplier. The results of those interviews are presented in table 5.

Case	Supplier risk sources/problems	Aspects to evaluated supplier	Actions to take

2. Interviewee: Technical planner	• Supplier who delivers to late • Delivery reliability	• Delivery reliability • Quality	• Ordering earlier • Procurement department should 'talk' with the supplier • No improvements than a fine for the supplier or phase-out supplier
3. Interviewee: Manager warehouse	• Dependency on the supplier • Problems with delivery from abroad • No inspection of incoming goods, so quality of materials cannot be checked	• Delivery performance • Quality • Service	
4. Interviewee: Quality manager	• Quality issues, due to supplier change • Transport damage	• Is supplier ISO 9001 certificated • Delivery performance • Does supplier has a contingency plan	• Inspection of production process of supplier • Inspection of incoming goods
5. Interviewee: Quality engineer (OPEX)	• Transport damage • Bad packaging materials	• Process change at supplier • Does supplier hold stock for calamities • Does supplier have disaster plans • Financial situation of supplier	• Inform supplier if there is a problem • Try to get rid of critical suppliers
6. Interviewee: Production manager	• Bad packaging materials	• Quality • If supplier can always deliver	• Partnership with supplier, frequently talking with each other to know what problems there are and how to solve them
7. Interviewee: Team leader	• Bad quality • Wrong measurements of materials • Materials too late • Bad packaging	• Quality • Materials conform measurements	
8. Interviewee: Manager maintenance & engineering	• Wrong material • Bad quality • Problems with materials on stock	• Returning problems • If supplier is not ISO 9001 certificated, than supplier should measure the special made parts and document it	• Improvement process with supplier • Problems with non-critical suppliers, try to find new suppliers • Meetings with suppliers
9.	• Delivery reliability	• Delivery reliability	• Educate supplier

Interviewee: Group leader maintenance	• Quality • Supplier does not think along for new products	• Quality	• Change supplier

Table 5. Results of supplier risk sources/problems, aspects to evaluate supplier and actions to take.
Source: Table invented by the author.

The results of the supplier risk sources/problems show that most of the respondents have mentioned that delivery performance and quality are the main supplier risk sources/problems which occur at Company X Delivery performance and quality are then also the most mentioned aspects where a supplier should be evaluated on. The respondents were also asked which actions should be taken if a supplier scores a bad result on the supplier evaluation. Several respondents have mentioned that the purchasing department should talk with the supplier to let them know there are problems and to make plans to fix these problems. One footnote should be mentioned by these results, as the employees have only given the answers based on their knowhow and experience. This has already been mentioned in chapter 3.2.1, as the so called blind spots of the employees.

As these results are checked with the findings out of the literature it can be concluded that from the four risk sources of the study from Hoffmann, the environmental, operational, financial and strategic risk sources, only two of these risk sources are mentioned by employees of Company X Namely, the operational and financial risk sources are only mentioned by the employees of Company X Note have to be made that the employees cannot be aware of the environmental and strategic risks. Also quality or delivery problems can be the results of the strategic risk source, as it could be that the supplier does not see a company as a very important buyer and therefore, does not use their best resources for it. Yet, it can be concluded that mostly operational and financial risks are seen as the most important aspect to focus on based on these interviews.

4.3 Portfolio approach the tool to measure supplier risk at Company Y

As mentioned before an interview with the purchasing manager of Company Y and a graduation student was held to gain insight into their risk management process. Company Y falls just like Company X under the business line FRP. The risk management process of Company Y consists of a category portfolio, which is based on the literature of Wildemann. This method looks like the method of Kraljic which have been discussed in chapter 2.1. This

category portfolio consists of two axes and four quadrants. The material groups of Company Y are scoring points on both axes and are then placed in one of the four quadrants based on the final score. The vertical axes rate the material groups based on the value. With an ABC-analysis, points are awarded to the material group. The horizontal axes rate the supply risk of the material group. The final score of supply risk is based on five criteria namely, market form/supplier structure, cost of supplier change, exit barriers at the supplier, preference structure/substitutability, complexity of the product. A score from one to ten should be given to the five criteria, also the five criteria have different weights, because some criteria have a bigger impact on the level of risk.

The four quadrants are uncritical material (low value, low supply risk), bottleneck material (low value, high supply risk), leverage material (high value, low supply risk), key material (high value, high supply risk). In this way Company Y knows which material groups are critical and needs more attention than other groups. For each quadrant some strategic points are formulated, which can be seen as recommendations how to deal with the material group in that specific quadrant.

The project owner has afterwards made a draft version of this model for Company X The results of the interview at Company Y and the draft version have been discussed with the procurement manager of Company X The decision has been made to do not go further with this model, as it only gives a certain strategy to use for a material group. The goal of this project is to evaluate not only a material group, but an individual supplier.

4.4 Presentation with internal stakeholders led to different approach of risk evaluation of suppliers

Halfway through the research project a presentation has been given to the project group. The goal of this presentation was to show the research results from the literature review, Company Y.

The project group was satisfied and positive about the findings of the risk management process and how it should be managed. Especially the part of continuous selecting relevant risk sources, measuring the level of risk with indicators and taking actions with mitigation strategies in order to take, diminish, counteract or eliminate the risk. Also the risk sources which have been mentioned by the employees of Company X were recognisable by the project

group members. Particularly the operational and financial risk sources. On the other hand, the project group did not see the relevance in the environmental risk source, which according to the project group is less relevant for Company X, as the most of the suppliers are located in the Netherlands or Western Europe. Afterwards additional research about the location of the suppliers has been performed. Table 6 shows the countries where suppliers of Company X are located. The results show that more than 75% of the suppliers are located in the Netherlands and even more than 90% of the suppliers are located in the Netherlands or Germany.

Country	Number of suppliers
Austria	3
Belgium	15
Czech Republic	2
Denmark	1
Germany	121
England – United Kingdom	4
Finland	2
France	3
Italy	3
Netherlands	598
Spain	2
Sweden	34
Switzerland	1
Turkey	1
United States	6

Table 6. Geographical location of suppliers of Company X
Source: Table invented by the author. Based on information of Company X

Besides the discussed risk sources from the literature, the project group also mentioned other subjects which are important within Company X and therefore, these subjects could possibly be taken into account in the supplier risk model. These subjects are the knowhow of a supplier and the environment and safety standards of a supplier. Within Company X environment and safety policies and standards are important. Company X is certified according to the environmental management system ISO14001 and safety is one of the key aspects at the plant.

During the presentation a first draft of the risk evaluation model has been presented to the project group. This draft version was an excel file with four risk categories, namely environmental risk, financial risk, operational risk and strategic risk. For each of the four risk categories different indicators were defined to measure the level of risk of the supplier. The indicators were based on the study of Hoffmann. The idea of this risk model was that an

employee of the procurement department should score the indicators of the four risk categories. For each indicator a score should be composed and based on the scores of all the indicators a supplier should be evaluated. This draft version was not completely what the project group was looking for. One of the major disadvantages of the draft version, according to the project group, was that it would take too much time to evaluate a supplier. The purchasing department only consists of three employees and therefore, this draft version would not fit in the perspective of risk evaluation of the procurement department.

Based on this presentation and the feedback, another approach to evaluate the suppliers was proposed, which was a self-assessment model. A self-assessment should take less time from the employees of the procurement department, as the suppliers score themselves according to a couple of subjects. During the discussion about the proposed idea of the self-assessment there were a few aspects mentioned which should be taken into consideration during the development of the self-assessment model. The model should consist of mostly closed questions, which could be answered with rating criteria. In this way the evaluation of the supplier should be easier and takes less time, because it should be possible to automatically calculate a score. Another aspect was that the self-assessment model should be developed with no costs attached. The restrictions to the research were not quite clear at the start of this thesis, but have been added in chapter 1.3 as restrictions towards the research.

After the first presentation the feedback and criteria of Company X have been followed up. In the period after the first presentation the development of the self-assessment model has been carried out. During this period more presentations and meetings with the project group have been held. Chapter 5 will give information about the developed risk evaluation model and how this works in practice.

4.5 Conclusion

With the interview results and the results of the business documentation a good overview have been created of the most important material groups and the material groups with the most deviations. Based on these results a list of critical material groups will be developed, which is stated in the next chapter. The most mentioned risk sources by the employees of Company X are quality and logistic risk sources. These sources are falling under the category operational risk in the model of Hoffmann. Furthermore, the environmental risk source has been excluded

from the model, as has been mentioned in chapter 4.4 that most of the suppliers of Company X are located in the Netherlands or nearby. Therefore, the decision has been made to exclude this risk source in the risk evaluation model.

The interview at Company Y has provided some information about their way of risk management. This have been worked out and discussed at Company X, but eventually the decision have been made that their method does not fit the purpose of this research and the expected outcome of it.

A draft version of a risk evaluation model, based on the study of Hoffmann, has been presented to the project group. Based on the comments and the restrictions given during this presentation, a different approach has been chosen. After this presentation a start with the development of the self-assessment model have been made. Chapter 5 will explain how this model has been developed and how it works.

5. Model: Self-assessment model developed to assess the level of risk of suppliers in different critical material groups

5.1 Critical material groups based on Mitchell's formula: the probability and impact of loss

The first step within this research is to determine what the critical non-metal components at Company X are. This has to be done, because it is not possible to assess all the suppliers of Company X with the risk model. This will be too time consuming and also not all suppliers are even important for Company X So a distinction should be made between critical and non-critical suppliers. Therefore, a list of critical material groups has been drawn up, see table 7. Where these material groups are considered as critical and therefore, the suppliers in these groups are seen as critical suppliers and will possibly be assessed with the supplier risk model. In the row 'Critical because:' the reason why the material group is critical is mentioned. This is based on the results, stated in chapter 4.1.

Critical material groups Company X		
Material group	**Sub-material group**	**Critical because:**
Packaging	Pallets and cases	• High amount of deviations • Key supplier Company Y/Z • Direct contact with final product
	Tubes	
Machines and spare parts	Knives and cutting blades	• High amount of deviations • Key supplier Company Y/Z • Direct contact with final product
Rolls		• High amount of deviations • Key supplier of Company Y/Z • Direct contact with final product
Casting		• Key supplier of Company Y/Z • Direct contact with final product
Lubricant and oils		• Key supplier Company Y/Z

		• Direct contact with final product
Mechanical services		• High amount of deviations • Mentioned several times during interviews

Table 7. Critical material groups Company X
Source: Table invented by the author.

This list has been drawn up based on the three different research approaches which have been conducted, which are the interviews with the employees of Company X, the deviation reports of Company X and the business documentation of Company Y and Company Z. Chapter 3.2 have described the methods of these three approaches and in chapter 4.1 the results have been discussed. The formula out of the study of Mitchell, chapter 2.2, has been used as a basis to determine the level of risk of each material group. The level of risk is according to Mitchell the probability of loss multiplied with the significance of loss.[137] With this definition in mind the empirical research findings have been analysed. As mentioned in chapter 4.1, it was difficult to select the critical material groups based on the interviews with the employees of Company X, due to the broad answers which have been given. Therefore, additional research, deviation reports of Company X and business documentation of Company Y and Company Z, has taken place and the analysis of the research findings of the deviations reports have given new insights in the material groups of Company X These findings of the deviation reports of the suppliers and the deviation reports of each material group can be considered as the probability of loss. These research findings give a good overview of the probability of a quality, logistical or service problem of each material group. So the first step of the formula of Mitchell is filled in based on the findings in the deviations reports.

The current definition of a supplier who is seen as critical by Company X is as follows: "The product of the supplier comes into contact with the (finished) product of Company X". Direct contact means in this case that a component, material or substance directly in contact is with the final product which has been produced. For instance a pallet where the final product is placed on, oil which is being sprayed onto the final product or a roll with which the final product is rolled. From this definition it can be considered that the significance of loss is the impact of bad quality products delivered by suppliers, which can cause problems on (finished)

[137] See Mitchell (1995), p. 116.

products of Company X This is the second step in the formula of Mitchell and therefore, this definition will still be used. Also three employees of Company X have mentioned that in their opinion critical materials are the ones with are directly in contact with the final product, see chapter 4.1. So the defined material groups consist of suppliers who are delivering products which are in contact with the (finished) product of Company X

A spend analysis have not been conducted as method to define which are the most critical material groups, as this only give information about the amount purchased. This method is used at Company Y, as can be seen in chapter 4.3. The purpose of this research is to develop a risk model which evaluates the suppliers on the availability and quality of the products and services they deliver. This with the goal of ensuring maximum production output as have been mentioned in chapter 1.3.

With Mitchell's formula and the research findings a way to define the critical material groups of Company X have been established. So the critical material groups are the ones that are causing the most problems and also can do the most damage to the finished product of Company X Based on this definition the critical material groups for Company X has been drawn up, as can be seen in table 7.

As can be seen in table 7 there are seven critical material groups defined. For the material group packaging two sub-material groups are established. This has been done, because out of the interviews it appears that there are quite some differences between pallets and cases and tubes. Also a sub-group, knives and cutting blades, is made up under the material group machines and spare parts. The material group machines and spare parts is rather large and out of this group knives and cutter blades are the ones that are directly in contact with the (finished) product of Company X Chapter 5.3 will go further in detail about the need for these different critical material groups.

5.2 Self-assessment model established to assess the level of risk of suppliers on five different subjects

The goal of this research is to create a model which Company X can use to determine the level of risk of their suppliers. Eventually, a self-assessment model has been created to do so, which have been discussed in chapter 4.4. Due to the restrictions of this research, stated in

chapter 1.3, a self-assessment model fitted the best in the current situation at Company X This chapter will explain how the self-assessment works and where it consists of.

One of the criteria of Company X, as mentioned in chapter 1.3, was that there should be no costs involved in the creation of the model. So therefore, the self-assessment model is built in Microsoft Excel, because there are no costs attached to this program. The self-assessment model consists of several different chapters which the supplier has to fill in. The first tab in the self-assessment model is an introduction, so the supplier is informed about the purpose of the self-assessment and how the self-assessment should be filled in. In the second tab the supplier should fill in general information about their company. The supplier has to fill in who the responsible managers are, how the organisational structure is build up and to which management systems their organisation is certified. With this information a first image of the organisation can be made. After those two tabs five subjects of the self-assessment model should be filled in by the supplier. The five subjects are:

- Quality;
- Logistics;
- Financial;
- Knowhow;
- Environment & Safety

The choice for these subjects has been made based on the literature review and the research results which are shown in chapter 4.2 and 4.4. Based on the literature two main categories of risk are determined, internal and external risk. These risks are further categorised by Hoffmann in four subjects and explained in detail. One of these categories is operational risk, which occurs when a supplier faces competence issues. This risk category is also commonly seen in the results in chapter 4.2., as quality and delivery issues are the most mentioned risk source by the employees of Company X Therefore, the subject's quality and logistics are part of the self-assessment model. Another subject of the self-assessment is financial, whereas this risk source is also mentioned in multiple articles. This risk occurs as a supplier face liquidity issues or bankruptcy. This risk source is also mentioned by employees of Company X, but not as common as the operational risk sources. Furthermore, the subjects knowhow and environment & safety are also part of the self-assessment. These subjects were

mentioned by the members of the project group as important aspects within Company X in chapter 4.4.

Some risks out of the literature are not taken into account in the self-assessment, which are the environmental and strategic risks. Environmental risk has not been added in the self-assessment, because most of the suppliers of Company X are located in the Netherlands or in Western-Europe, as can be seen in chapter 4.4. It can be assumed that environmental risks are less likely to occur at these suppliers. So it the decision has been made that the environmental risk source is not added in the self-assessment model. Strategic risks are not taken into account, because it will be difficult to measure this risk with a self-assessment. The questions in the self-assessment are formulated on an organisational level, so for instance in the quality chapter the supplier has to answer questions based on how several production processes at the supplier's organisation are in place. Strategic risks are about the relationship between the buyer and the supplier and being the preferred customer. So therefore, this is difficult to measure within the self-assessment of Company X

As it is clear why the five subjects are chosen for the self-assessment, now a clarification will be given how the self-assessment works. Each of the five subjects consists of several questions, divided in several sub-subjects. Input for the questions came from different documents. For instance, the IATF-16949 and ISO9001 standards have been used to define the questions for the quality subject. Especially, the Automotive Quality Management System Document (MAQMSR) of the IATF-16949 has been used for choosing the different sub-subjects within the quality subject. As mentioned in chapter 2.8 organisations can use this document to evaluate the quality management system of their suppliers. As the sub-subjects for the quality subject were clear the IATF-16949 standard have been used to define the questions for these sub-subjects. In the IATF-16949 standard these subjects are mentioned and criteria are mentioned were an organisation should comply with. With this input the questions have been formulated in the self-assessment model. Also several documents from other companies have been used to get inspiration and ideas for defining the questions. So for instance, a supplier questionnaire of the company DAF has been used. This questionnaire applies as the supplier evaluation method of DAF. Questions out of this document have been used as input for the questions in the self-assessment model of Company X Employees of Company X have been involved in this process, as the questions in every subject are defined

in collaboration with an expert. The questions of the quality and knowhow part have been established in collaboration with the quality assurance manager. The logistical questions were checked with the supply chain coordinator. The questions in the environment & safety subject have been defined in collaboration with an environmental engineer and a safety employee. Also the financial subject has been drawn up with the help of the director of finance and control. So these experts have checked the questions which were defined by the project owner and adjusted them if necessary or deleted them if the question did not have any added value. Also the experts came up with questions which should be added to the self-assessment model. The experts were chosen based on their knowhow and expertise in their discipline. So they know what is important in their discipline and what a supplier should have for qualities. Therefore, it seemed a good method to involve the experts as they could translate the qualities a supplier should have into questions.

Employees of the supplier has to score the questions with a rating of 0 (bad), 1 (average) or 2 (good). Rating criteria have been chosen, because one of the restrictions of Company X was that there should be closed questions in the self-assessment model. With rating criteria these questions can be easily answered and a calculation of the score can be made. There have been chosen for 3 rating options, so the supplier could answer the question with a no (0) or a yes (2), but also with a 1 which means that the supplier partly complies with the questions. If we look at the following question out of the self-assessment: “Does your organization has materials on stock to supply to customers in case of emergency situations?” It could be that the supplier has material on stock to supply to customers in case of emergency situations, but not for all their customers. A supplier is given the possibility to answer these questions with a score of 1 and can give additional information in the comment box next to the question. Also there is a possibility to fill in ‘Not applicable’, the supplier can choose this option if the question is not applicable for the supplier’s organisation. The financial chapter is different than the other four chapters, as the supplier has to fill in some financial ratios of their organisation, so an insight is given in the financial stability of the supplier.

At the top of each of the 5 subjects the employee who fills in the respective questions of the subject should fill in some personal information, see figure 5. This has been done, because the questions of the subjects should be filled in by employees who have the knowhow and expertise of the certain subject. So for instance, the financial subject should be filled in by an

employee of the financial department and the logistics subject should be filled in by an employee of the supply chain department. With the personal information of the employees who have filled in the questions of the subjects it will also be easier to get in contact with these employees, if needed.

Filled in by	
Name:	
Function:	
Email:	
Telephone:	
Date:	

Figure 5. Personal information employee.
Source: Figure invented by the author.

With a self-assessment it could be hard to say if the employees of the supplier are filling in all the questions truthfully. Therefore, a recommendation towards Company X is to ask for a signature of the CEO of the supplier. In this case the CEO of the supplier gives the authorisation that the questions are filled in truthfully. In this case we can assume that the employees who are answering the questions are more likely to do this accurate, as the CEO have to place his signature and can check if the questions are really filled in based on the true situation.

Based on the ratings which are filled in by the supplier a score is calculated. For each of the five subjects, and also the sub-subjects, a percentage if given. This percentage represents the supplier's level of risk on the several subjects, the higher the percentage, the lower the level of risk. Chapter 5.3 will give a deeper explanation about how the results are evaluated and the supplier's level of risk is determined.

5.3 Different critical material groups led to different evaluation norms

As the critical material groups of Company X have been defined, see chapter 5.1, and the self-assessment model has been explained, this chapter will elaborate how the supplier's results will be evaluated. As mentioned in chapter 5.2 a percentage is calculated for each of the five subjects if the supplier has filled in the self-assessment. There is also a norm established for each of the five subjects, which is the minimum level a supplier has to achieve. If the supplier achieves the norm on all of the five subjects the supplier is considered as not risky and no further action is needed. If the supplier does not achieve the norm on one or more

of the subjects, this indicates that there is a certain level of risk discovered. Therefore, follow up actions can be considered, which are further explained in chapter 5.4.

Different norms, the so called supplier profiles, have been defined for the different critical material groups of Company X which are stated in chapter 5.1. This has been done, because for a supplier in material group A, a subject can be more important than for a supplier in material group B. For instance, the norm of environment and safety is higher for the suppliers in the material group lubricants and oils than for the suppliers in the material group pallets and cases. The environmental and safety subject is considered as an important aspect for lubricants and oils suppliers, because they work with more dangerous materials than suppliers of pallets and cases do. So for each of the critical material group a different supplier profile has been established.

These supplier profiles have been established in collaboration with employees of Company X, the so called focus groups. In chapter 3.2.3 it is already mentioned that focus groups were used within this research. For each of the critical material groups employees were invited to form a group. As mentioned in chapter 3.2.3 these respondents could be seen as experts in the particular material group, as they are working with the products/services the suppliers are delivering and should have the most knowhow of it within the company. Table 8 shows the participants for each of the critical material groups.

Focus group	**Participants**
Pallets and cases Tubes	Coordinator Planning Supply Chain Coordinator Team Leader Packaging Quality Assurance Manager
Rolls Lubricant and oils	Manager Production Support Manager Maintenance & Engineering Process Instructor Annealing Quality Assurance Manager
Casting	Casting Specialist Casting Specialist
Knives and cutting blades	Process Engineer
Mechanical services	Measurement Equipment Engineer

Table 8. Focus groups.
Source: Table invented by the author.

The participants have been chosen based on their function and, as already mentioned, based on their expertise in the respective material group. The focus groups have been invited to a meeting with the project owner and the procurement manager. Beforehand, the

participants have been informed about the purpose of the meeting and the self-assessment model has been sent to the participants, so the participants could go through it and prepare themselves. This has been done, so the participants know on which subjects the supplier will be evaluated on and which questions were asked. Some participants have filled in the self-assessment with the scores they wanted the supplier to score, so an end score was calculated and could be discussed. This was finally beneficial for the efficiency and quality of the meetings. During the meeting the five subjects of the self-assessment model have been discussed and the participants gave their opinion about how important each of the five subjects in their material group is. Based on this information the project owner made notes for each of the critical material groups. In these notes for each of the five subjects the level of importance was mentioned. With this information in mind and the notes as backup the project owner established the final norm for each of the seven critical material groups. This has been done by filling in all the questions in the self-assessment, which leaded to a percentage score for each of the five subjects. The percentages which were given in the self-assessment were the norm for the respective critical material group. Both the notes and the filled in self-assessment has been send to the respondents of the focus groups. The respondents were asked to check whether the strategy and the norm out of the filled in self-assessment were correct. If not, the respondents provided their comments to the project owner. So based on this approach the norms for the different critical material groups, the supplier profiles, are created and implemented in the self-assessment model.

During the meeting with the respondent for the critical material group mechanical services, it appears that the self-assessment did not completely fit this group. The self-assessment is more focused on suppliers who are providing products or components. Therefore, the decision has been made to develop a self-assessment specially for the critical material group mechanical services. The design of the self-assessment did not change, even as the five subjects. Only the questions within these five subjects have been adjusted, so it would fit the circumstances of mechanical service suppliers.

5.4 Self-assessment model part of the new supplier management process of Company X

At the start of this thesis it has been mentioned that in recent times cooperating with suppliers is necessary to satisfy customer goals and that supplier management is in that case extremely important. Chou and Chang gave several methods which procurement departments can use to manage their suppliers effectively, for instance supplier selection, supplier coordination, supplier evaluation and supplier development.[138] At Company X there are also some of these methods in place, the so called procedures. The procedures of Company X give the employees of the procurement department some sort of direction how to handle in several situations. The procedures consist of a workflow where for every step information is given how to handle and when to proceed, also a model is used which indicates the employees who are responsible for performing the different actions. As there is a new tool developed, the self-assessment model, the procedures need to be changed. The procedures need to be adjusted, so it is clear when the self-assessment model will be used and how this process is carried out.

The procurement department of Company X has nine procedures in place. For instance, the procedures supplier selection, supplier evaluation and performing supplier audit. Most of the procedures have a certain level of overlap with each other, as one procedure follows up another procedure. This will also be the case with the self-assessment model, as it can be used for multiple purposes and follow up actions can be performed based on the results of the suppliers. Therefore, a new supplier management process has been developed which consists of four procedures, see figure 6. The supplier management process of Company X is a continuouis process of four stages. These four stages are following each other up in a logical order. Nevertheless, the four stages can also be seen as individual processes performed when necessary. All the four procedures consist of a workflow, detailed information and a responsibility table. For some steps there are work instructions established, which gives detailed information about how to perform the action. For instance, a work instruction is made up for performing a supplier self-assessment, which give the employees of the procurement department detailed information from the start till the end of this action. The full supplier management process has been added in appendix VII.

[138] See Chou and Chang (2008), p. 2241.

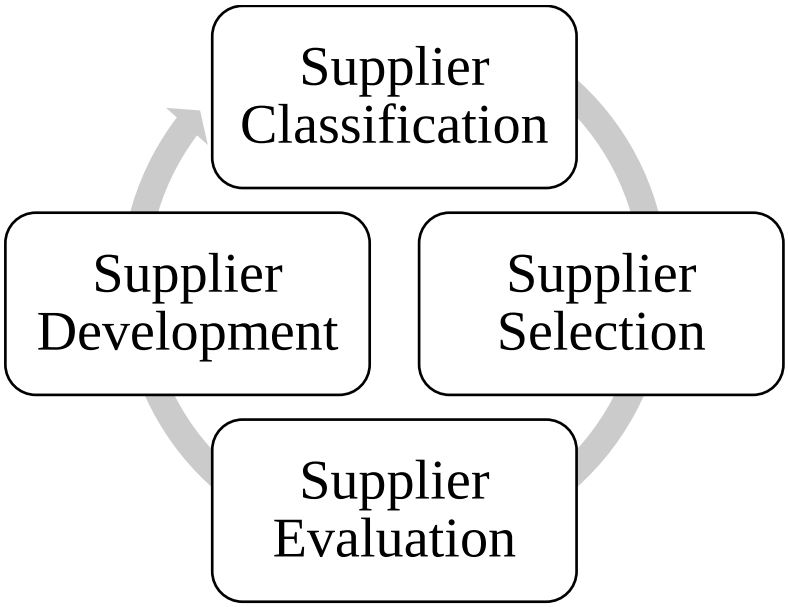

Figure 6. Supplier Management Process.
Source: Figure invented by the author.

The first step in this process is supplier classification. Out of the literature review it seemed that there is not one way of dealing with all the suppliers and that different approaches or practices are needed. This also applies for Company X, as there are a lot of different suppliers. Therefore, the steps of the supplier classification procedure consist of classification of critical material groups, defining a strategy for the critical material groups and establishing risk profiles for the critical material groups. These steps are also performed during this research and the results have been discussed in chapter 5.1 and 5.3.

In chapter 2.1 it has been mentioned that supplier evaluation is done during the supplier selection phase and also on a regular base over time. The self-assessment model will also be used for these two purposes. First of all, during the supplier selection process. The supplier selection process is important for a company, as bad decisions in this stage can lead to negative firm performances.[139] The supplier selection process at Company X starts when a product or service request has been submitted by an internal customer. First of all, the approved vendor list will be checked to see if there is already a suitable supplier available. If that is not the case than the procurement department have to search for a new supplier. In this stage several evaluation methods can be used to check whether the supplier is suitable. The supplier self-assessment model is one of these methods, as suppliers can be evaluated based on

[139] See González et al. (2004), p. 492.

the results of the self-assessment. Performing an evaluation with the supplier self-assessment is mandatory for the suppliers in the critical material groups, but could also be used for suppliers in non-critical material groups. Based on the evaluation results the procurement manager decides if the supplier is approved.

The supplier evaluation process for current suppliers starts based on the year plan, performance measurement, changes in supplier classifications or internal needs. The supplier has to fill in the self-assessment model and the results are checked according the criteria in table 9. These criteria are discussed during the meetings with the project group and have been approved by this group. So the norms are not based on a formula or academic research findings, but just introduced to have a certain guideline for evaluating the self-assessment results.

Score of the supplier	**Action**
Equal or higher than the norm (green)	No further action needed, complete supplier evaluation
Until 5% below the norm (yellow)	Procurement Manager decides if the results should be discussed with a specialist
More than 5% below the norm (red)	The results must be discussed with a specialist

Table 9. Criteria guideline for supplier evaluation.
Source: Table invented by the author.

If the results are below the norm, the results must be discussed with a specialist. Table 10 gives an overview of the specialist which should be invited for the several subjects. These specialists have also made a contribution towards this research in an earlier stage, as they have helped with defining the questions in the self-assessment and some of them were also invited during the meetings to develop the norms for the critical material groups.

Evaluation subject	**Function**
Quality	Quality Assurance Manager
Logistics	Supply Chain Coordinator
Financial	Employee Financial Department
Knowhow	Quality Assurance Manager
Environment	Environmental Engineer
Safety	Safety Engineer

Table 10. Specialist for discussing the evaluation results.
Source: Table invented by the author.

Based on the discussion between the procurement manager and the specialist a decision will be made to approve the supplier, phase-out the supplier or start a supplier development

program. Supplier development is the last phase in the supplier management process. It starts with defining the goal of the program, so the aspect which should be improved at the supplier. The goal will be defined based on the results of the supplier self-assessment, as the results indicate a bad performance at the supplier. The next steps in this procedure are choosing the supplier development program, composing a team, planning the actions and performing the supplier development program. Chapter 2.7 describes a number of supplier development programs which are known in the literature. This list has been discussed with the procurement manager of Company X Based on this discussion the procurement manager picked out some of the actions which would fit within the procurement department. The following supplier development programs have been chosen:

- **Feedback of evaluation:** The results of the evaluation can be communicated with the supplier. The supplier can be asked to clarify some scores or to provide additional information.
- **On-site audit:** An on-site audit can be performed to get extra information about how the supplier's processes are designed. Beforehand, a specific team and specific inspection objects can be determined based on the results of the supplier evaluation.
- **Request for improvement:** Based on the results of the supplier evaluation or the results of the on-site audit, a request for improvements can be made. The supplier is asked to make a plan/idea for the requested improvement objective.
- **Inviting supplier's personnel:** The personnel of the supplier can be invited to bring a visit to Company X, in order to create more awareness of how their product is used or to propose improvement objectives.
- **Supplier certification programme:** Oblige the supplier to get a certificate, for instance a quality certificate like ISO9001.
- **Training/education of supplier's personnel:** Giving training/education to the supplier's personnel, in order to increase the performances.

5.5 Adjustments in self-assessment made based on feedback of suppliers

The self-assessment model has been tested, as it was send to a number of suppliers of Company X Table 11 gives an overview of the suppliers, and the respectively critical material group, which have participated in the test phase.

Supplier	Critical material group
Supplier	Pallets and cases
Supplier	Pallets and cases
Supplier	Tubes
Supplier	Tubes
Supplier	Rolls
Supplier	Lubricant and oils
Supplier	Lubricant and oils
Supplier	Mechanical services

Table 11. Test group of the supplier self-assessment.
Source: Table invented by the author.

The goal of the test phase was to check if the supplier self-assessment would work properly and to get some feedback of the suppliers. After the self-assessments were returned by the suppliers, each supplier has been called to give feedback. The questions which were asked can be found in appendix VII.

The feedback results were very useful to adjust a number of things in the self-assessment model. For instance, the suppliers were asked if the questions were formulated in an understandable way. Most of the questions were according to the suppliers, but there were also a few questions which were difficult to understand or difficult to answer with the rating criteria. Based on the feedback those questions were adjusted. Furthermore, all of the suppliers agreed that the self-assessment model was clear, easy to fill in and that the rating criteria to answer the questions were useful. The suppliers are given two weeks the time to complete the self-assessment and send it back to Company X This is based on the reactions of the suppliers during the feedback call. In the introduction tab of the self-assessment more information about the purpose of the self-assessment is added. Some suppliers mentioned that the purpose of the self-assessment was not quite clear. One of the biggest changes in the self-assessment has been made in the financial tab. In the first place the supplier had to fill in the financial figures of the organisation, such as figures out of the balance sheet and the income statement. Only one supplier had completely filled in all of these figures and most of the suppliers mentioned during the feedback call that it was too much work to fill in all these figures. Some suppliers also mentioned that these figures were available in the annual report of the company or could be retrieved from the Kamer van Koophandel (KVK). A meeting have been scheduled with an employee of the financial department and the manager finance and control to discuss this matter. Based on the feedback and the meeting the financial tab has been adjusted and in the current self-assessment only some financial ratios are asked, see figure 7. These ratios were

suggested during the meeting by the employee of the financial department and the manager finance and control, as this are in their opinion the ratios which gives a good overview of the financial situation of a company. In this case the supplier has to fill in less figures and the ratios could also be filled in based on the available annual report or retrieved from the KVK. For the Supplier X a financial report was requested at the Kamer van Koophandel. This report shows a number of financial ratios and these were filled in in the self-assessment model. Not all of the ten ratios could be filled in and therefore, a score was calculated based on the ratios which were filled in. This gives a distorted final score on the financial subject. So with the changes in the financial subject it will hopefully be easier for a supplier to fill in this part. Yet, the financial subject will still be seen as the bottleneck of the self-assessment model. As the future should reveal of this change indeed leads to more response on the financial subject and that it will not always be possible to get all of the financial ratios based on Kamer van Koophandel reports.

Financial ratios
1. Balance sheet total
2. Net sales
3. Net profit margin
4. Current ratio
5. Quick ratio
6. Return on equity
7. Solvency
8. Debt ratio
9. Interest coverage ratio
10. Inventory days

Figure 7. Financial ratios.
Source: Figure invented by the author.

All of the eight self-assessments from the test phase have been returned. From the eight suppliers who filled in the self-assessments, six of them achieved the norm. The Supplier X in the critical material group pallets and cases did not achieve the norm. This supplier scored 24% below the norm on the subject quality and 9% below the norm on the subject logistics. This score was not quite surprising, because this supplier also has the most deviation reports. In the subject quality one sub-subject scores very low, which is the sub-subject part approval. The norm for this sub-subject is 86% and the supplier only scores 6%. This could also indicate the high level of deviation reports, because the most mentioned problem in the

deviation reports is that the pallets and cases are not according to the requirements of Company X Because the scores were below the norm actions have been taken. The purchasing manager of Company X has visited the company and has discussed the results of the self-assessment. The supplier development action 'Request for improvement' out of chapter 5.4 has been chosen, as the purchasing manager has asked the manager of the company to make a plan of improvement, to improve the quality of their products. Furthermore, Supplier Y the mechanical service provider also scored below the norm. On the subject knowhow and quality the scores were below the norm. This matter will be discussed with a purchasing employee and the measurement equipment engineer, which is responsible for this material group. This meeting have not taken place yet, so further information cannot be provided.

For Company X it is also important to check whether the self-assessment is working properly. This means does it really measure what it should be. A few options can be proposed to check this. First of all, this could be checked by doing on-site audits and check whether the answers which are given in the self-assessment are also apply at the company for real. For instance, the first questions in the quality subject are about control plans and it could checked whether there are really control plans in place if the supplier have answer this question with a positive score. The supplier can also be asked to send prove, so for the example of the control plans the supplier can be asked to send the control plans to Company X So, doing a check by on-site audits or asking for proof can be a way to measure if these questions are truthfully filled in and also measure this in the way it should be measured. This chapter have described the follow up actions at Supplier X, because the measured risk. The action which has been taken is a request for improvement. When the improvements have been carried out by the supplier, Company X can check whether these improvements have decreased the level of risk and if the supplier's score have increased. This can be done by sending out another self-assessment form and evaluation the results.

Not only the suppliers have to be evaluated, but also the self-assessment model, risk sources and critical material groups of Company X As mentioned in chapter 2.3 risk should also be identified continuously, because environments and organisations changes. Risk identification is a continuous process, which should be carried out from time to time to see if current risks are identified.[140] If new risks are identified or current risks are not seen as

[140] See Tchankova (2002), p. 293.

important any more, the self-assessment model should be adjusted to this. Also the critical material groups and the norms they have to achieve should be evaluated, as there could be changes in this area too, due to changes in the environment or organisation. For instance, the norm on the subject of logistics for the suppliers of pallets and boxes is quite high at the moment, but if extra storage space for pallets and boxes becomes available at Company X it affects the criticality of this issue. Then this norm could be decreased as the risk for availability of the pallets and boxes have decreased.

6. Conclusion: Goal of the research achieved by the development of an effective supplier management process

6.1 Self-assessment model gives Company X the possibility to determine the level of risk of their critical non-metal components suppliers

This research started, because the procurement department of Company X had a business problem which needed to be solved. The problem was that there was not a model in place which could assess the level of risk of the suppliers of Company X, while in current times managing and mitigating supplier risk has gotten increased attention. Therefore, the goal of this research was to make a model which could assess the level of risk of critical non-metal component suppliers of Company X With the use of the business problem solving methodology this research has been successfully conducted.

Coming back to the first part of the research question, it seems to be possible to determine critical material groups of companies by making use of the theory of Mitchell and three sorts of methods. Which are interviews, deviations reports and business documentation. For Company X seven critical material groups are formed. Therefore, it is possible for companies to focus on those suppliers who are really important and critical. To determine the level of risk of the suppliers in the critical material groups, a self-assessment model has been developed. With this model it is possible to evaluate suppliers and check if they are meeting the expectations, the norms of an organisation, or not. The self-assessment model consists of five subjects, which are based on the research findings. Some of the risk sources which are known in the literature were also commonly mentioned as a source of risk by the employees of Company X For instance, the most mentioned risk sources by the employees of Company X were quality and delivery risks. These risks are known in the articles of other researchers as operational risks. Another subject of the self-assessment model is financial and this subject is also commonly mentioned as a source of risk in the literature. It can be concluded that organisations are not fully cooperating in sharing their financial figures, as during the test phase of the self-assessment only one supplier have provided this information in full. Also it can be concluded that risk sources are organisation specific, as based on the research findings it was not necessary to include the environmental risk source at Company X, as most of the

suppliers are located in or nearby the Netherlands. The strategic risk source is not included, because this risk source is hard to measure in a self-assessment model.

The last part of the research question is about the actions which have to be taken to deal with the suppliers where a certain level of risk is discovered. Based on the literature review and the meetings with the project group, a list with a number of supplier development actions has been defined. These actions are part of the supplier management process, which has been developed for Company X Based on the results of the self-assessment, the procurement manager is able to start a supplier development program, in order to reduce the discovered level of risk. The supplier management process consists of four steps and gives Company X the right directions how to manage their suppliers in an effective way. It also describes how the self-assessment model should be used, as it can be used in the supplier selection phase as well as the supplier evaluation phase.

The test phase of the self-assessment was useful to check whether the self-assessment was measuring what is should be and if it works properly. It can be concluded that for Company X the intention of the self-assessment and the supplier management process works properly. As for one supplier who has not reached the norm, what also was the expectation, the supplier management process was fully followed. For this supplier development actions have been taken. Note should be made that the self-assessment and supplier management process works properly for Company X, but that this is based on the test phase.

6.2 Regularly updating the self-assessment model and the supplier management process important task for the procurement department

In chapter 3.1 the methodology of business problem solving is explained. In most cases the project owner leaves a company when the solution design is finished, but not in this case, as the project owner was also able to work on the intervention and evaluation steps. So the implementation of the self-assessment model and the new supplier management process are already finished for Company X For Company X it is important that the self-assessment model and the supplier management process will be updated once in a while. Current risk sources can change or be no risk any longer at all, as well that new risk sources can be identified or of interest for Company X This also applies to the critical material groups.

A limitation of this research was that the strategic risk source is not taken into account in the self-assessment model. This is very unfortunate, because this is one of the newest discovered risk sources. Another limitation of this research is that based on the interviews and the other research methods no statistical significant statements can be made. This does not mean that this research is not valuable as it provides a lot of new information and a model which can be used to assess the level of risks of suppliers. Note should be made that this model is specially designed for Company X, so this model cannot exactly be copied by other companies, but can be used if it is adjusted to their own circumstances.

This thesis will made a contribute to the academic literature in the form of extending the literature with a new specific application of measuring risks of suppliers with the form of a self-assessment model.

As this research was fully focused on solving a business problem of Company X the contribution to literature is minimal. This research has mostly provided recommendations and implementations actions specifically for Company X The contribution to literature is that a model have been made based on risk sources and risk management steps out of other studies, so the information out of these studies have been used in the model and so these findings have been used in a practical way. For future research it could be possible to check whether this risk model with the risk sources, questions and supplier management process really works in practice. So in other words checking if the risk evaluation model is really measuring the risks in a significant way.

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Appendix I: Interview protocol – Company Y

1. **Opening segment – Establish a level of comfort and explain the purpose of the research**

1.1 Start with an introduction of yourself to the interviewee and appreciate the time for the interview.
1.2 Explain the purpose of the research. State that the results will be published anonymised and that the interview will have a huge contribution towards the research. Finally, ask for allowance to record the interview.
1.3 What is your function at Company Y and what are you responsible for?
1.4 What is your vision about the position of the purchasing department in the organisation of Company Y?

2. **Middle segment – Questions specific related to the research question**

2.1 What are in your opinion the biggest risks that can occur at Company Y?
2.2 Does your organisation make use of a supplier risk management model?
2.3 If yes, how is this supplier risk management process organised within your organisation?
2.4 How do you make a differentiation of your material groups?
2.5 Are there any problems/risks with particular material groups and why?
2.6 Are some material groups more important towards the production process (OEE/Yield) and do you handle with these material groups in a different way? (difference OPEX/CAPEX)
2.7 What kind of supplier risks do occur at Company Y? (Risk sources)
2.8 What is the probability that these risks occur and what is the impact?
2.9 Which suppliers do you assess with a risk analysis?
2.10 On what aspects do you assess these suppliers and how? (Risk measurement)
2.11 Which measurement tools do you use to assess the level of risks?
2.12 How are scores formulated and where are these scores based on?
2.13 How do you make sure the same scores are rewarded if two people do an assessment?
2.14 What will you do if a high level of risk occurs at a supplier?
2.15 How many times do you assess your suppliers?
2.16 What kind of actions do you take to reduce risks? (Risk mitigation strategies)
2.17 What are the customers of Company Y expecting of your risk management process?
2.18 In what extend are ISO-certifications playing a role in the supplier risk analysis?
2.19 Do you make adjustments towards the risk model based on the new ISO rules or in general?

3. **Concluding segment – Work towards a sense of wrapping up the interview**

3.1 Do you have any final points or additional thoughts which can contribute to the supplier risk analysis?

3.2 Thank the participant for his or her time and emphasise the contribution towards the research.

Appendix II: Interview protocol – Company X

1. **Opening segment – Establish a level of comfort and explain the purpose of the research**

1.1 Start with an introduction of yourself to the interviewee and appreciate the time for the interview.
1.2 Explain the purpose of the research. State that the results will be published anonymised and that the interview will have a huge contribution towards the research. Finally, ask for allowance to record the interview.
1.3 What is your function at Company X and what are you responsible for?
1.4 In which way are you/your department working together with the purchasing department?
1.5 How is this collaboration going?
1.6 What is your vision about the position of the purchasing department in the organisation of Company X?

2. **Middle segment – Questions specific related to the research question**

2.1 With which of the following material groups are you working within your department? (Showing list of the 38 material groups of Company X)
2.2 Do you have any problems with one of these material groups lately?
2.3 Which of these material groups are in your opinion influencing the OEE/Yield of the organisation?
2.4 What are in your opinion the biggest risks that can occur at Company X?
2.5 In contribution towards the last question, what kind of risk at your department can influence the overall risk for Company X?
2.6 What kind of problems/risks occur due to failure of a supplier?
2.7 What kind of supplier problems have you experienced and which are the most common?
2.8 What is the probability that these risks occur and what is the impact?
2.9 What kind of actions do you take to reduce these risks?
2.10 On what aspects should procurement assess the suppliers?
2.11 What kind of information do you want to know of a supplier, their process and their products?
2.12 Are you in contact with customers? If yes, what are they expecting of Company X risk management process?

3. **Concluding segment – Work towards a sense of wrapping up the interview**

3.1 Do you have any final points or additional thoughts which can contribute to the supplier risk analysis?
3.2 Thank the participant for his or her time and emphasise the contribution towards the research.

Appendix III: Material groups Company X

Material group	Description of material group	Account description
Heat exchange	Installation, mechanical equipment, heat exchangers	Supplies for maintenance of machinery
Disposal insurance	Disposal, government, insurance	Sanitation
Professional services	Special items, professional services	Maintenance services
Mechanical services	Mechanical services	Sanitation
Electrical services	Electrical services	Electricity
IT services	IT-services	Other consulting services (third party)
Chemicals	Chemicals (without laboratory), additives, cylinder gases	Production supplies
Packaging	Emballage (without small packaging)	Packaging supplies
Furniture	Office furniture and equipment, shelves and workshop cabinet	Office supplies
Fuels	Coal, coke, residual oil, fuels	Production supplies
IT	Software and hardware (including maintenance), office equipment	IT-hardware
Electro high >1000V	High/medium voltage technology	Supplies for maintenance of machinery
Electro low <1000V	Low voltage technology	Supplies for maintenance of machinery
Motors	Motors	Supplies for maintenance of machinery
Measurement	Measurement equipment	Other tools
Data communication	Telecommunications and radio communications, network infrastructure	IT-software (third party)
Flange and fittings	Gray and steel, pipes, flanges and fittings, iron and steel	Supplies for maintenance of machinery
Fasteners	Screws, mechanical fasteners, bearings	Supplies for maintenance of machinery
Bearings	Bearings	Supplies for maintenance of machinery
Machines and spare parts	Tools/machines included spare parts	Other tools
Rolls	Rolls	Supplies for maintenance of

		machinery
Lifting equipment	Lifting equipment (hoists, winches, chains, cordage, ropes)	Supplies for maintenance of machinery
Machine parts	Machinery accessories and spare parts, hydraulics	Supplies for maintenance of machinery
Pumps and compressors	Pumps, fans, compressor, sanitair	Supplies for maintenance of machinery
Vehicles	Vehicles and vehicle equipment, bicycles, wheels, casters	Supplies for maintenance of machinery
Promotion materials	Promotional measures and items, small packaging, labels	Office supplies
Office supplies	Printed materials and forms, office supplies	Office supplies
Books and photo	Books, magazines, loose-leaf publications, photo items	Office supplies
Chemicals lab	Fine chemicals, laboratory equipment and supplies	Production supplies
Sanitation	Coatings and paint, detergents, soaps, skin care products	Toilet supplies
Building and site	Construction and assembly	Supplies for maintenance of machinery
Casting	Building materials (without additives), wood	Supplies for maintenance of machinery
Lubricants and oils	Lubricants, oils, greases	Production supplies
Hoses and coating	Rubber products, rubber coatings, belts, graphite material	Production supplies
Safety	Textiles, filters, hoses, protective clothing	Safety equipment
Seals	Isolation, gasket and seals	Production supplies
Filters	Filters	Supplies for maintenance of machinery

Table 12. Material groups Company X
Source: Table invented by the author. Based on information of Company X

Appendix IV: Suppliers and number of deviation reports

Supplier	G8D report	Deviation report	Service disapproval	Total
Supplier A		8		8
Supplier B	5	2		7
Supplier C		5		5
Supplier D	1	4		5
Supplier E		4		4
Supplier F		4		4
Supplier G		3		3
Supplier H	1	2		3
Supplier I	1	2		3
Supplier J		3		3
Supplier K		2		2
Supplier L		2		2
Supplier M		2		2
Supplier N	1	1		2
Supplier O	1	1		2
Supplier P		2		2
Supplier Q		2		2
Supplier R		2		2
Supplier S		2		2
Supplier T		2		2
Supplier U		2		2
Supplier V	1			1
Supplier W		1		1
Supplier X		1		1
Supplier Y		1		1
Supplier Z			1	1
Supplier AA		1		1
Supplier AB		1		1
Supplier AC		1		1
Supplier AD		1		1

Supplier AE		1		1
Supplier AF		1		1
Supplier AG		1		1
Supplier AH		1		1
Supplier AI		1		1
Supplier AJ		1		1
Supplier AK		1		1
Supplier AL	1			1
Supplier AM	1			1
Supplier AN		1		1
Supplier AO			1	1
Supplier AP	1			1
Supplier AQ		1		1
Supplier AR		1		1
Supplier AS	1			1
Supplier AT		1		1
Supplier AU		1		1
Supplier AV		1		1
Supplier AW		1		1
Supplier AX		1		1
Supplier AY	1			1
Supplier AZ		1		1
Supplier AAA		1		1
Supplier AAB		1		1
Supplier AAC		1		1
Supplier AAD		1		1

Table 13. Suppliers and number of deviation reports.
Source: Table invented by the author. Based on information of Company X

Appendix V: Material groups and number of deviations

Material group	Number of deviations
Machine & spare parts	25
Mechanical services	21
Machine parts	18
Rolls	11
Packaging	8
Measurement	8
Flange and fittings	8
Fasterners	8
Electro low	7
Casting	7
Safety	7
Filters	7
Electrical services	6
Pumps and compr	6
Motors	5
Lifting equipment	5
Hoses and coating	5
Seals	5
IT services	4
Office supplies	4
Building & site	4
Bearings	3
Chemicals lab	3
Heatexchance	2
Furniture	2
Electro high	2
Lubricant and oils	2
Metal	1
Prof services	1
IT services	1
Fuels	1
Data communication	1
Vehicles	1
Disposal ensurance	0
Chemicals	0

Promotion material	0
Books and photo	0
Sanitation	0

Table 14. Material groups and number of deviations.
Source: Table invented by the author. Based on information of Company X

Appendix VI: Critical material groups Company Y and Company Z

Company Z	**Company X**
Anti-stain	Lubricant and oils
Roll coolants	Lubricant and oils
Milling cutters	Machines & spare parts
Slitter knives	Machines & spare parts
Press room tooling	Machines & spare parts
Calibration services	Measurement equipment
Outside processing	-
Fluxes	Casting
Work roll chroming	Rolls
Graphite (Synthetic)	Casting
Company Y	**Company X**
Wooden packaging	Packaging
Foil	Packaging
Wrapping paper	Packaging
Chemicals production	Chemicals
Lubricants	Lubricants and oils
Production tools	Machines & spare parts
Foundry tools	Machines & spare parts
Mechanical spare parts	Machines & spare parts

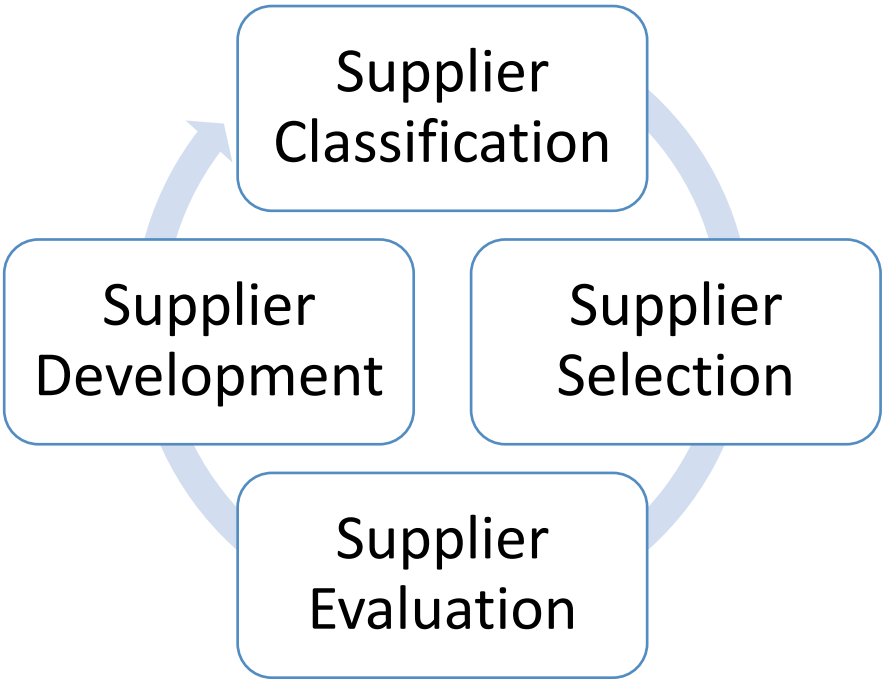
Table 15. Critical material groups Company Y and Company Z
Source: Table invented by the author. Based on information of Company X

Appendix VII: Feedback questions

1. Have the questions been formulated in an understandable way?
2. If questions were unclear, can you indicate which questions were unclear?
3. Do you object sharing the financial data of your organisation? If so, why?
4. Have the various subjects been filled in by the employees with the desired level of knowledge of that subject?
5. Is the format of the self-assessment model clear?
6. Is the format of the self-assessment easy to fill in?
7. Are the rating criteria to answer the questions useful?
8. How many days do you require to return the completed self-assessment?
9. How much time in total has been spent on completing the self-assessment?
10. Do you have any other comments regarding the self-assessment?

Appendix VII: Supplier Management Process

M.S.P. 310.10 Supplier Management Process

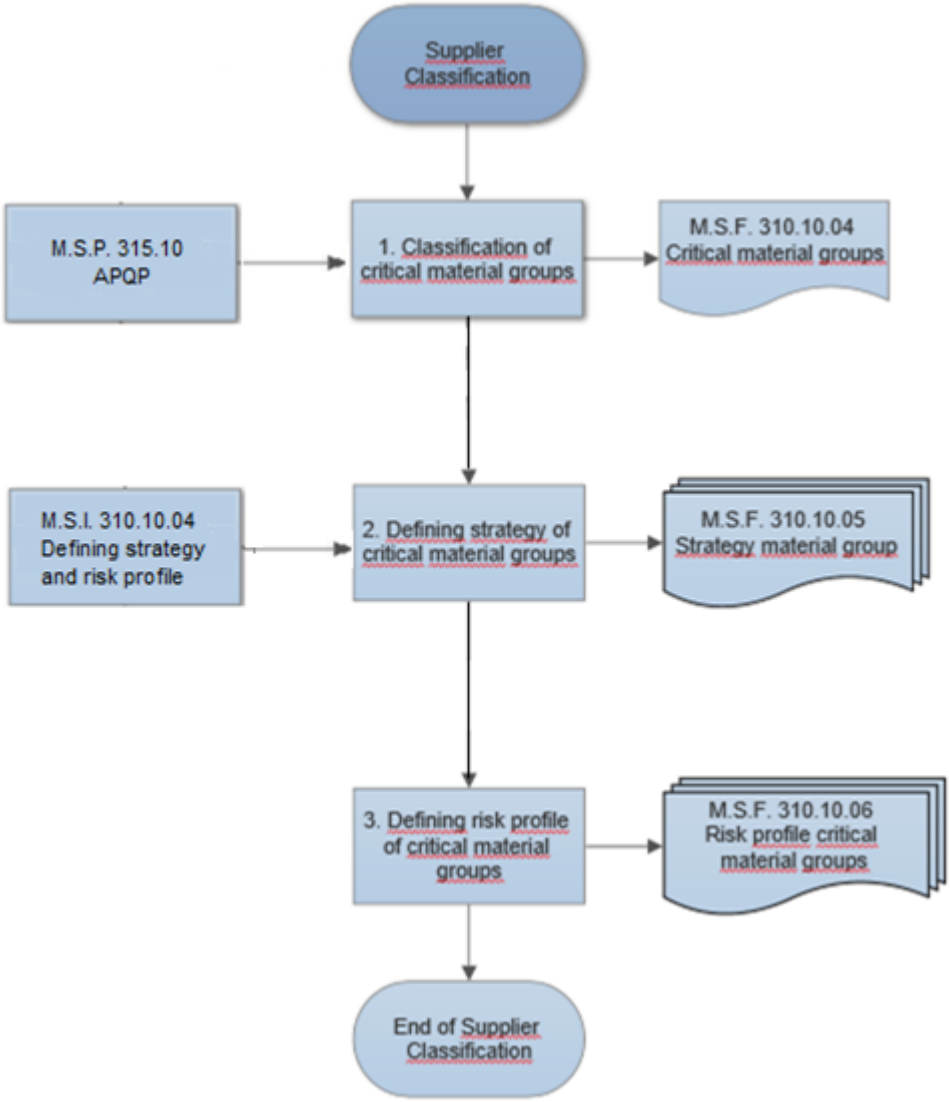


The Supplier Management Process of Company X is a continuouisly process of four stages:

- Supplier Classification
- Supplier Selection
- Supplier Evaluation
- Supplier Development

These four stages are following each other up in a logical order. Nevertheless, the four stages can also be seen as individual processes performed when necessary.

M.S.P. 310.10.01 Supplier Classification



Function	Step 1	Step 2	Step 3
Procurement manager	A	A	A
Buyer	R	R	R
Internal customer		C	C
R = Responsible; A = Accountable; S = Supportive; C = Consulting; I = Informed			

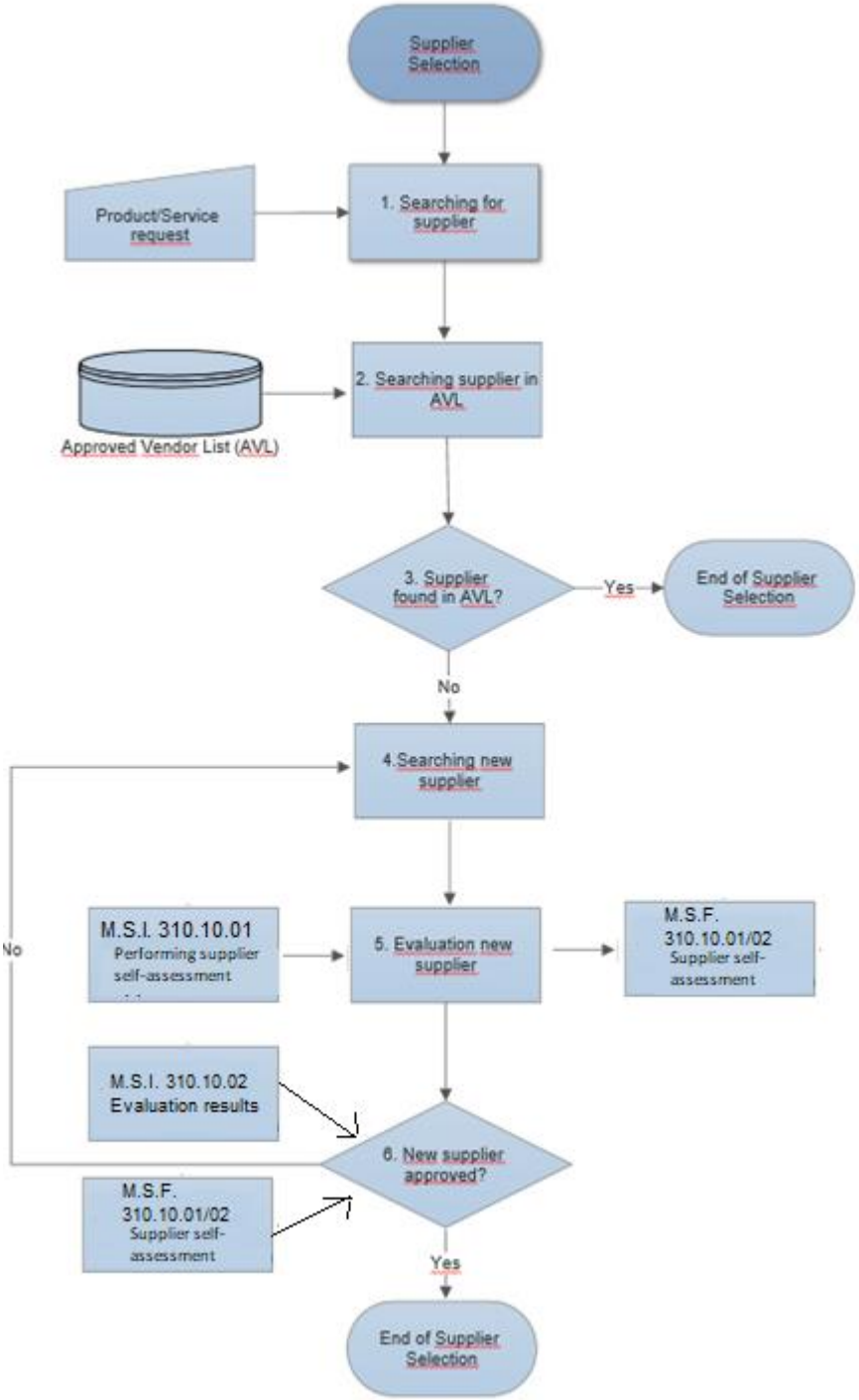
Supplier Classification Procedure

1. Classification of critical material groups
   - Material groups of Company X are classified as critical or non-critical.
   - Classification of critical material groups is based on the following definition: “Product/service of the supplier comes in direct contact with the finished product of Company X”
   - Critical material groups should be mentioned in M.S.F. 310.10.04 Critical material groups.
   - Classification should be done at least every 3 years or according to the start of M.S.P. 315.10 APQP procedure

2. Defining strategy of critical material groups
   - For the critical material groups a strategy should be prepared, based on 5 subjects: Quality, Logistics, Financial, Knowhow and Environment & Safety.
   - This should be done in collaboration with the internal customer(s) of the specific critical material group as they could be seen as a specialist and therefore, can give the necessary information of the most important aspects of the critical material group.
   - The strategy of the critical material group should be drawn according to M.S.I. 310.10.04 Defining strategy and risk profile for critical material groups
   - Defining a strategy should be done at least every 3 years or according to the start of M.S.P. 315.10 APQP procedure

3. Defining risk profiles of critical material groups
   - For the critical material groups a risk profile should be prepared, based on 5 subjects: Quality, Logistics, Financial, Knowhow and Environment & Safety.
   - This should be done in collaboration with the internal customer(s) of the specific critical material group as they could be seen as a specialist and therefore, can give the necessary information of the most important aspects of the critical material group.
   - The risk profile of the critical material group should be filled in according to M.S.I. 310.10.04 Defining strategy and risk profile for critical material groups
   - Defining a risk profile should be done at least every 3 years or according to the start of M.S.P. 315.10 APQP procedure

M.S.P. 310.10.02 Supplier Selection



Function	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Procurement manager	A	A	A	A	A	A
Buyer	S	R	R	R	R	R
Internal customer	R	C	I	S	S	I
R = Responsible; A = Accountable; S = Supportive; C = Consulting; I = Informed						

Supplier Selection Procedure

1. Searching for supplier
   - The supplier selection process starts when a product/service request has been submitted by an internal customer.

2. Searching supplier in AVL
   - First of all, the Approved Vendor List (AVL) will be checked to see if there is already a current supplier in the database who can provide the request.
   - The AVL can be retrieved form the SAP system.

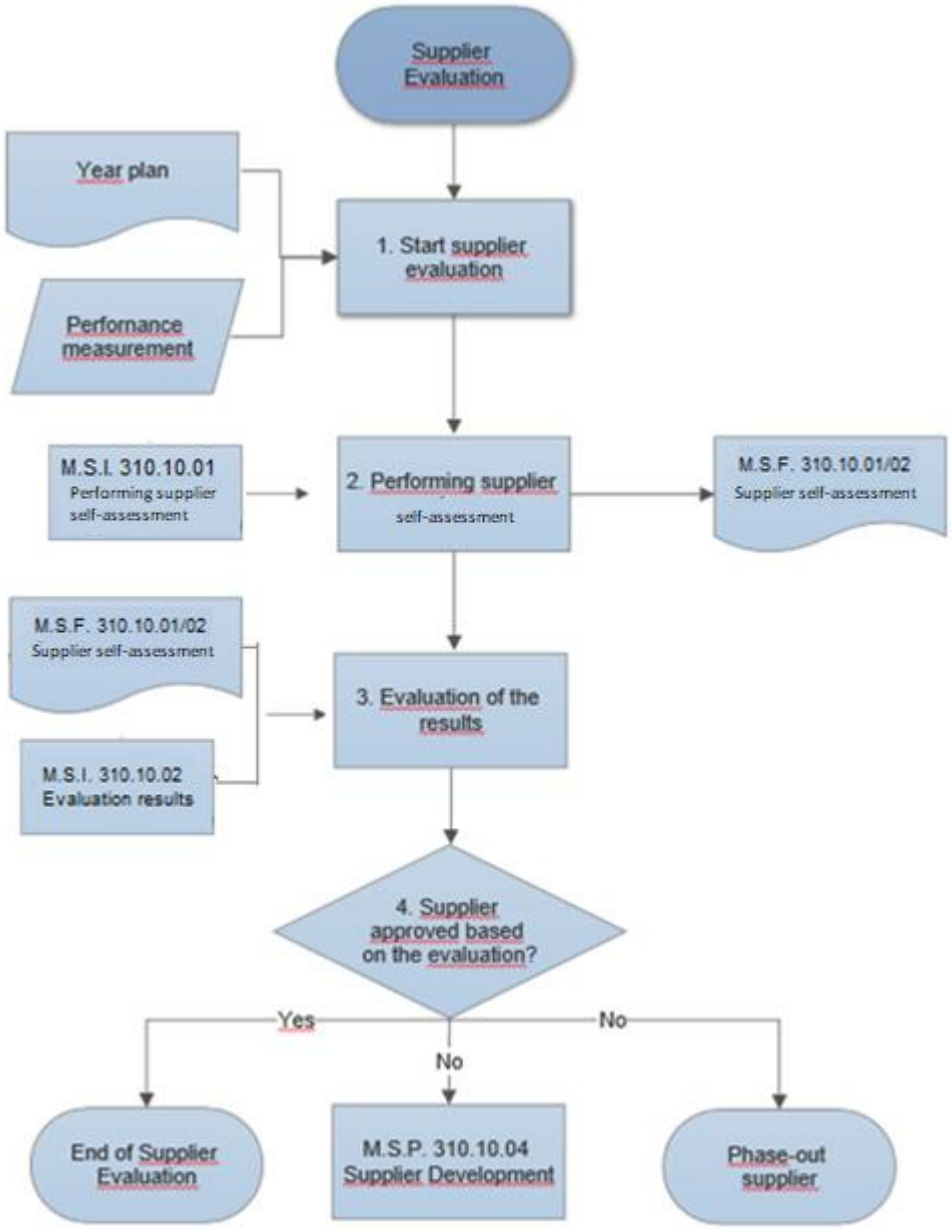
3. Supplier found in AVL?

4. Searching new supplier
   - If no suitable supplier is found in the AVL, a new supplier has to be searched for.

5. Evaluation new supplier
   - The supplier will be evaluated to see if it fits the requirements of the request.
   - For the supplier evaluation one or more of the following possibilities can be used:
     - Company visit of the buyer/supplier
     - On-site audit
     - Supplier Self-Assessment
   - A Supplier Self-Assessment is mandatory to carry out for suppliers in critical material groups, but could also be used for suppliers in non-critical material groups.
   - M.S.I. 310.10.01 Performing Supplier Self-Assessment has to be followed to start the Supplier Self-Assessment.

6. New supplier approved?
   - The Procurement Manager makes the decision, based on the evaluation, if the supplier is approved.
   - For suppliers in critical material groups M.S.I. 310.10.02 Evaluation Results has to be followed to decide if the new supplier will be approved.

M.S.P. 310.10.03 Supplier Evaluation



Function	Step 1	Step 2	Step 3	Step 4
Procurement manager	A	A	A	A
Buyer	R	R	R	R
Internal customer	C		S	I
R = Responsible; A = Accountable; S = Supportive; C = Consulting; I = Informed				

Supplier Evaluation Procedure

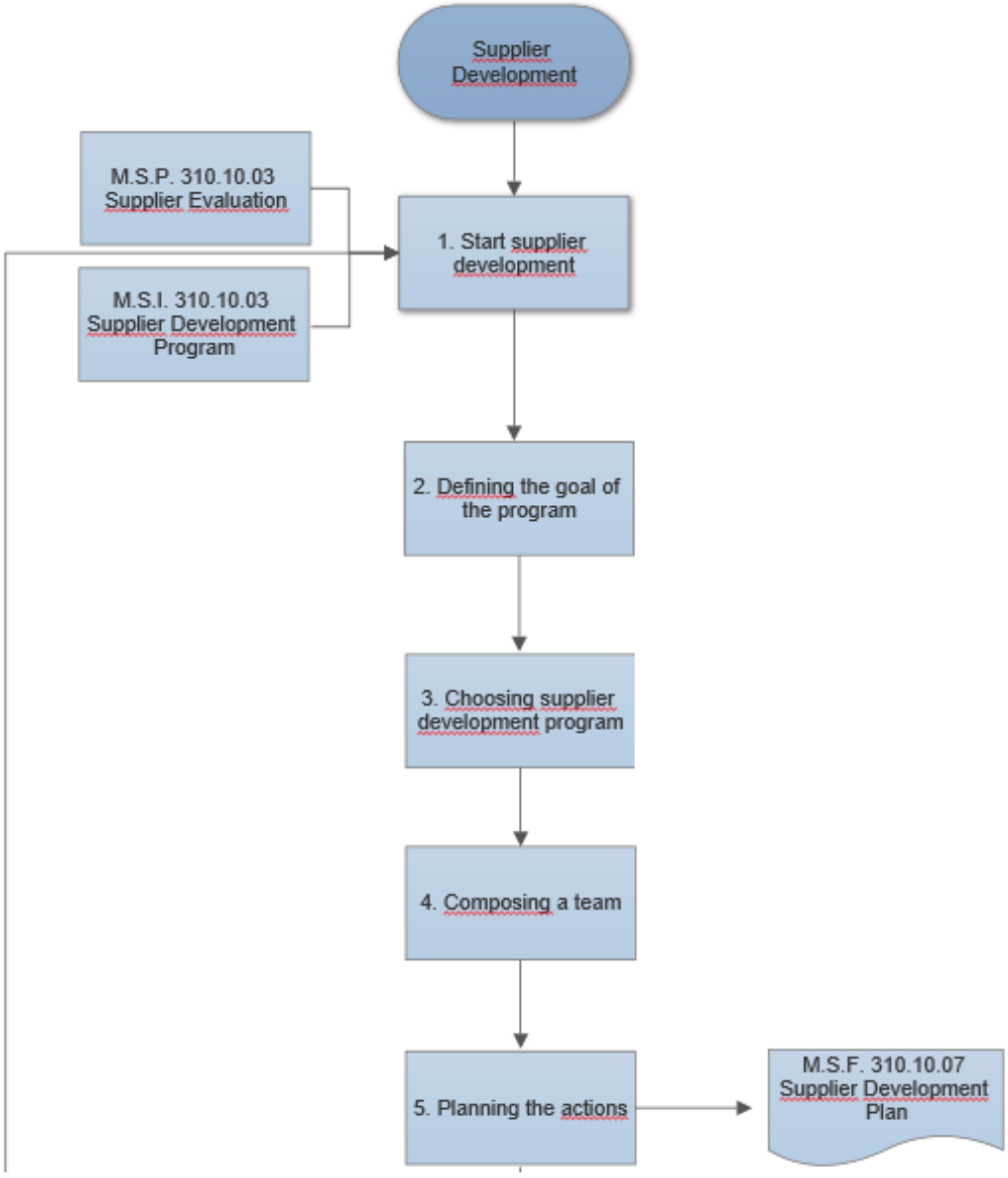
1. Start supplier evaluation
   - The supplier evaluation process for current suppliers starts based on:
     - The year plan
     - Performance measurement
     - Changes in supplier classifications
     - Internal needs

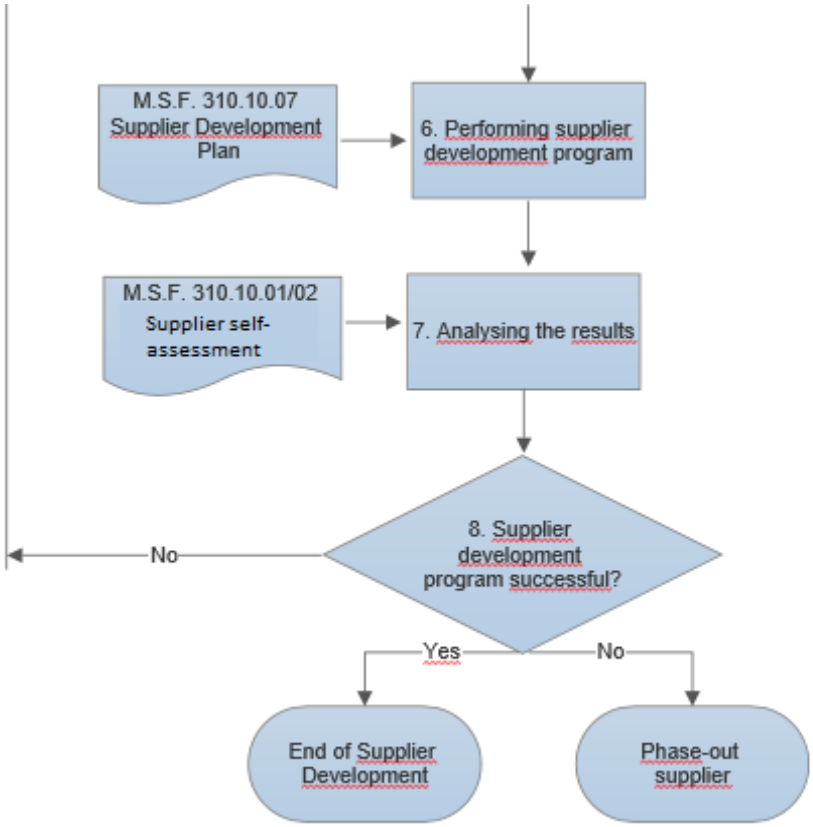
2. Performing supplier self-assessment
   - M.S.I. 310.10.01 Performing Supplier Self-Assessment has to be followed to start the Supplier Self-Assessment.

3. Evaluation of the results
   - M.S.I. 310.10.02 Evaluation Results has to be followed for the evaluation of the results.

4. Supplier approved based on the evaluation?
   - If the supplier is approved based on the evaluation than the Supplier Evaluation process stops.
   - If the supplier is not approved based on the evaluation than M.S.P. 310.10.04 Supplier Development process should be started.
   - If there is no perspective for supplier development the Procurement Manager can decide to phase-out the supplier.

M.S.P. 310.10.04 Supplier Development





Function	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Procurement manager	A	A	A	A	A	A	A	A
Buyer		R	R	R	R	R	R	R
Internal customer				S	S	S	S	I
R = Responsible; A = Accountable; S = Supportive; C = Consulting; I = Informed								

Supplier Development Procedure

1. Start supplier development
   - The Supplier Development process starts based on M.S.P. 310.10.03 Supplier Evaluation.
   - The Supplier Development process can also be started based on internal needs.
   - M.S.I. 310.10.03 Supplier Development Program has to be followed during this procedure

2. Defining the goal of the program
   - The goal of the supplier development program has to be defined and filled in in the table
   - The input comes out of M.S.P. 310.10.03 Supplier Evaluation, as during this procedure a gap between the results of the supplier and the norm of Company X has be found
   - The goal has to be filled in in M.S.F. 310.10.07 Supplier Development Plan

3. Choosing supplier development program
   - A supplier development program has to be chosen based on the goal which is defined
   - In M.S.I. 310.10.03 Supplier Development Program several programs are listed which can be chosen
   - The program which is chosen has to be filled in in M.S.F. 310.10.07 Supplier Development Plan

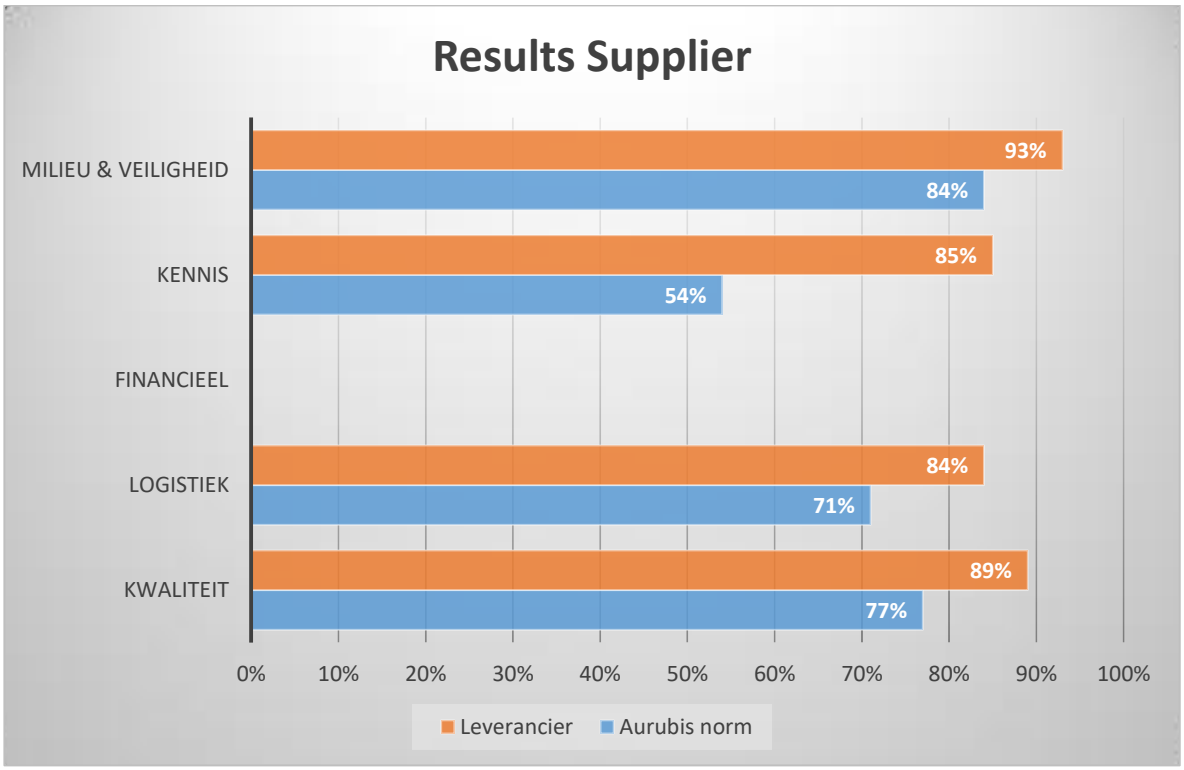
4. Composing a team
   - If necessary, a team can be composed with internal customers who are part of the supplier development program
   - The team members should be filled in in M.S.F. 310.10.07 Supplier Development Plan

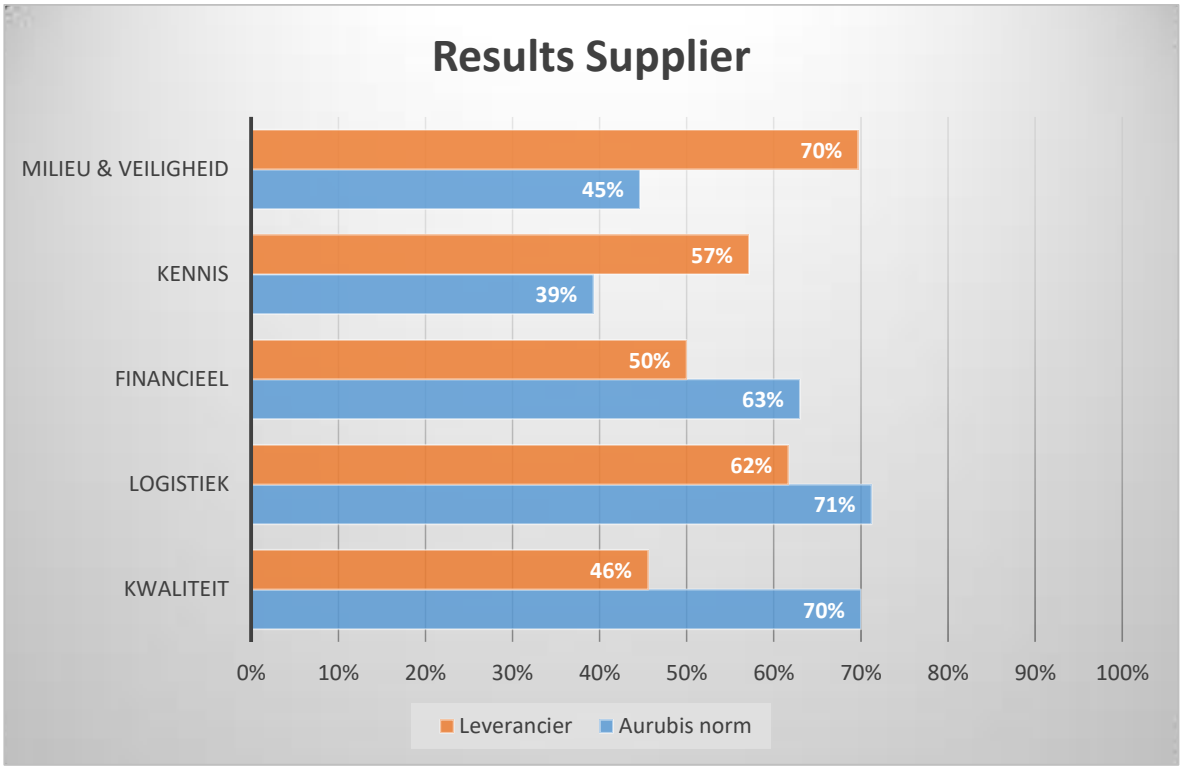
5. Planning the actions
   - Actions of the program should be defined
   - A date and responsible person should be addressed to the actions
   - The actions, date and responsible person should be filled in in M.S.F. 310.10.07 Supplier Development Plan

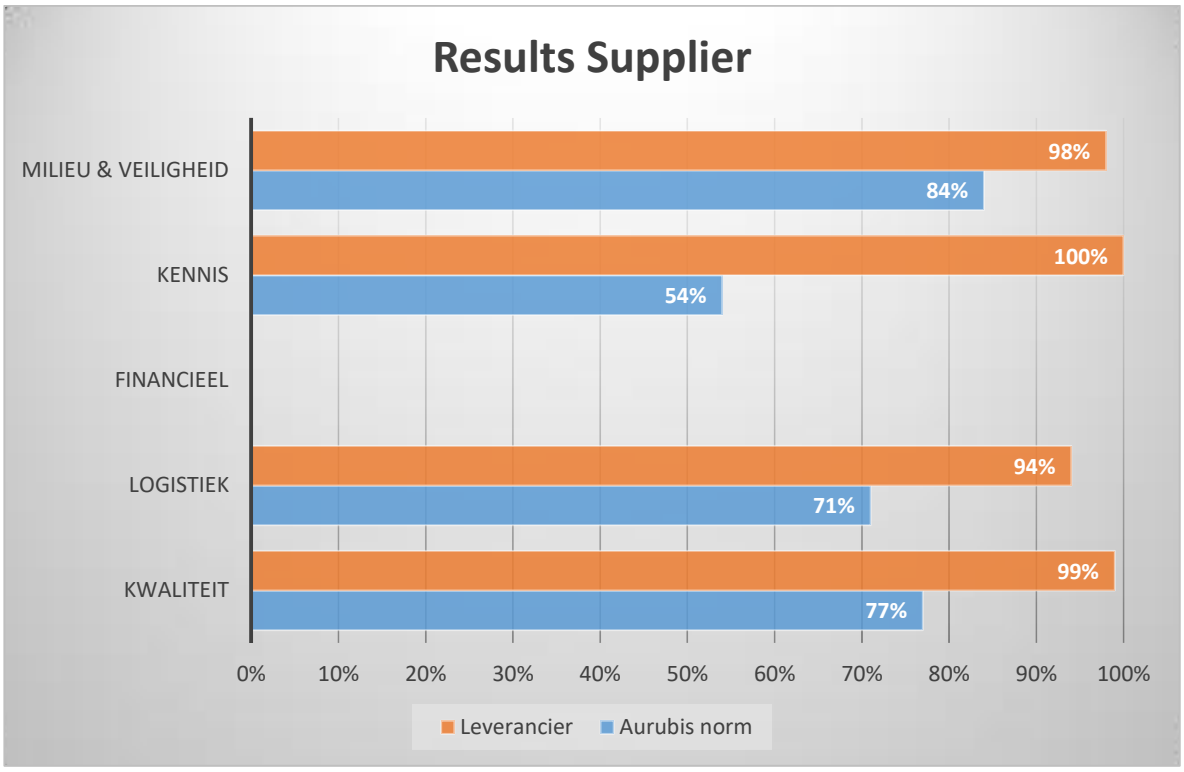
6. Performing supplier development program
   - The supplier development program has to be carried out according to M.S.F. 310.10.07 Supplier Development Plan
7. Analysing the results
   - The results of the supplier development program should be analysed according to M.S.I. 310.10.03 Supplier Development Program

8. Supplier development program successful?
    - The supplier development process ends when the program has been successfully completed, see M.S.I. 310.10.03 Supplier Development Program.
    - If the supplier development program is not successfully completed than a new supplier development program can be started.
    - If there is no perspective for supplier development the Procurement Manager can decide to phase-out the supplier.

Appendix IX: Results test phase Self-Assessment






Results Supplier
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KENNIS
FINANCIEEL
LOGISTIEK
KWALITEIT
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84%
100%
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71%
99%
77%
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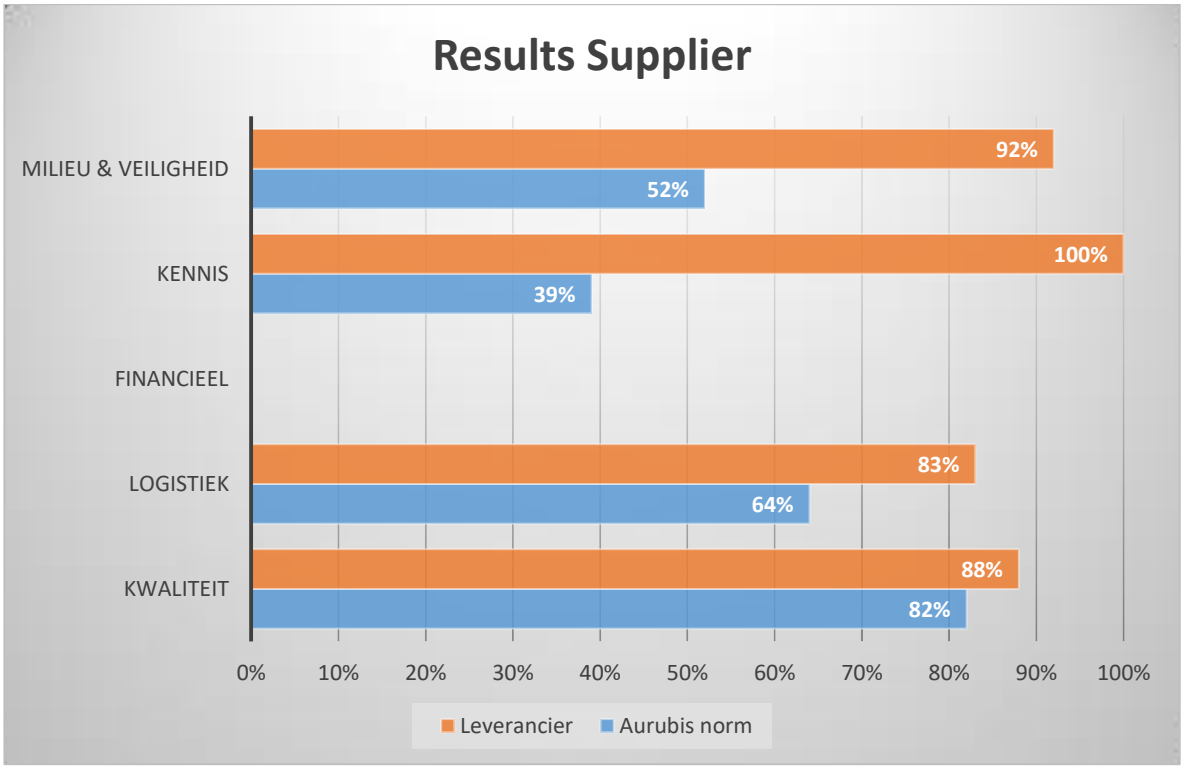
Aurubis norm


Results Supplier
MILIEU & VEILIGHEID
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LOGISTIEK
KWALITEIT
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52%
100%
39%
83%
64%
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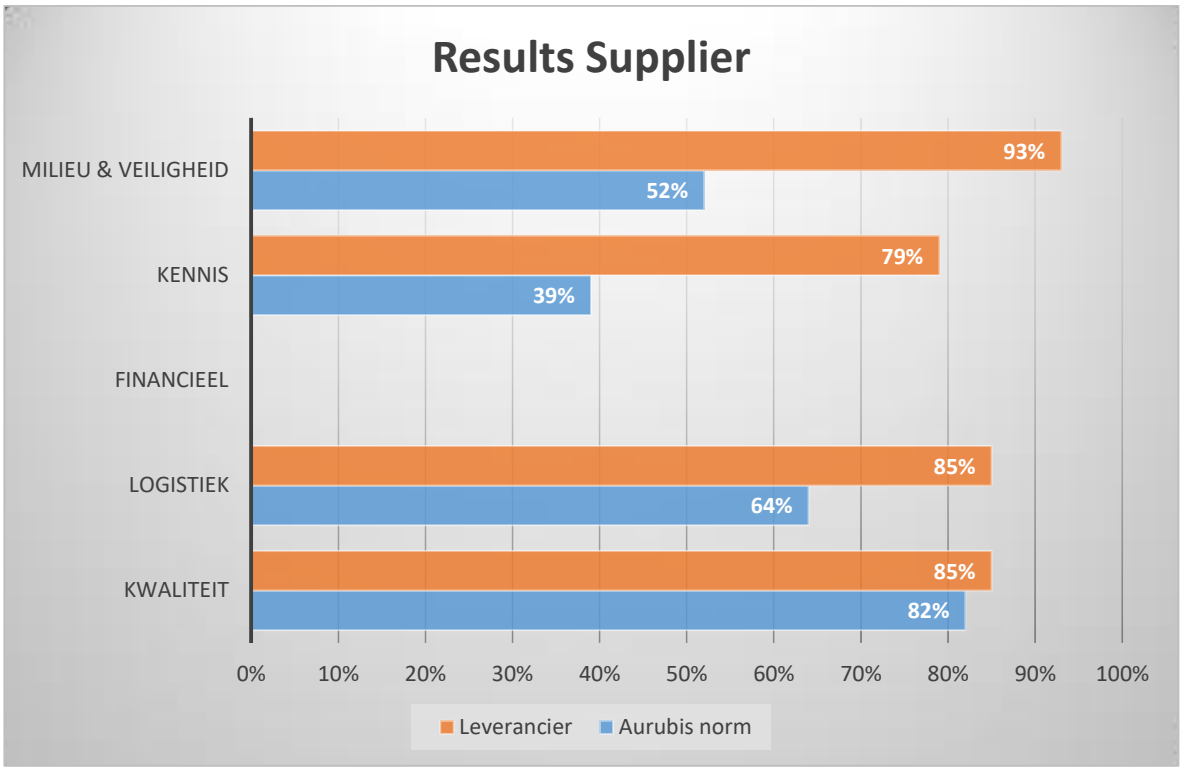
Aurubis norm


Results Supplier
MILIEU & VEILIGHEID
KENNIS
FINANCIEEL
LOGISTIEK
KWALITEIT
93%
52%
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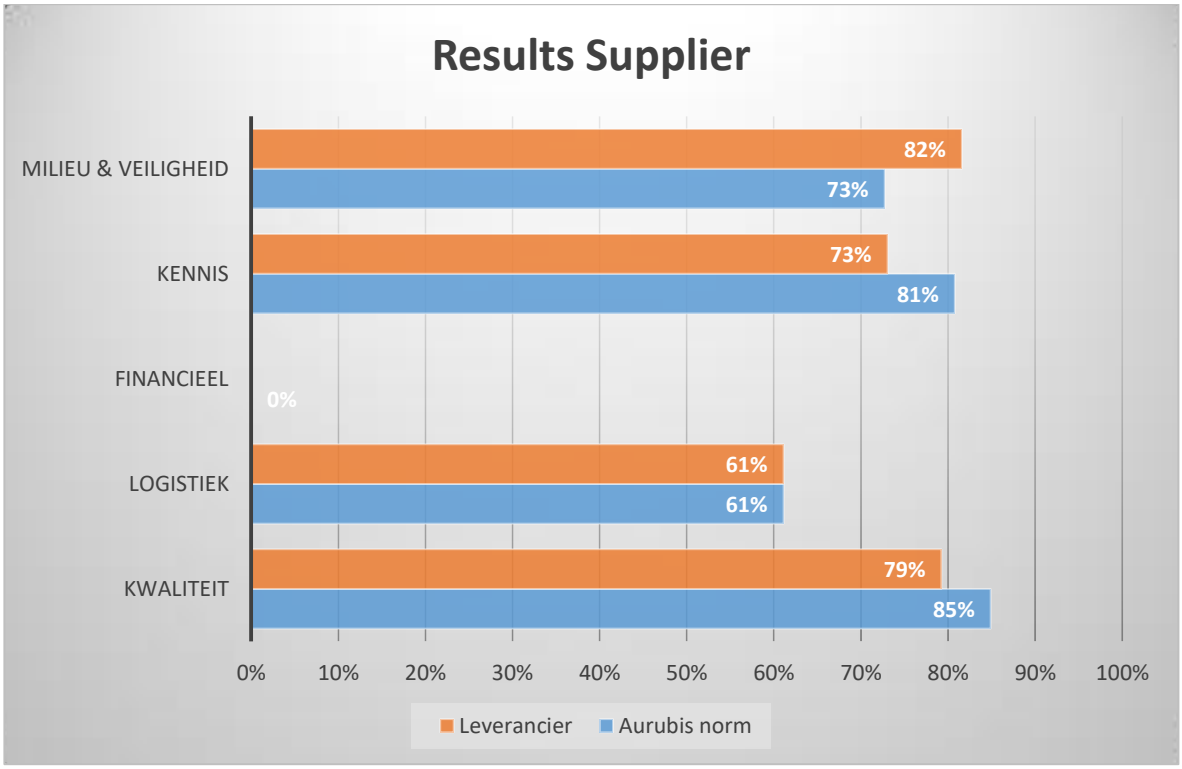
Results Supplier
MILIEU & VEILIGHEID
KENNIS
FINANCIEEL
LOGISTIEK
KWALITEIT
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81%
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61%
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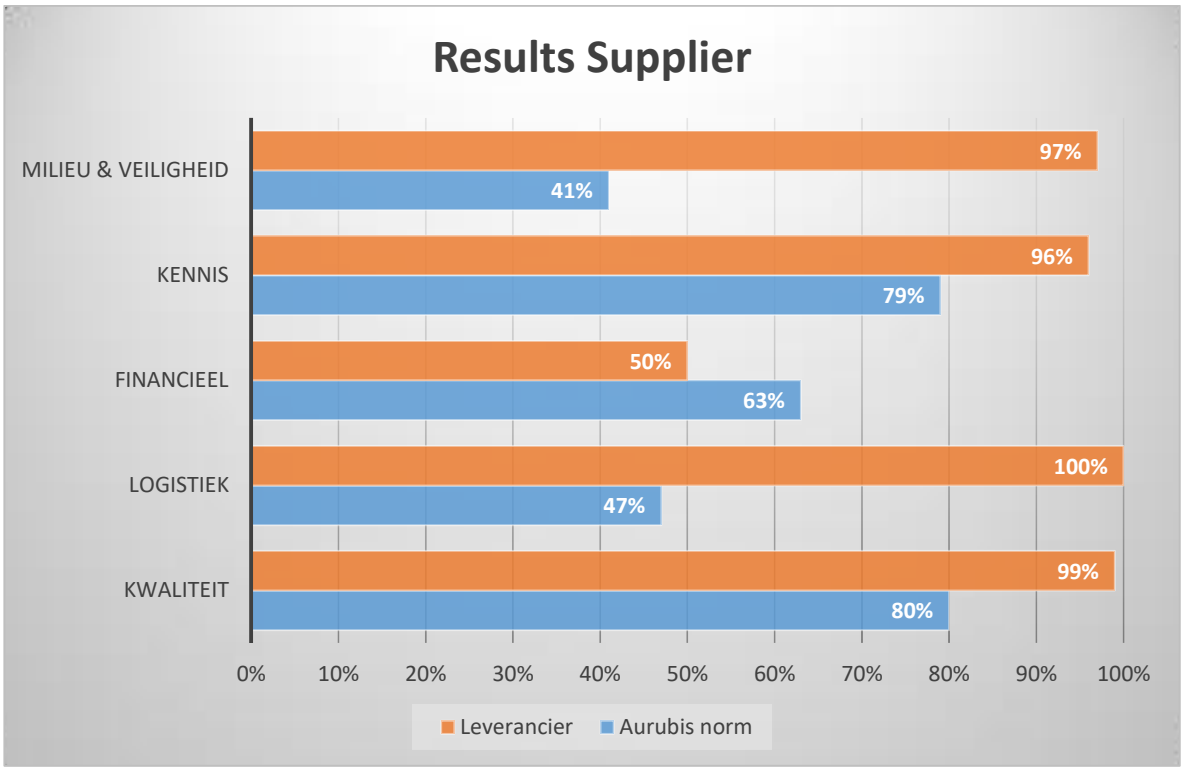
Aurubis norm


Results Supplier
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LOGISTIEK
KWALITEIT
97%
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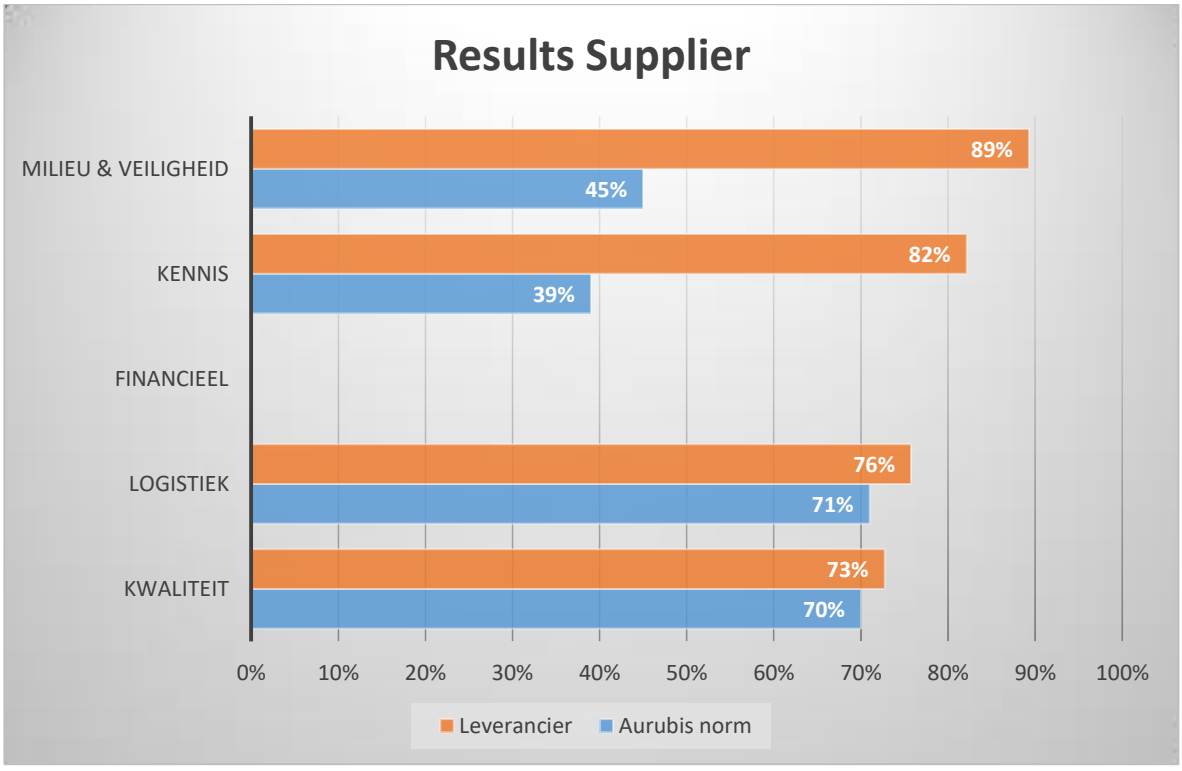
Results Supplier
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