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Master Thesis

Title: Supply Chain Management: A comprehensive Analysis of how to control, assess and maintain Risks and Transparency in complex Supply Chain Systems

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1. Introduction

Globalisation has changed the world. The fact that companies internationalize their supply chains to gain synergies is nothing that just appeared. For many years, free trade and liberalism have led to outsourcing or relocations of production facilities in order to cut cost or to maximize profit. These undertakings have significant impact on the supply chain in form of complexity because the more firms and different countries are part of one supply chain, the more difficult it is to manage, control and assess risks and transparency throughout the system. However, globalisation means an increase in complexity of systems.

Managing complexity is one of the most difficult challenges for multinational companies. Managed well, innovative supply chain solutions may lead to sustainable competitive advantages but not managed well, the complexity of large organisations can lead to failures. In complex systems, it is essential to understand that every action that has been taken is going to lead to one or more results. Furthermore, companies need to be aware that the actions of business partners also have impact on their supply chain performance. Usually, firms are not aware of the actions of their deep-tier or even first-tier supplier. This non-transparent relationship might lead to risks, failure and avoidable costs.

As we live in a dynamic and continuously changing business environment, the risk is high that unexpected factors have impact on the supply chain performance. This underpins that organisations need to be prepared in order to face complexity and the need of transparency. Therefore, businesses must focus on comprehensive supply chain risk management as well as on the importance of inter-organisational information sharing. Organisations need to be able to identify, analyse and overcome supply chain risks and transparency issues by creating appropriate tools that measure the relationship and causality of actions and results under certain environmental conditions. Supply chain controlling is thereby important in order to control, assess and maintain risks and transparency in a complex supply chain system in an appropriate way.

This master thesis provides an overview and definition of supply chain management and discusses more deeply the aspects of supply chain risk management as well as transparency in supply chain systems. Furthermore, this paper tries to find solutions in form of supply chain controlling in order to maintain supply chain risks and transparency. This procedure should underline the importance of transparency along a supply chain and the role of

suppliers, not only direct suppliers but also deep-tier supplier, because a supply chain needs to be seen as one complex system that exists of many different subsystems.

1.1. Theoretical background

Supply chains which involve more than just one country are nothing new. For many years now, companies have increasingly used internationalisation to gain financial synergies in order to generate a higher profit. At the first view, it may sound easy to optimise the financial situation of an organisation by going global: The expectation is that a relocation of processes or production facilities from high- to low-wage countries is going to lead to lower production cost. This cannot be denied and in many cases, the profit is also higher due to comparably low transportation- and transaction costs. However, internationalisation offers many opportunities but also many risks. For instance, company A and B are the only companies in a market with similar products and the same production methods. The only difference between these two companies is their supply chains. Company A has local production facilities in Germany, one central warehouse and a few shops within the country. Company B has a similar structure but wanted to become the market leader by relocating their production to an Asian country where the cost of labour is, in this example, 50% lower than cost of labour in Germany. After adding transportation and duty costs, company B was able to manufacture its goods 20% cheaper than company A. Company B has decided to decrease the current price by 5% and to keep an extra profit of 15%. After 3 months of importing, the new production facility was damaged by an earthquake and the shops in Germany had nothing to sell due to a lean just-in-time production without building up any safety stocks. The cost of repairing the production facility have not been high and after one month the production was running again but back in Germany, people stopped buying the products. Firstly, the image was damaged because the company cut jobs in Germany and secondly, people couldn't get the product constantly. Now, people are willing to pay more for the product of company A because they trust in their products, for example in terms of availability. At the end, a good business idea has become a disaster because of an earthquake, which is a natural phenomenon that cannot be influenced.

1.2. Problem statement

Company B identified a potential but failed because an earthquake hit the production facility. This fictive example has underlined the importance of a comprehensive supply

chain risk management system. Of course, lower wages and low transportation cost can lead to a higher profit but a production abroad including a long way of transportation brings an enormously increasing complexity with it. Another crucial aspect in supply chain systems is transparency and therefore business relationships and information sharing. The problem regarding this theme is that many firms are not aware of the fact that the whole supply chain acts as one system and transparency and shared information might help to overcome possible challenges and risks. In the mid-50s, Jay W. Forrester, professor and researcher at the MIT in Boston has invented the concept of system dynamics. The basic idea of system dynamics is that organisations are systems that consist of many subsystems which are interrelated. Every activity in one of the subsystems will have impact on other subsystems and therefore on the whole system itself. The relation between an action (cause) and a result is nothing but a causality chain. Forrester illustrated these causality chains by using so called feedback loops. Basically, there are two types of feedback loops. Firstly, there is reinforcing loops which are characterized by positive feedbacks and balancing loops which are characterized by a negative feedback. For instance, the more of a cause I put into a reinforcing feedback loop, the more result I will get. On the other hand, the more of a cause I put into a balancing feedback loop, the less effect I am going to get. One key aspect of those loops is that the effect does not appear immediately. Often, effects are going to happen after a certain delay. Therefore, one of the key problems in systems is to find reasons that cause delay. Other main aspects in organisations are to identify linear causality chains, to understand the nature of their feedback loops and to find appropriate activities that affect the loop as needed. One challenge in system dynamics is that the behavior within one loop can change. For instance, the more money I spend on advertising, the higher will get the popularity of my product. This will lead to an increase in sales, most probably after a certain delay. But what if I spend more on marketing but sales start to decline? One reason might be the delay and I need to be patient but another reason might be an inappropriate marketing method. Maybe it worked for a while but a competitor with a similar product has started a campaign which is more attracting and the more I do my advertising, the more people start to avoid buying my product. Firstly, it was a reinforcing feedback loop, I did advertising and I received a higher number in sales but then the loop changed to a balancing feedback loop due to a change in the macro environment. The new marketing campaign of a competitor has changed my feedback loop. This is a simple example of how complex the business environment nowadays is. Imagine, Firm A is part of a market with perfect competition and many firms on the supply side. If it wants to be

successful in the long-term, it needs to be aware of the high complexity. Firstly, what causes delays? Secondly, how can delays be shortened or removed? Thirdly, how can the firm affect their causality chains so that the wanted effect is going to happen? Fully aware of the internal complexity, the firm also needs to continuously monitor the external environment as it is even more complex than the internal environment because it is changing endlessly. Another aspect that underlines the importance of systems thinking is called side effects. So far, it seemed that feedback loops are closed processes meaning that there is one activity (cause) which leads to one effect (result) but of course often one effect is caused by many activities as well as one activity can lead to many effects. The feedback loop might be a closed process so that the company knows exactly what effects going to happen but not rarely activities have side effects that cannot be foreseen. As we understand a firm as one system, one activity might improve the situation of one subsystem but a side effect can occur which can have significantly bad impact on other subsystems. In this case, one subsystem might be optimised but the subsystem optimisation has led to a deterioration of the whole system. Therefore, the optimisation has not been an optimisation. Peter Senge, professor and member of the system dynamics group at the MIT in Boston, analyses these kind of issues as the learning organisation in his book “the fifth discipline” (1990).¹

As many enterprises have global supply chains, they need to manage complex systems with many supply chain risks. In this master thesis, we are going to focus on both, supply chain risks and transparency within a supply chain system. Assuming an organisation that has production facilities in ten different countries in Europe, Asia and South America. Every production facility has ten direct, local suppliers and works together with one logistics partner who transports the produced goods to the headquarter in Germany. This simple system or network already consists of more than 100 organisations. Well, transparency along the network can be ensured by auditing direct suppliers or partners. Besides, certain rules, for example in terms of corporate social responsibility, sustainability or quality, can be set but usually this works only for direct relations. For instance, the production facility in Bogotá, Columbia can audit its ten suppliers and its logistics partner but it is not able to audit the suppliers’ suppliers. We need to assume that every supplier has its own network of suppliers or logistics partners. This increases the risks of lacking

¹ Cf. Peter M. Senge (1990) *The fifth discipline: The Art & Practice of The Learning Organization*. New York, USA: Doubleday, P.220

transparency heavily. By auditing a direct supplier, the company can ensure that this supplier fulfils certain criteria. Perhaps, it is possible to agree that the supplier must audit his suppliers in terms of the same criteria but it is not possible to audit the suppliers of the suppliers' suppliers. Basically, that is the point where a company cannot be transparent anymore. For instance, the Italian confectionery group Ferrero was recently blamed for using child labour to assemble their Kinder chocolate eggs in Romania.² Ferrero, of course, is against any kind of child labour but now Ferrero is going to investigate because this incident might have happened at one of their suppliers in Romania. This example shows that supply chain transparency or supply chain risks generally should be key aspects in all global acting organisations as the complexity of supply chain risks increase simultaneously with the complexity of supply chains themselves.

2. Supply chain management

2.1. Definition

Supply chain management is process oriented and should be taken as a system approach. It is necessary to explain the term supply chain or value chain first. The supply chain begins by the raw material which goes through the purchase process and the production as well as sales and after sales. Therefore, various stages and departments of an enterprise are involved in the supply chain. Every industry and company has its own value chain which is organised in a different way respective the internal and external business environment and needs.³ Certain circumstances led to the fact that businesses payed more attention to their supply chain. These circumstances were for example on the one hand that the companies want to satisfy customer needs and on the other hand that customer continuously want to have improved products for a lower price. Furthermore, another changing circumstance that forces companies to focus on their supply chain are shorter product life cycles. However, in the past businesses cut costs as much as it was possible which means that they have to look at all parts of their business as a whole to improve and produce more efficient.

² Cf. Reuters (2016) Ferrero, prosecutors investigate Kinder egg child labour allegations. [Online] available from: <http://www.reuters.com/article/us-romania-childlabour-ferrero-idUSKBN13J02H> [Last Accessed: 06.01.2017, 12:49pm]

³ Cf. Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management. *Journal of Business logistics*, 22(2), 1-25

In this context companies put their focus on their supply chain in order to reduce costs and improve profits.⁴

Furthermore, companies need to develop an effective supply chain management strategy which fits their needs to improve services and reduce costs. This strategy has to take all undertakings and interactions between the various stages of the supply chain into consideration in order to be successful.⁵

Therefore, the key aim in supply chain management is optimisation in every process and undertaking during the whole value chain. In general, supply chain management is deeply connected with the KAIZEN concept which was developed by Toyota. Kaizen is compiled from two different Japanese words which are “Kai” that basically means “change” and “Zen” which means “for better”. The concept of KAIZEN is shown in supply chain management because this management system tries to identify potential optimisations and change the disruptions into a better way so that the flow of the value chain is going to improve. Both, KAIZEN and supply chain management seek for a continuous improvement.⁶

In general, the definition which is used in this paper is defined as follows:

Supply chain management is the development of a strategy that takes all levels of the supply chain into consideration which basically means the integration of suppliers and production facilities as well as inventory and sales including aftersales to reduce costs and implement a more efficient production by producing and delivering all components at the right time at the right location.

Taking this definition, it is important to say that it is necessary for a company to not only focus on cost reduction but to focus on the whole value chain and thus develop a strategy which approaches the whole system of the particular supply chain. The definition takes the whole supply chain into consideration which includes strategic departments as well as tactical and operational levels which all need to be included and involved in the process of continuous optimisation. The three different levels also have to make decisions which are

⁴ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 1

⁵ Cf. Fawcett, S. E., Magnan, G. M., & McCarter, M. W. (2008). Benefits, barriers, and bridges to effective supply chain management. *Supply Chain Management: An International Journal*, 13(1), 35-48

⁶ Cf. Paul Brunet, A., & New, S. (2003). Kaizen in Japan: an empirical study. *International Journal of Operations & Production Management*, 23(12), 1426-1446

based on different time frames. The strategic level has to make decisions which have huge impact on the whole company. Some examples of these decisions are the discrepancies between vertical integration or outsourcing as well as product design and the selection of suppliers including warehouses and the quantity and location of the different storage areas as well as with whom the company should form a strategic partnership. The decisions made at the tactical level are renewed almost quarterly which is a smaller timeframe as in the previous level. The operational level has to decide on daily issues like scheduling or lead times. These facts show that supply chain management need to be aware of certain superordinate strategies like market share or set business goals as well as that communication along the supply chain is important in order to discuss for example abnormalities in order to reach a continuous improvement.⁷

There are some challenges which have to be pointed out when talking about supply chain management. The first challenge is that a single supply chain cannot be seen in isolation. Every undertaking within a company or between business partners is linked to something else, thus, a supply chain system is a complex framework. The supply chain is also linked to the research and development department of a company even though they are not directly connected. When a business only focuses on the main parts of a supply chain without taking the remaining departments and external business environment into consideration, the strategy might fail or at least will not reach the optimum of improvement.⁸ Secondly, today's businesses are generally globally organised and have different parts of the supply chain in different countries or even continents. This increases the difficulty of reaching a system wide improvement regarding cost reduction and service improvement. Mainly, the process of developing an international strategy which includes the whole system, is called global optimisation.⁹

The term global optimisation brings a lot of difficulties with it. Speaking of this type of optimisation, it is important to know that supply chain systems which are organised globally are highly complex systems. These systems are widely scattered geographically

⁷ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 12

⁸ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 3

⁹ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 4

and therefore contain different cultures and languages which increases the complexity of communication. Objectives are important and need to be defined by every business individually and thus every company has different objectives which suit their needs best. Imagining that a business processes and the whole supply chain of a company are connected with other businesses makes managing a globally organised supply chain even harder because the objectives of both companies might stay in conflict or even will not complement to each other. Time is also a very important factor while developing a supply chain strategy as well as implementing a supply chain itself. Both, the planning process and implementation of strategies take time. Furthermore, supply chain systems that strive for global optimisation evolve over time. Factors, that influence supply chain systems, might change over time like customer demand or even purchase demand of a company. These influences affect the supplier-buyer-relationship which needs to be developed continuously. Nevertheless, global optimisation is a continuous improvement and on these grounds, a company sometimes has to think about system variations because the internal and external business environment changes dynamically and in order to still fulfil customer needs, the company has to change certain business processes. Some examples could be seasonal fluctuation, trends, risks like natural disasters or even product developments and innovations of a competitor. However, global optimisation is not only a term used to optimise departments or parts of one company but also to optimise processes and strategies regarding the whole supply chain.¹⁰

2.2. Key issues in supply chain management

As mentioned before, supply chain management and global optimisation are very complex and thus appear many issues while implementing business strategies. Issues can appear in all parts of a business. To divide issues, a manager could use the approach of three different levels: strategic, tactical and operational level. One issue could be regarding warehouses which are used inefficiently or due to changes in business or business environment it is needed to undertake certain actions. There are different situations that could cause necessary changes in a warehouse like a change in product demand, the implementation of a different product or even the need to change locations. These circumstances lead to certain actions and decisions which have to be made. One action that the firm might need to do is to look for new suppliers because of the change in locations or

¹⁰ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2004). *Managing the Supply Chain*. Mc Graw Hill Education, New York. P. 4-5

change in production requirements due to a different customer demand. Businesses need to be aware of these issues and address the right solutions towards them. One issue which is connected with the warehouse is the management and control of a firm's inventory. Every firm needs to consider the amount of inventory which is needed in order to satisfy customer needs. At this point, it is necessary to identify the causes of demand changes so that it is easier to react on them and to decide on the amount of inventory needed.¹¹

Another issue is that suppliers can have different objectives than the particular buyer. Every firm focuses on their single business and tries to gain the most profit possible. This single-minded focus might lead to issues like miscommunication and information asymmetry. Another negative outcome could be that both firms are not able to improve their systems to an optimum because the overlapping processes or the used information technologies are not complementary to each other. The relationship between supplier and buyer needs to be in a continuous communication in order to overcome a pareto optimum and establish improvements for both parties.¹²

Transportation costs and production costs are connected because when a firm wants to reduce production costs by having different parts of a product manufactured at different places, the transportation costs will raise. On the other hand, when a firm wants to reduce logistical costs, they need to produce as much parts as possible at one place so that transportation is less needed. This is one example where issues can be addressed because businesses need to identify the right balance between production and transportation costs as well as production efficiency.¹³

Distribution manners are also highly related to transportation issues as a company has to face the decision how they want to distribute their products and under which circumstances which strategy is the most efficient. Furthermore, it is important to decide whether

¹¹ Cf. Lambert, D. M., & Cooper, M. C. (2000). Issues in supply chain management. *Industrial marketing management*, 29(1), 65-83

¹² Cf. Carr, A. S., & Pearson, J. N. (1999). Strategically managed buyer-supplier relationships and performance outcomes. *Journal of operations management*, 17(5), 497-519

¹³ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 13

centralise or decentralise distribution. Those issues are addressed to the strategical level because they have a long-lasting effect on the firm.¹⁴

The price of a product needs to be chosen well because if the price is too high customers won't buy it and when it is too low, the company might not make any profit. The price needs to cover all costs including inventory. Managing these issues successfully could be done by using smart pricing strategies.¹⁵

Technology is very important for a today's company because it helps to collect, store and analyse data. The amount of data which a company collects daily is needed but not all kinds of data are needed for every purpose. Therefore, it is necessary to sort information and take only those into consideration which are important for a particular purpose because otherwise there will be an overload of information and this could lead to serious challenges like time issues. Technology systems can help to sort and analyse information in order to classify not required and needed information and thus support decision-making processes.¹⁶

Not only the product, also the after sales service and the company itself, need to satisfy customer needs. Customer relationship management could help to improve services and products and make customers feel important or as a part of the company. A company has to decide on which approach they are using to achieve that their customers are satisfied. Businesses could for example use technology systems but overall it is necessary to know what supply chain management itself contributes to generate customer loyalty.¹⁷

However, besides the ability to run the supply chain cost-effective and fast, firms need to make their supply chains agile, adaptable and aligned which is an issue that needs to be addressed by every supply chain management. Agility means that companies need to be able to respond to changes in supply or demand quickly even though they are short-term changes. This means that firms need to have the ability to recover quickly after disruptions like cyber-attacks or natural disasters. Therefore, agile supply chain systems are in the

¹⁴ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 13-14

¹⁵ Cf. Fleischmann, M., Hall, J. M., & Pyke, D. F. (2004). Smart pricing. *MIT Sloan Management Review*, 45(2), 9

¹⁶ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 14-15

¹⁷ Cf. Chen, I. J., & Popovich, K. (2003). Understanding customer relationship management (CRM) People, process and technology. *Business process management journal*, 9(5), 672-688

position to handle and react to unexpected changes and disruptions cost-efficiently and easily. Adaptability refers to external market changes and the ability to react on those changes. The changes in strategy and adaptations of new conditions evolve over time like new environmental regulations or law changes. The third aspect which needs to be addressed is that the supply chain should be aligned. The main issue in that aspect is that companies need to motivate their business partners to implement strategies and processes in order to improve the performance of the complete supply chain.¹⁸

2.3. Supply chain management integration

As already discussed, the conventional form of a supply chain consists of suppliers, manufacturers and retailers or shops. There are several activities that have to be coordinated along the supply chain when a company wants to integrate the strategy and achieve cost reduction as well as improvement in services and to optimise the use of resources. Businesses need to be aware that the most difficult part of integrating the supply chain is that customer demand determines the transportation and production segment. Information and information availability are very important for the supply chain integration because every industry and company has a different amount of information available on which the supply chain is built. Some businesses have the purpose to build supply chain in order to gain information, others have already information and use them to build the supply chain. However, there are three supply chain strategies which are the pull strategy, push strategy and a hybrid between both of them which is called push-pull strategy.¹⁹

The pull strategy is based on customer demand instead of forecasting. This means that the business only produces when there is an actual demand and therefore the company has no inventory. To use this strategy a firm has to have a fully developed information system so that every segment of the supply chain is immediately informed if there is a specific order. If the order is received, the necessary production processes can begin and they can pull the needed material. This strategy has the advantages that it decreases lead times which helps to organise and anticipate incoming orders better as well as it leads to a decrease in inventory at the firm itself and at the retailer because none of the parties are bound to lead

¹⁸ Cf. Lee, H. L. (2004). The triple-A supply chain. Harvard business review, 82(10), 102-113

¹⁹ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2004). Managing the Supply Chain. Mc Graw Hill Education, New York. P. 42

times. The decrease in lead times also has the advantage that variability in the system decreases. Due to the reduction of inventory, it is easier to manage resources which as well reduces system costs. Every system and strategy has its downsides, so does the pull strategy. Many businesses like to take advantage of economies of scale which is almost impractical with the pull system because the production only reacts on customer demand which might not be as high to reach economies of scale. Another negative aspect is that this strategy is hard to implement in firms that have long lead times which makes it difficult or even impossible to react on information regarding specific orders or customer demand.²⁰

On the other side, there is the push-based supply chain strategy. On the contrary to the pull-based supply chain, this system is based on long-term forecasts. Businesses that apply this strategy receive and collect information which build the base for the forecasts. This application takes much more time to react on customer demand fluctuation. Therefore, the inventory is high. If customer demand changes and another product is requested, it might be the case that the inventory might not be used anymore and thus takes place in the warehouse which then binds capital which is costly. The bullwhip effect applies in this strategy and thereby the warehouse and the retailer face a higher variability in demand.²¹

The third supply chain strategy is a combination of both, the push-based and pull-based supply chain to overcome the pitfalls of each strategy. The supply chain is therefore divided into two parts by an interface which is called push-pull boundary. However, a company which applies such a strategy builds its products according to customer demand. Therefore, this means that the stock level of components is based on forecasts but final production is based on specific order and customer demand. This means that the production begins with the assembly of the components at the push-pull boundary. In general, the effect of uncertainty is lower in component demand than in finished goods because the same component might fit into several products which increases the flexibility of business processes and decreases the company's safety stock.²²

²⁰ Cf. Cachon, G. P. (2004). The allocation of inventory risk in a supply chain: Push, pull, and advance-purchase discount contracts. *Management Science*, 50(2), 222-238

²¹ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2004). *Managing the Supply Chain*. Mc Graw Hill Education, New York. P. 42-43

²² Cf. Ghrayeb, O., Phojanamongkolkij, N., & Tan, B. A. (2009). A hybrid push/pull system in assemble-to-order manufacturing environment. *Journal of Intelligent Manufacturing*, 20(4), 379

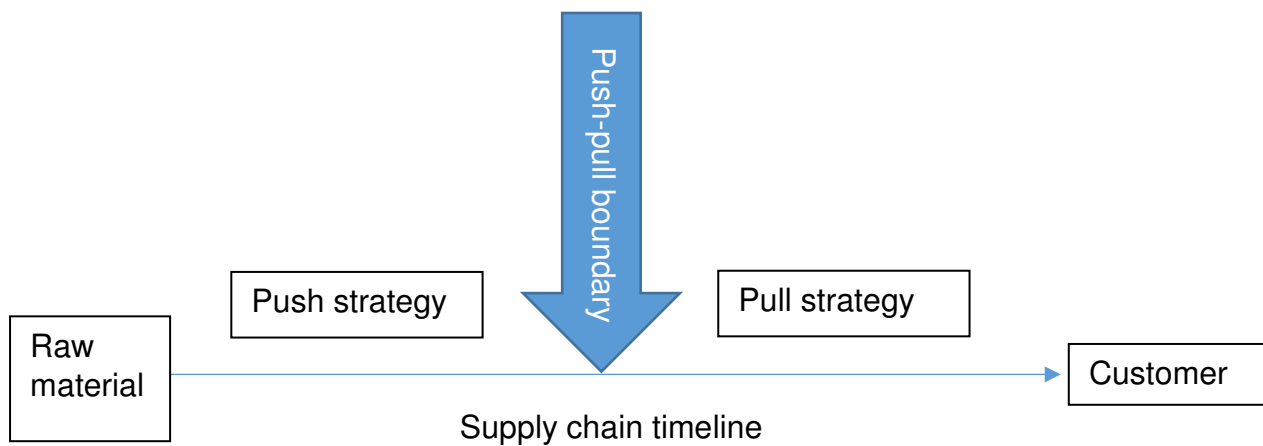


Figure 1: Supply chain timeline²³

Having these three options, a company has to decide which strategy suits their company and business processes best. The decision should be based on the volume of uncertainty in customer demand and the dependence on or need for economies of scale. Based on this information, the firm can decide either on a pull strategy when the information given tend to a high uncertainty in customer demand or a push strategy when the uncertainty in customer demand is smaller regarding the assumption that everything else is equal. A company would also decide on a push-based strategy when economies of scale are important to reduce costs. In this case, the firm would need a forecast to manage their supply chain. If a company does not depend on aggregated demand, a pull-based strategy would be advantageous. Nevertheless, integrating one of these strategies requires to consider many factors like lead times, product design and the complexity of the supply chain as well as the relationships between supplier and buyer.²⁴

2.3.1. Manufacturing technologies and strategies

To gain a competitive advantage against a firm's competitor, businesses were forced to change aspects in their system like business processes or technology. Businesses need strategies or technologies which help them to compete better in their markets and to gain a higher market share. As well, the ongoing globalisation puts businesses in a situation of

²³ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 190

²⁴ Cf. Ghrayeb, O., Phojanamongkolkij, N., & Tan, B. A. (2009). A hybrid push/pull system in assemble-to-order manufacturing environment. *Journal of Intelligent Manufacturing*, 20(4), 379

fierce competition with different competitors from other countries which might benefit from cheaper production factors such as lower wages. However, Companies want to develop different strategies and manufacturing technologies to reduce costs in their system in order to gain these competitive advantages. The following pages describe some business strategies that help companies to gain advantages.

2.3.2. Just-in-time (JIT)

This system was developed by Toyota to reduce waste for example in form of unused time and therefore costs. In general, the just-in-time system is a logistics and regulation concept to manage the material flow of a supply chain. The necessary material is only delivered when it is needed. Furthermore, it is going to be delivered directly to the location where the production requires this material or component. This concept helps organisations to reduce costs by reducing inventory because full warehouses bind capital and are therefore very cost-intensive. If the production flow is managed well, Just-in-time production decreases the amount of required warehouses. Not only the reduction of storage facilities helps to reduce costs, this strategy also reduces the time of throughput and decreases the capital commitment by financing less buildings and setting capital free because of less inventory. Furthermore, the firm's supply chain system needs to have a certain material and production flow along the whole supply chain which requires trust and reliability to implement this production and delivering method.²⁵ Over the time, Just-in-time developed to even more efficient production methods such as just in sequence. This concept is even more time-scheduled than JIT because the material which is needed for the production is delivered in just the sequence of the production when it is needed. Therefore, in contrast to JIT there is even less inventory needed which leads to an even higher cost reduction. On the other hand, this type of sourcing is even more demanding than JIT because it requires different factors like a perfectly planned time schedule as well as good supplier-buyer-relationships and information sharing systems. Furthermore, industries that apply either one of these strategies are characterised by a large variety of products and a large series size as well as modular systems. Beside these facts such companies usually have a strong competitive position.²⁶ However, this system aims to have a higher customer orientation

²⁵ Cf. Sugimori, Y., Kusunoki, K., Cho, F., & Uchikawa, S. (1977). Toyota production system and kanban system materialization of just-in-time and respect-for-human system. *The International Journal of Production Research*, 15(6), 553-564

²⁶ Cf. Wagner, S. M., & Silveira-Camargos, V. (2011). Decision model for the application of just-in-sequence. *International Journal of Production Research*, 49(19), 5713-5736

and a continuous material and information flow along the supply chain while reducing costs and setting capital free. A higher customer orientation applies with this system because the business can react better to demand fluctuation due to less unbalanced inventory surplus. On the other side, technological systems which help to organise the time schedule and delivering processes are required.²⁷

Advantages	Disadvantages
Cost reduction	Prone for delay
Reduction of capital commitment	Buffer time might occur
Faster throughput	Prone for external influences
Continuous material flow	Investment in technological support systems
Continuous information flow	
Higher customer orientation	
Higher market orientation	
Shorter lead times	

Table 1: Pros and cons of Just-in-time production - Table at own construction

2.3.3. Kanban

Kanban is a system to regulate the production process more efficient. Kanban is based on the pull principle which means that every production section pulls the needed material from the section beforehand. Kanban is Japanese and means “card”. These Kanbans have to be developed for every company and industry individually because every supply chain is organised differently and products need different parts at different stages. Basically, this system starts with the customer order which is written down on the cards. The cards show every worker necessary information regarding for example quantity and shape. A production consists of upstreaming and down streaming production segments which work together in order to manufacture the end-product. Upstreaming production segments produce parts of the product which are needed for the following down-streaming production segments. As mentioned earlier, Kanban is based on the pull principle because the down-streaming production segments tell the upstreaming production segments what they need for the certain customer order by using Kanbans which show all necessary

²⁷ Cf. Sugimori, Y., Kusunoki, K., Cho, F., & Uchikawa, S. (1977). Toyota production system and kanban system materialization of just-in-time and respect-for-human system. *The International Journal of Production Research*, 15(6), 553-564

information. This system allows businesses to reduce storage to a minimum because particular parts of the product are only produced when the float of this particular part is exhausted and the upstreaming production segment gets the information of restocking by Kanban. This makes it possible for businesses to react better to demand fluctuation and leads to a better throughput of material and information which reduces costs and capital commitment. Overall, it is necessary that all information required are described in as less Kanban cards as possible to prevent misleading information and miscommunication which might result in a waste of time and an increase of costs. Kanban systems are mostly used in combination with just-in-time strategies because of the increase in flexibility. The following diagram shows the production and information flow which occurs by using the Kanban system in a manufacturing organisation.²⁸

Production process by Kanban

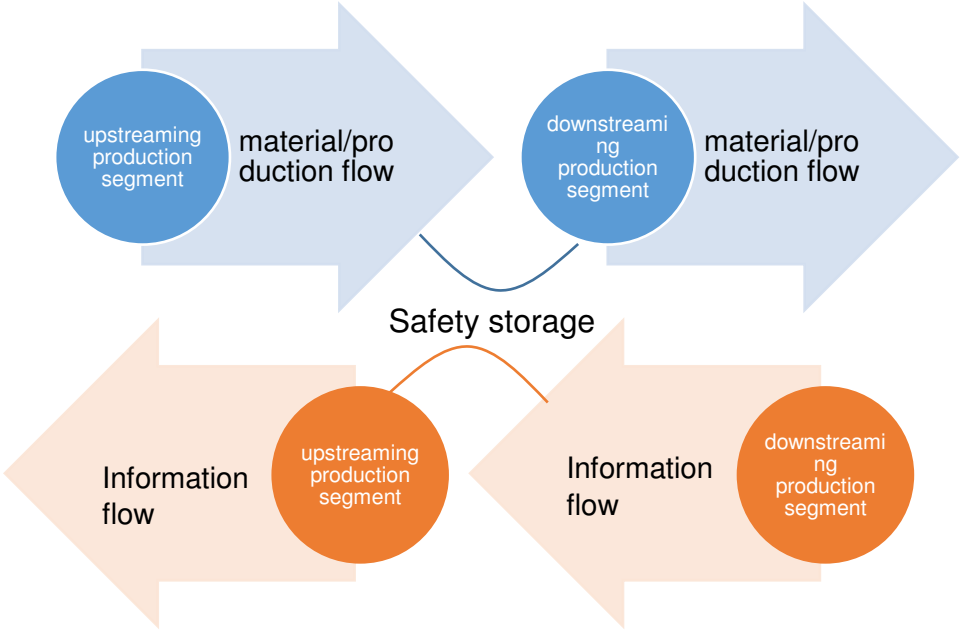


Figure 2: The Kanban process - Illustration at own construction.

Advantages	Disadvantages
Influence on material flow	Stable systems are needed
Increase in flexibility	Not usable for project or single

²⁸ Cf. Sugimori, Y., Kusunoki, K., Cho, F., & Uchikawa, S. (1977). Toyota production system and kanban system materialization of just-in-time and respect-for-human system. The International Journal of Production Research, 15(6), 553-564

	manufacturing
Less coordination needed	Safety stock needed
Cost reduction	
Better reaction to fluctuation in demand	
Reduction of regulation effort	
Increase in process transparency	

Table 2: Pros and cons of Kanban - Table at own construction.

2.3.4. Lean manufacturing

Lean manufacturing or lean management describes the continuous process of reducing waste within the value chain. Waste in the context of lean management stands for production activities in any kind which do not add value to the process or product and thus for the customer. Some examples of waste are over production, too high inventory, bound capital, long transportations which are time and cost intensive as well as down or waiting times in the production process. These actions interrupt the flow and are thus considered as waste as well as complex and time-consuming processes because they are hard to control and limit flexibility. Another waste is knowledge and skills which are not used to optimise the process. Nevertheless, every employee needs to fully commit to the system so that all knowledge and information can be used to achieve continuous improvement and reduction of waste.²⁹

However, lean production tries to reduce unnecessary processes and undertakings which lead to time saving and cost reduction. Basically, this concept of production is very organised and system-oriented. Lean management also supports that a company mainly focuses on their core values. Restructurings in form of outsourcing are also part of lean management because the main incentives for outsourcing complement the incentives of lean management like cost reduction as well as the focus on key competencies.³⁰

There are key principles which have to be applied in order to implement lean manufacturing beneficially. Some principles are for example that fully commitment of all

²⁹ Cf. Abdulmalek, F. A., & Rajgopal, J. (2007). Analysing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. *International Journal of production economics*, 107(1), 223-236

³⁰ Cf. Abdulmalek, F. A., & Rajgopal, J. (2007). Analysing the benefits of lean manufacturing and value stream mapping via simulation: A process sector case study. *International Journal of production economics*, 107(1), 223-236

business and employees is required as well as the reduction of waste and continuous improvement. These principles are followed by the fact that if something is not going well or if there is another more efficient possibility, changes or restructurings are needed.³¹ The consequence of these principles are mainly lower hierarchies, implementation of technical equipment in an efficient way like Kaizen, quality management, implementation of just-in-time systems, process orientation and the improvement of skills and commitment. However, these principles show that lean production is a set of tools and techniques to improve efficiency and reduce costs.³²

Advantages	Disadvantages
Low hierarchy	Investment in technological support systems
Faster decision making	Release of employees
Better communication	Time-intensive implementation
Higher productivity	
Cost reduction	
High commitment of all employees	
Higher flexibility	

Table 3: Pros and cons of lean manufacturing - Table at own construction.

2.3.5. Total quality management (TQM)

Total quality management is a manufacturing strategy that includes all parts of an organisation to ensure quality along the supply chain in order to increase value for the customer. This strategy is the implementation of actions and business processes that continuously collect, store, analyse and control information to introduce and ensure total quality along the value chain. However, total quality management is built on several principals to fully commit and implement this strategy. One principle is that quality always depends on the customer’s preferences and thus the customer always determines the quality.³³ Quality itself is not only seen in the product but also in internal processes which need to have a certain standard to ensure the requirements. Nevertheless, a company has to

³¹ Cf. Warnecke, H. J., & Hüser, M. (1995). Lean production. *International Journal of Production Economics*, 41(1), 37-43

³² Cf. Shah, R., & Ward, P. T. (2003). Lean manufacturing: context, practice bundles, and performance. *Journal of operations management*, 21(2), 129-149

³³ Cf. Douglas, Thomas J., and William Q. Judge. "Total quality management implementation and competitive advantage: the role of structural control and exploration." *Academy of Management Journal* 44.1 (2001): 158-169

be aware that quality is not an aim but a continuous process which implies energetic actions. These actions need to be applied by every employee to use all available information to improve quality on a continuous scale. These principles lead to the assumptions that employees need to have a high commitment towards the company and should be educated about all processes and the requirements.³⁴ The main aspect of total quality management is that quality is not determined by technical functions but also on the relationship between customer and company as well as buyer and supplier by considering the supply chain. Superordinate is the aim that businesses which apply total quality management want to ensure total customer satisfaction.³⁵

2.4. Differentiation between supply chain management and logistics

In order to be able to explain the difference between supply chain management and logistics, it is important to have both definitions. As mentioned earlier supply chain management is in this paper defined as:

“Supply chain management is the development of a strategy that takes all levels of the supply chain into consideration which basically means the integration of suppliers and production facilities as well as inventory and sales including aftersales to reduce costs and implement a more efficient production by producing and delivering all products at the right time at the right location.”

Logistics on the other hand needs to be discussed more deeply at this point. Overall, the term logistics in a business context means the organisation of resources, storage, production and distribution. Resources in this context doesn't only mean material, it also means that personnel requirements are included. Furthermore, logistics is in charge of the planning, organisation, execution and control of those aspects and processes which also include the procurement of a company. However, logistics like all other departments has to act and react to achieve the superordinate goals and objectives of the company.³⁶

The descriptions given of logistics and supply chain management lead to the assumption that logistics is a part of supply chain management. Supply chain management goes

³⁴ Cf. Goetsch, D., L. & Davis, S. (2014). *Quality Management for Organizational Excellence: Introduction to Total Quality*. Seventh Edition. International Edition. Pearson, London. P. 3

³⁵ Cf. Fynes, B., & Voss, C. (2002). The moderating effect of buyer-supplier relationships on quality practices and performance. *International journal of operations & production management*, 22(6), 589-613

³⁶ Cf. Harrison, A., & van Hoek, R. I. (2008). *Logistics management and strategy*. Third Edition. Pearson Education, London. P.10

beyond the point of the procurement and organisation of materials; it includes the whole supply chain from the supplier and sometimes deep-tier supplier to customer satisfaction at the end of the value chain. To see this argumentation from a company’s point of view, it is necessary to point out that logistics only deals with the issues within its company. Supply chain management on the other hand tries to optimise material and information flows also between supplier and buyer or the company and customers. Therefore, supply chain management involves a wider range of activities than logistics.³⁷

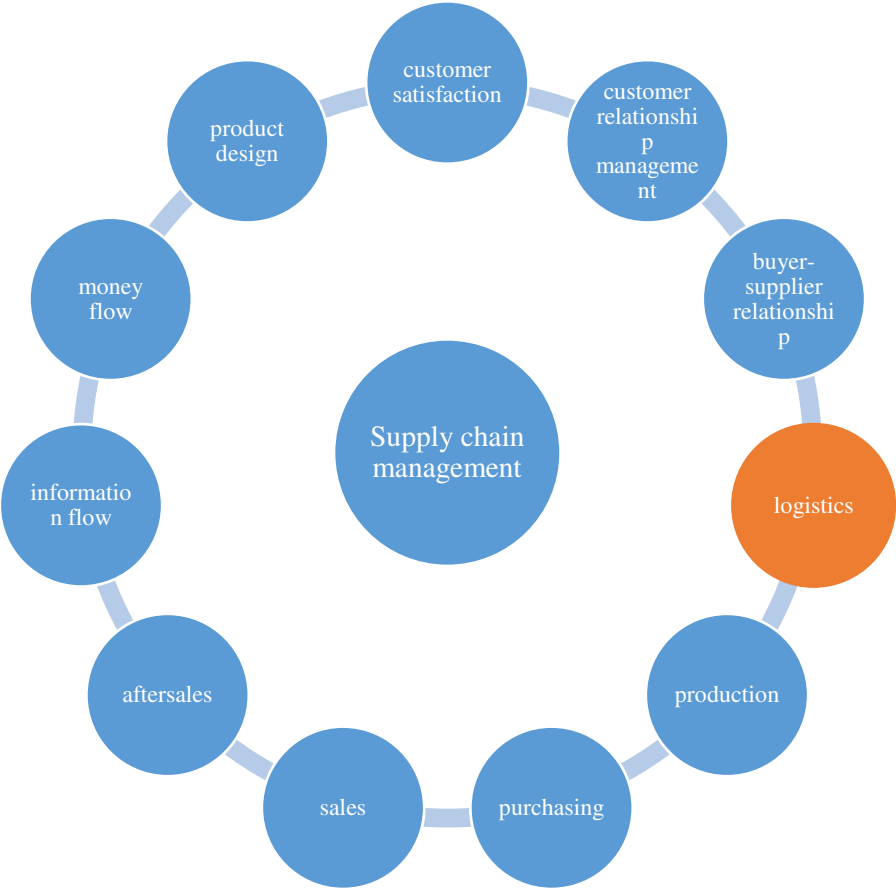


Figure 3: The functions of supply chain management - Illustration at own construction.

2.5. Sustainable supply chain management

Global warming and the fact that humanity and industry take advantage of resources of the earth are only two incentives for companies to implement environmentally sustainable practices, production methods and supply chains. Sustainability means that undertaken developments should be able to meet the current needs without compromising the needs of

³⁷ Cf. Christopher, M. (2016). Logistics & supply chain management. 4th. Pearson Higher Ed P. 3

future generations.³⁸ Furthermore, the ongoing globalisation and increase in information sharing makes it even more likely for companies to assemble their production towards a green concept. Focal companies that are in charge of product design and production are thus even more responsible for the actions of their supplier because information is spread rapidly. Negative information such as a pollution which is above the ordinary or cruelty to animals, for example, lead to a bad image and therefore to a decrease in sales and drop in profits. This is facilitated by social media platforms on which people can easily spread information. Because of these aspects, there is a need for open, honest and a high level of communication and cooperation between suppliers and manufacturers.³⁹ Nevertheless, companies have to be aware of environmental and social challenges in their supply chain to prevent unforeseen negative impact. However, to prevent those negative influences on the business as well as to limit waste and reduce needed resources and energy, companies start to implement sustainable and green supply chain management. This management strategy takes the theme of supply chain management on an even higher complexity level than it was already before because it takes more factors into consideration than supply chain management itself. The key target of sustainable supply chain management is to create a supply chain which involves environmentally friendly and sustainable practices. This includes every stage of the supply chain; from product design over purchasing, production and distribution, consumption and recycling. Beside the wider range of operational issues which need to be addressed, sustainable supply chain management also widens the objectives by taking social dimensions into account. This underlines the factor of high complexity in supply chain systems.⁴⁰ Sustainable supply chain management requires serious activities and knowledge about local, regional and international influences on the environment regarding human beings and animals. Industrial undertakings shouldn't intervene the quality of life and health of the environment. Logistics and especially transportation is an important factor regarding this topic because a high need in transportation results in higher pollution caused by trucks, trains or airplanes. Especially globalisation and that firms act on an international scales with plants all over the world,

³⁸ Cf. Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International journal of physical distribution & logistics management*, 38(5), 360-387

³⁹ Cf. Koplin, J., Seuring, S., & Mesterharm, M. (2007). Incorporating sustainability into supply management in the automotive industry—the case of the Volkswagen AG. *Journal of Cleaner Production*, 15(11), 1053-1062

⁴⁰ Cf. Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, 9(1), 53-80

transportation and thereby connected emission is a high discussed field of interest.⁴¹ Overall, sustainable supply chain management is highly related to corporate social responsibility.⁴² Another incentive for companies to implement sustainable practices is that many governments offer support or monetary incentives for developing a sustainable supply chain. Nevertheless, in many countries rules and regulations are made that protect the environment and safety and security including the health of animals and human beings. These laws need to be considered and applied by organisations that want to practice in the particular countries and want to be sustainable.⁴³ However, firms that apply sustainable supply chain management are thoughtful about their carbon footprint and try to reduce waste in any form and to develop their production to a more environmentally friendly manufacturing. Therefore, all actions, undertakings and supply chain facilities can be optimised by using sustainable practices. Besides the fact of the achievement of a greener supply chain, customers will recognise and honour the way companies try to reduce resources and energy and this might lead to higher sales and thus more profit.⁴⁴

Corporate social responsibility (CSR) is connected with business ethics and the ethics standards of the particular company. Basically, it means that companies need to have a full understanding about their social responsibility and that they need to do their business and make their decisions in a sustainable context. Companies have to be aware of the social, environmental and economical outcomes of their decisions and actions. CSR also considers the working conditions and environmental aspects. Companies need to stay focused towards their economic growth because if a company is not profitable it has to cut costs by, for example, cutting jobs which leads to a decrease in the overall welfare.⁴⁵ Every company should develop their own definition of CSR because it is necessary to consider

⁴¹ Cf. Srivastava, S. K. (2007). Green supply-chain management: a state-of-the-art literature review. *International journal of management reviews*, 9(1), 53-80

⁴² Cf. Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International journal of physical distribution & logistics management*, 38(5), 360-387

⁴³ Cf. Beamon, B. M. (1999). Designing the green supply chain. *Logistics information management*, 12(4), 332-342

⁴⁴ Cf. Green Jr, K. W., Zelbst, P. J., Meacham, J., & Bhadauria, V. S. (2012). Green supply chain management practices: impact on performance. *Supply Chain Management: An International Journal*, 17(3), 290-305

⁴⁵ Cf. McWilliams, A., Siegel, D. S., & Wright, P. M. (2006). Corporate social responsibility: Strategic implications. *Journal of management studies*, 43(1), 1-18

the business' environment and strategic approach while creating a CSR code.⁴⁶ The definition used in this paper for CSR is:

Corporate social responsibility means that companies act as a corporate citizen and undertakes actions and makes decisions under the assumption that it appears to support positive social, environmental or economical outcomes beyond required laws and the firm's interest.

Having the definition of CSR, sustainable supply chain management could be seen as one part of this concept because it consists of actions that support the health of the environment and life of human beings as well as animals. This means that companies which apply sustainable undertakings fulfil one part of CSR.

2.6. The role of suppliers on business performance

As it was pointed out in the previous pages the role of suppliers is getting more and more important regarding various aspects. Most companies are aware of processes and information for their 1tier supplier but they have only little visibility when going deeper in the supply system. Many times, when a deep-tier supplier is facing a disruption, companies only realise that they have a problem after a certain period of time.⁴⁷ The SCOR model already included suppliers and even supplier's suppliers because they might have direct or indirect impact on a company's supply chain and business performance. The role of supplier is not only important regarding supply chain design or performance, it is also essential regarding shared information because it is crucial to account the supplier's reputation. If the information a company gets from a supplier is not reliable or usable, the supply chain and business performance will suffer. For example, the supplier agrees to delivering dates which then have not been realised. This situation causes production problems and also delivering problems to the firm's customers so that at the end the company is not able to meet customer needs. These problems do not only occur related to time, there could also appear challenges regarding product quality or communication. Business partners agree to certain conditions when assuming a relationship. One of these conditions is the way the ordered product should arrive and under which circumstances. These circumstances include a quality standard which the product should have as well as

⁴⁶ Cf. Frederick, W. (2008). Corporate Social Responsibility: Deep Roots, Flourishing Growth, Promising Future. In *The Oxford Handbook of Corporate Social Responsibility.*: Oxford University Press

⁴⁷ Cf. Sheffi, Y. (2015). *The power of resilience: how the best companies manage the unexpected.* MIT Press, Massachusetts. P.161

delivering conditions and lead times. If the supplier doesn't fulfil the contract under any circumstances, it will have impact on the firm's performance.

As discussed earlier, the superordinate aim of a business is customer satisfaction because customers determine the degree of capacity utilisation of a business. If a customer isn't pleased with the product or delivering delays, it will have negative impact on a business' reputation. Not only the delay in production which results in delivering delays is a problem that could be caused by suppliers, also the corporate social responsibility of the supplier's business is hold up onto focal firms. If a supplier of a well-known company doesn't apply corporate social responsibility, for example in terms of working conditions, due to globalisation and easily spread information it will have bad impact on the focal firm's image because customers will link this negative incidence with the well-known firm.⁴⁸

Nevertheless, it is necessary for firms to not only look at their business in isolation, it is important to think of the whole supply chain as a system. It is not efficient to improve only one part of a system and leave everything else as it is because there might occur challenges at overlapping points with other subsystems that in total illustrate a superordinate system. Furthermore, if upstreaming or down streaming positions are not improved, they might slow down the whole process so that improvements in one part are not really efficient or even cause challenges for following processes which are not prepared for different lead times for example. These misunderstandings need to be resolved in order to design an efficient supply chain from sourcing to sales. In order to resolve these challenges, business partners need to build a solid communication base and train their employees to share information and use the necessary IT if relevant. When a company tries to improve their processes and their parts of the supply chain, they should communicate with vertically related business partners so that they can adjust their systems to make the whole supply chain more efficient.

However, suppliers somehow determine, to a certain extent, the production and supply chain of a company. Firms are dependent on their supplier's reliability and product quality because otherwise, as discussed, it will lead to a decline in business performance. Besides physical exchange of products, businesses are dependent on their business partner's information. Therefore, the informational exchange takes a big or even bigger part of

⁴⁸ Cf. Koplin, J., Seuring, S., & Mesterharm, M. (2007). Incorporating sustainability into supply management in the automotive industry—the case of the Volkswagen AG. *Journal of Cleaner Production*, 15(11), 1053-1062

importance in communication than the physical exchange in a buyer-supplier-relationship. The informational exchange determines the physical exchange as well as improvements and changes in the process.

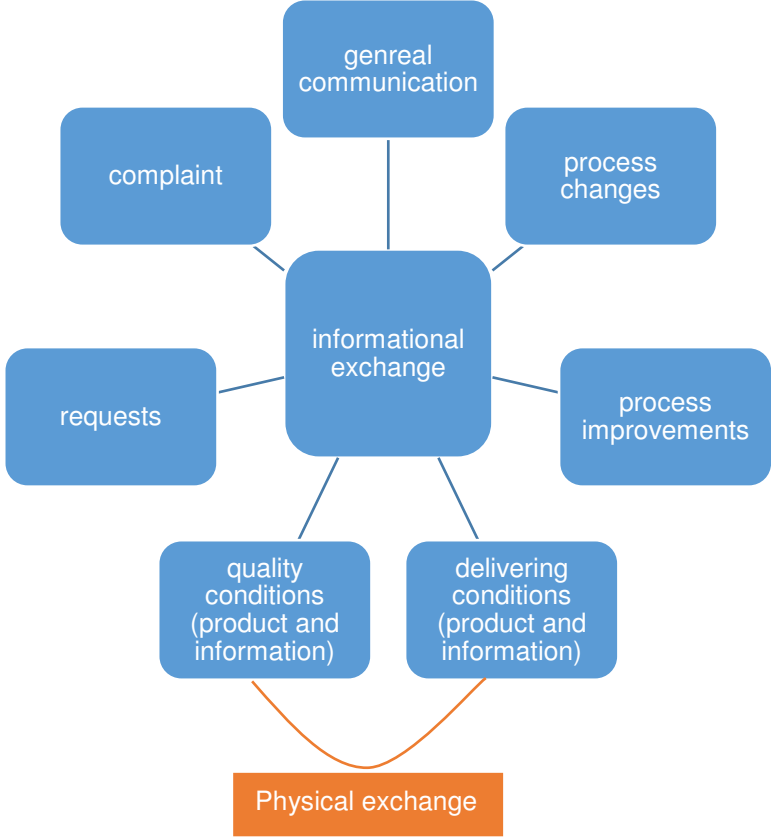


Figure 4: The types of informational exchange – Illustration at own construction.

The factor that many businesses try to focus on their core competencies and therefore outsource non-core competencies underlines the importance of the role of suppliers. The increasing dependence of businesses towards their suppliers is significant and however emphasises the importance of carefully assess and select a supplier. There are different criteria a supplier should fulfil in order to be selected. One criterion is that the supplier should be willing to share information so that the firm can satisfy the buyers long-term needs. Nevertheless, a supplier should fully commit to the relationship so that the overlapping processes and physical exchanges can be performed without challenges. However, these criteria should be performed by the suppliers because otherwise it might have a large negative impact on a firm’s performance.⁴⁹

⁴⁹ Cf. Kannan, V. R., & Tan, K. C. (2002). Supplier selection and assessment: Their impact on business performance. *Journal of Supply Chain Management*, 38(3), 11-21

2.6.1. Drivers for business partnerships and how to build supplier relationships

It is very important for managers to know the drivers behind every action including the desire of business relationships. This helps them to identify and understand the conditions that either support or hinder cooperation. If these conditions are identified, businesses can develop processes and activities they need to perform in order to implement or improve the relationship. Furthermore, partnerships and deep supplier relationships are very cost intensive and complex. Businesses should be careful in their desire of a partnership and carefully evaluate the drivers and chose the partner.⁵⁰ The illustration below shows the partnership model:

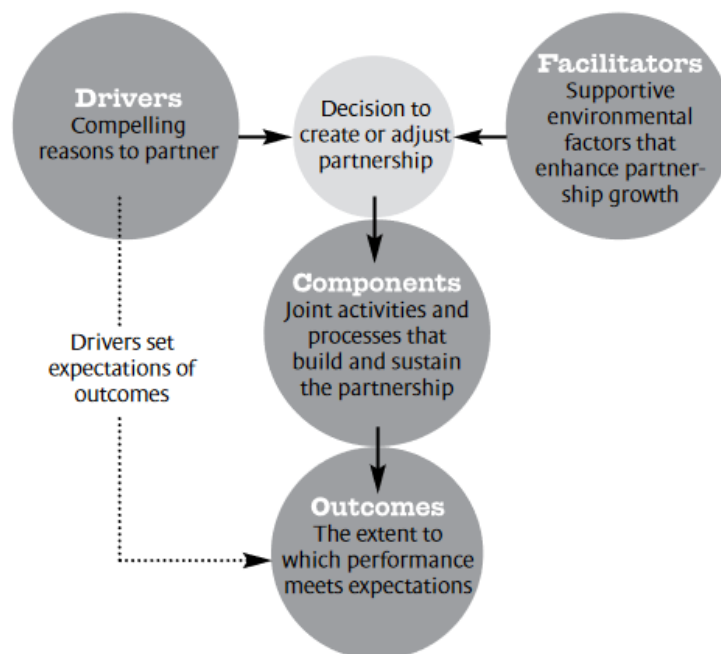


Figure 5: The partnership model⁵¹

The drivers can be divided in four categories: customer service enhancement, marketing advantages, cost efficiency and assets as well as profit growth or stability. These drivers should be formulated to concrete goals in order to lead to a beneficial relationship. If a

⁵⁰ Cf. Lambert, D. M., & Knemeyer, A. M. (2004). We're in this together. Harvard business review, 82(12), 114-124

⁵¹ Lambert, D. M., & Knemeyer, A. M. (2004). We're in this together. Harvard business review, 82(12), 114-124

company is not able to develop drivers for these categories, the costs for a deep business relationship might be too high.⁵²

However, in today's economy and complex supply chain systems, a good relationship with suppliers is essential. The amount of components and services which companies buy from different suppliers increases steadily due to the increasing interest in outsourcing. Therefore, businesses are dependent on their suppliers and also rely on them when the firm wants to reduce costs, increase quality or develop and improve products and processes faster than their rivals. The superordinate goal in terms of buyer-supplier partnerships is to build supplier "keiretsu". This term describes a close network of suppliers that work together with their business partners and mainly with their focal company in order to continuously learn and improve. It is very difficult for companies to build a good relationship with suppliers. It exists a supplier-partnering hierarchy which is basically the approach businesses can apply to achieve a stable and deep supplier relationship.⁵³

⁵² Cf. Lambert, D. M., & Knemeyer, A. M. (2004). We're in this together. *Harvard business review*, 82(12), 114-124

⁵³ Cf. Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. *Harvard business review*, 82(12), 104-113

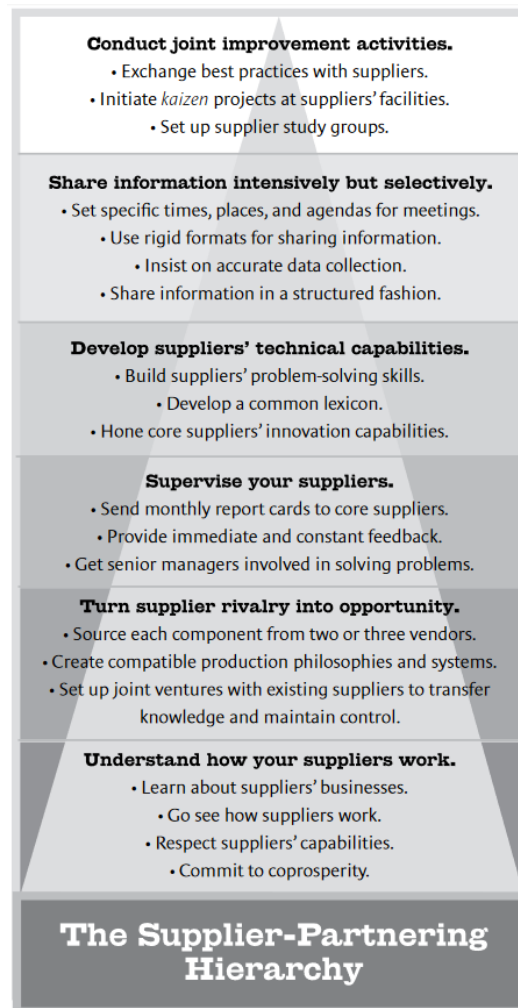


Figure 6: The Supplier-Partnering Hierarchy⁵⁴

The foundation for the relationship is that companies need to know and understand how their supplier works as well as respect the supplier's capabilities. Focal firms should be proactive and learn the processes of their supplier. The next step is to create opportunities out of supplier rivalry. In order to do so, firms should source components and raw material from different suppliers. One possibility is to encourage competition by asking for the same products at different suppliers and the suppliers with the best solutions get the contract. This improves efficiency, quality and competition. If the performance of a selected supplier decreases, the business has the possibility to award following contracts to an opponent. Furthermore, if a company acts in different countries with different suppliers for the same component, it might be useful to try to get the competitors to work together which could be in form of a joint venture. Another very important part of the pyramid is

⁵⁴ Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. Harvard business review, 82(12), 104-113

that companies should support and supervise their supplier. Companies can show their will and trust with constant feedback and monthly information sharing in form of reports. Nevertheless, firms should be interested in their supplier's challenges and risks and support them with help in any way possible. This is connected with the next step of building supplier's risk assessment and problem-solving capabilities. The communication between buyer and supplier must also be clear so that product development can be done as requested. A catalogue or lexicon for product characteristics which describes the purpose and meaning is therefore essential to prevent misunderstandings. However, the next step points out that information should be shared but companies should be selective about them and when they share information it should be intense. Meetings should be specific in time, place and agenda so that it is clear for every participant which topics are discussed and how much time is scheduled. The information shared should be structured and standardised so that it is easy for suppliers to understand the information. One important fact for successful information sharing is that data should be collected accurately. As already mentioned, firms should be informed about the processes of their supplier. Focal firms could then use the information to set meetings in order to give suggestions for investments so that the business is in the focus of the supplier. This means that the firm could use opportunities to influence the strategical level of their supplier. When a company fulfilled all these steps, they build trust and a good buyer-supplier-relationship. This is the foundation for the last step which indicates the exchange of best practice and also that focal firms could introduce kaizen or other improvement projects at the supplier's facilities. One way to support suppliers is to set up teams and study groups that help suppliers to improve operations.⁵⁵ When a company reached the last stage of the pyramid, they might also be able to introduce the system of the supplier-partnering hierarchy to their supplier so that it continuous to deep-tier supplier which than might be under control and develop better risk assessment.

One negative aspect of this approach is that it is more difficult for small buyer to build a deep relationship with their supplier because they might not have the market position to put different suppliers in a competitive advantage. Companies need to develop incentives for their suppliers to build a relationship which is difficult for small companies.

⁵⁵ Cf. Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. *Harvard business review*, 82(12), 104-113

2.7. Forecasting

2.7.1. Definition

Forecasting can simply be defined as an attempt to predict the future. J. Scott Armstrong, professor at The Wharton School, University of Pennsylvania, analysed human behaviour in terms of forecasting in the book: “Principles of Forecasting in which situations forecasting is used, why it is used and whether it is beneficial or not.” He comes to the result that every individual, social group or organisation tries to predict the future in any way. The reason why people spend so much time on thinking about the future is supported by a quote of Confucius which says that “If a man gives no thought about what is distant, he will find sorrow at near hand.”⁵⁶

2.7.2. Objectives

Key objective of forecasting is to identify risks which could potentially harm a business enterprise. As explained earlier, a key issue of supply chain management departments is to manage complexity. Managing complexity involves a comprehensive supply risk management that identifies potential sources of delay within the logistical system. In dynamic, complex organisations, the nature of risks is diverse. Risks can occur due to wrong decisions or actions undertaken by managers or employees of an organisation but risks can also be caused by external factors. These external factors could be very complex. Some might be easy to understand and to control but there are some external factors that are highly complex itself and very difficult or not possible to monitor. For instance, anticipating consumption for a product might be easy but what if the product was manufactured in a region where earthquakes are highly likely to happen. This would have a significant impact on the supply chain. This example underpins the objective of forecasting. Forecasting should not be about anticipating future demand but about anticipating risks that could harm a supply chain. Customer demand is only a result of many variables. If I offer something additional to my product which nobody else in the market is offering, the demand for my product would increase. Therefore, future demand does not need to be anticipated but those factors that have impact on customer demand need to be understood and anticipated.

⁵⁶ Cf. Scott Armstrong, J. (2002) Principles of Forecasting: A Handbook for Researchers and Practitioners. Dordrecht, USA: Kluwer Academic Publishers, P. 1

Furthermore, forecasting should be used as a tool that helps to make supply chain decisions in order to maximise the system efficiency. Basically, there are three levels of decisions in supply chain management. Strategic decisions, tactical decisions and operative decisions. Based on this categorisation, decisions are differentiated by time character. Does the decision have a long-term impact on the supply chain strategy or does the decision affect the daily operations? This categorisation can be applied to the forecasting process, too. However, companies need to identify risks that harm the organisation strategically and tactically but also operationally.

Using this approach, forecasting functions as an early warning system that monitors certain parameters or activities in order to prevent delays or disruptions in the supply chain system and maintain service or product quality.

2.7.3. The bullwhip effect

This effect describes the phenomenon that the further you go up the supply chain, the higher is the fluctuation in orders. We assume a supply chain with a retailer, wholesaler, distributor, factory and supplier to explain this phenomenon. However, the effect means that customer demand and thus the sales of the retailer fluctuates less than the orders the retailer places by its wholesaler. Furthermore, the placed orders from the retailer by the wholesaler have a lower volatility than the orders placed by the distributor. The distributor again places orders by the factory which fluctuate even more. At the end it is the factory that places orders to its suppliers which have the highest fluctuation in this example. The fluctuation happens because the upstreaming stations have to determine the order quantities from the down streaming facilities of the supply chain by forecasting for which the respective stations don't have the necessary information because they are in the down streaming business's data base. In order to meet the demand of the upstreaming station, the down streaming facility has to have a high safety stock. Taking this analysis along the supply chain means that the further you go down the supply chain, the higher is the safety stock each station has to carry.⁵⁷ The figure below shows a broad visualisation of the bullwhip effect without any specific numbers. This means that the lines shown in the graph can differ on the assumption of the supply chain and the present information.

⁵⁷ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 153-155



Figure 7: Visualisation of the bullwhip effect - Illustration at own construction.

Being aware of this effect, businesses need to develop techniques to control the phenomenon to decrease order volatility along the supply chain. There are five main factors that refer to an increase in variability. Price fluctuation is one factor that influences variability. At promotion times, the orders are generally higher than when the product is offered constantly at a regular price. When a retailer offers the product in general at a low price, there will not be a fluctuation in orders because customer demand will be constant. Another factor is inflated orders which are placed during shortage periods. Retailers or even wholesalers or distributors assume a short supply of a product and try to get their supply in the right proportion. After the shortage period, the retailer turns back to its standard ordering system while leaving any kind of variability of demand estimation. Furthermore, a retailer who places an order with a large quantity followed by periods of no orders and coming back to a large order is a so called batch ordering. This type of ordering also encourages fluctuation in orders in the supply chain. Lead times are also a factor that influences the variability in orders because the safety and base-stock are calculated considering the lead times. Therefore, the higher the lead time, the more effect it has on the particular stocks as well as on the variability in orders in the supply chain. The remaining factor is demand forecasting. Traditional forecasting techniques like periodic review policy are based on base-stock level and safety-stock level. These level changes over time with

the increasing amount of information. This leads firms to estimate their demand and therefore increase the fluctuation in their orders along the supply chain.⁵⁸

For a business, it is important to quantify the bullwhip effect to better control their system. Generally, the bullwhip effect is the increase in variability of orders along the supply chain. This variability needs to be quantified to better develop strategies that react against this phenomenon. There are two assumptions for the equation to quantify the fluctuation. One assumption is that we have in a supply chain only a retailer and a factory and that the retailer uses the moving average for forecasting. The second assumption is that the retailer calculates a new standard deviation and a new mean in every period based on the most recent information. Therefore the equation as follows is shown below:⁵⁹

$$(1) \quad \frac{\text{var}(Q)}{\text{var}(D)} \geq 1 + \frac{2L}{p} + \frac{2L^2}{p^2}$$

Thereby, L stands for the lead time that the retailer faces and p is the average of previous observations of demand. Var(Q) is the variance of orders placed by the retailer seen by the manufacturer and Var(D) is the variance which the retailer is facing from customer demand.⁶⁰

Thus, it is shown that the higher the average observation and the lower the lead time, the less is the bullwhip effect. Vice versa, if there is an increase in lead time and a decrease in p, the bullwhip effect will increase. Taking the example of p=8 and L=2 the equation would look like:

$$(2) \quad \frac{\text{var}(Q)}{\text{var}(D)} \geq 1 + \frac{4}{8} + \frac{4^2}{8^2}$$

$$(3) \quad \frac{\text{var}(Q)}{\text{var}(D)} \geq 1 + 0,5 + 0,25$$

$$(4) \quad \frac{\text{var}(Q)}{\text{var}(D)} \geq 1,525$$

The example above shows that the fluctuation in orders from the retailer is at least 52,5% higher than the variance in customer demand which the retailer is facing.

⁵⁸ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 155-156

⁵⁹ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 156-157

⁶⁰ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 157

3. Transparency

3.1. Definition

Companies are faced with the question how much information should be shared with suppliers, customer or even within the company. There are different kinds of information a company can have. For example, there are confidential information which mainly contain material that is very important in order to stay in a competitive advantage. If that particular information is shared with supplier or is made public the impact is significant on the whole company because competitors or even supplier can use this information to strengthen their position in the market or get more power in bargaining processes. On the other side when too less information is shared, the involved partners face higher costs. One example for that is the bullwhip effect which was explained in more detail earlier in the paper. The variability in orders is based on information asymmetry. This information asymmetry leads to higher lead times, increase in safety and based-level stocks and thus to overall higher costs. There are different incentives a company has to share information and to develop their transparency. The incentives and the need to share information are also depended on the particular supply chain including the processes as well as the industry the company is doing business in. Some businesses need to analyse their supply chain through their supplier's supplier as well as their customer's customer because these parties also influence the company's supply chain performance. This analysis can also go further to deep-tier supplier to mitigate risks and increase transparency. Having the theme of sustainable supply chain management and corporate social responsibility in mind negative, information about a supplier's production can lead to a decrease in sales of one's product because customer can easily gain information and, therefore, know that the product is manufactured by using material which is for example dismantled under no humanely circumstances. One example which addresses this topic was given in the chapter Problem statement. Because of the fact that globalisation is an ongoing process and information sharing increased due to better technology, businesses need to be careful by sourcing their material around the world and building relationships with suppliers in different countries and cultures.

However, the objective of supply chain management is to optimise all possible systems, to reduce costs and be efficient. Under that assumption the information sharing process should be integrated in the supply chain management system. In general, it is easier to

organise, calculate, forecast and analyse when all parts of a particular supply chain have the same information available. This approach would help companies to reduce costs in form of inventory as well as unprofitable systems and procedures. Henceforward, this paper talks about supply chain management in the definition given above including the need of increasing transparency in form of information sharing along the supply chain to build buyer-supplier-relationship and to reduce costs, increase efficiency and mitigate risks without risking exploitation.

3.2. Problems related with transparency

The increase in complexity also increases the probability that the amount of challenges that might occur increase as well. When a firm decides to share information with business partners and opens up information to them, they need to assess the reliability and seriousness of the supplier. Not rarely, companies are afraid that shared information would be misused and given to competitors which might provide them with valuable knowledge about strategic decisions or product related developments. Another challenge could be that the information shared is not understandable or usable so that the physical exchange of products is negatively affected. The IT which is used for information sharing could also be a possible challenge because both parties need to have certain facilities that are connectable. If this is not possible, information sharing and transparency throughout the supply chain is hard to gain or even not possible without high investments.⁶¹ On the other hand, if a company tries to have too much transparency they might share information that are confidential and related to business performance or the company's strategy. This information should stay in the company and should not be shared with any business partner because external companies could take advantage of this information and might change to other business partners if the company performance is not going to be good in the future. Furthermore, when a focal company requires transparency throughout their supplier's supplier or even further more supplier stages, the firm might have an overload of information which they cannot analyse and use.⁶² This overload of information might lead to high costs and inefficiency due to the higher need of storage facilities as well as employees.

⁶¹ Cf. Hartono, E., Li, X., Na, K. S., & Simpson, J. T. (2010). The role of the quality of shared information in interorganizational systems use. *International Journal of Information Management*, 30(5), 399-407

⁶² Cf. Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter, M. W. (2007). Information sharing and supply chain performance: the role of connectivity and willingness. *Supply Chain Management: An International Journal*, 12(5), 358-368

However, every company that has business partners should decide on the extent of their transparency and information sharing along their supply chain. If these boundaries are not clearly defined, the company might either lack information which is needed to efficiently run their supply chain or it might occur that there is an overload of information which also results in inefficiency and high costs.

3.3. Types of shared information

There are several shared information types in a supply chain. Every information type serves a different purpose. However, each business of a supply chain has its optimisation in focus without having the whole picture in mind. To effectively optimise a supply chain, all participants of this value chain need to be aware of the necessity of information sharing. However, some supply chains require an analysis that also takes the suppliers' supplier or customers' customer into consideration because they influence the overall supply chain performance. Having that in mind, all different types of shared information have benefits to point out and need to be discussed if it is worth taking the risk or better stay as confidential as before.

As discussed earlier, sales data is information that is likely to be communicated to decrease the impact of the bullwhip effect. Usually, the different supplier facilities in a supply chain communicate their demand information through orders. However, demand information placed on orders can be distorted as well as misguide upstream facilities regarding their inventory and production management. The variance and distortion increase the difficulty of demand forecasting. Furthermore, this affects the efficiency of a supply chain badly. Therefore, the benefits for facilities in a supply chain that share sales data are on the one hand a better inventory level as well as on the other hand better anticipation and preparation of sales in a volatile market which lead to a decrease in costs and needed time.⁶³

Capacity information is also a possibility of what could be shared in order to decrease the effect of the bullwhip phenomenon. When an upstream facility shares its capacity information with its downstream facilities in a supply chain, the downstream partners have the opportunity to better prepare and coordinate in advance for shortages. However, it is a

⁶³ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93.

possibility to improve the performance of a supply chain and to better control volatile demand.⁶⁴

Connected with the bullwhip effect is forecasting as mentioned in the previous sides. Therefore, it might be beneficial for companies in the supply chain to share information about their forecasts because multiple independent forecasts support the bullwhip effect and that results in inefficiency. However, it might be recommendable to have a collaborative forecasting for all facilities in a supply chain to avoid inefficiency and reduce costs.⁶⁵

Inventory information can be another type of shared information that is exchanged in a supply chain. Imagine a simple supply chain with a retailer and manufacturer. When both parties share their inventory status, they could reduce inventory stock or even decrease safety stock which would decrease cost and time. To create this information sharing, both businesses need to arrange their warehouse management towards the new circumstances and educate their employees for a better communication with business partners.⁶⁶ The multi-echelon inventory optimisation is aimed at having the right safety stock at each inventory interconnection point between all different stock-keeping units of a supply chain. This approach considers all complex interdependences that could occur like fluctuated lead times or variation in demand. Furthermore, this inventory optimisation tries to focus on the whole supply chain as one and not all facilities separately.⁶⁷ In the case of an implementation of echelon-based inventory control, the upstream facilities need to keep tabs on the inventory level of the downstream facilities. It is necessary that the echelon inventory level is low so that the facilities can start to produce. One benefit of the echelon inventory control is that upstream companies can make better determination regarding the time and product they have to produce. The benefit for downstream facilities is that they have the opportunity to improve their inventory and service level.⁶⁸ These benefits could only occur when both partners fully commit to the increase in communication and

⁶⁴ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93

⁶⁵ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93

⁶⁶ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93

⁶⁷ Cf. Clark, A. J., & Scarf, H. (1960). Optimal policies for a multi-echelon inventory problem. *Management science*, 6(4), 475-490

⁶⁸ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93

information sharing because otherwise the firm which doesn't share all necessary information play on the acquired information and might change over to a competitor.

Another opportunity for companies in a supply chain to reduce costs is to share their order status and that business partners are somehow in the position to track this information. One possibility to do so could be to link each other's webpages where the order status is shared so that the required business partners can easily access the information without manual communication. Another opportunity might be that businesses allow their partners to access their order database which is the most direct way of communicating the status of orders.⁶⁹

To improve the production and delivery processes, companies along the supply chain could share their production and delivery schedule for a better coordination of the production of both business partners. If a buyer knows the supplier's production and delivery schedule the business can better estimate incoming orders and delivery times as well as manage their production more efficient. Scheduling is very important in a today's business because a still stand in a production is very costly, therefore, time need to be used beneficial. The supplier on the other side can also benefit from this form of information sharing because the company can proof its reliability and profitability so that the buyer-supplier relationship improves, whereas resupplies are considered as reliable.⁷⁰

Furthermore, information like lead times, product quality, delays as well as service performances are also shared in a supply chain. This is most of the times illustrated in a performance matrix. In general, a performance matrix has the function to show and measure a company's performance, behaviour and activities. The information that result from such a matrix can also be shared in the supply chain because it might help to identify the source of shortages and delays and therefore help to improve the overall performance of the supply chain. Within these performance metrics are key performance indicators developed to measure the different influences of productivity, transparency, sustainability or other important factors for a particular company.⁷¹

⁶⁹ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93

⁷⁰ Cf. Lee, H. L., & Whang, S. (2000). Information sharing in a supply chain. *International Journal of Manufacturing Technology and Management*, 1(1), 79-93

⁷¹ Cf. Hausman, W. H. (2004). Supply chain performance metrics. In *The practice of supply chain management: Where theory and application converge* (pp. 61-73). Springer US.

3.4. Supply chain operations reference model (SCOR)

The supply chain operations reference model was developed by the supply chain council in the US. It is a standardised model to analyse all aspects of a supply chain within a company and the interactions between the different facilities of a supply chain. The SCOR model provides firms with a solution how to determine the source of issues that occur along the supply chain. Furthermore, the model provides a firm with its current supply chain performance as well as identifies contributing factors. The definitions and processes which are used and provided by SCOR are applicable for many different businesses. The concept of the SCOR model and processes starts by the suppliers' supplier and ends with the customers' customer to fully cover the whole supply chain because it is important to have the whole process in mind and not only every facility for itself. However, these processes include all customer and market interactions as well as all that products include for example the required equipment, transactions and software. Furthermore, SCOR model does not consider all business processes like research and development, sales and marketing as well as it only adopts administration, information technology and quality. The overall purpose of the SCOR model is that firms have the ability to describe their processes to key partners and develop a way of communication within a company for a better understanding about the complex process architecture.⁷²

The SCOR model contains of different tools, concepts and models. One aspect of the model is a standardised performance metrics which measures process performance. Another part of SCOR model is that management processes have a standardised description and provides a framework for process relationships. Furthermore, on the one hand it contains of management practices that show and produce best performances as well as on the other hand are people included because they need to be trained and have to have certain skills to fulfil the requirements of the process and metrics.⁷³

⁷² Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 5-6

⁷³ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 6

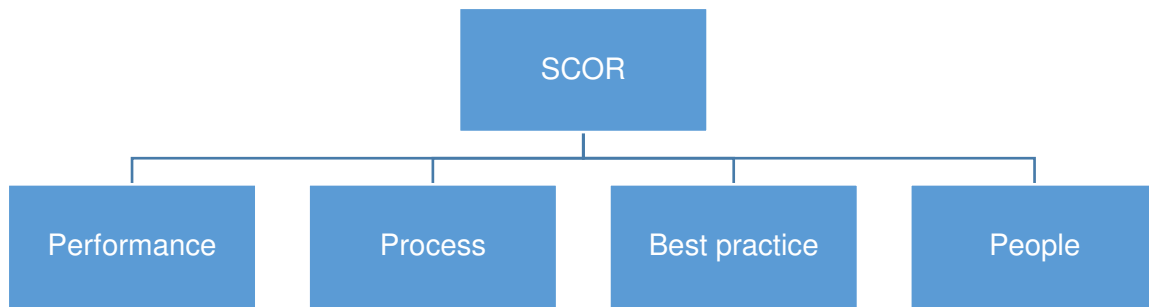


Figure 8: The SCOR model⁷⁴

SCOR's performance section is described in performance attributes and metrics. Basically, a performance attribute describes a strategy because attributes cannot be measured and therefore it helps to put those attributes into strategic directions. On the other hand, metrics measure the capability of a supply chain so that the considered attributes and with them the strategies can be achieved. Five core attributes are identified by SCOR:⁷⁵

1. Reliability
2. Responsiveness
3. Agility
4. Costs
5. Assets

The diagnostic metric of SCOR model is a standardised model to measure the performance of a process. Nevertheless, the model has three levels of metrics that has to serve a certain order and is therefore hierarchical. The first level is a strategic metric and includes key performance indicator to diagnose the condition of a supply chain. This level helps a firm to introduce supportive targets towards strategic objectives. The level two metric acts as a diagnose for the first level to better identify the source of issues for the first level metric. In the terms of the second level, the third level metric also acts to diagnose causes of issues in the second level metric. The three level metrics are a decomposition that helps to identify those processes that need to be improved.⁷⁶

⁷⁴ Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 6

⁷⁵ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 7

⁷⁶ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 8

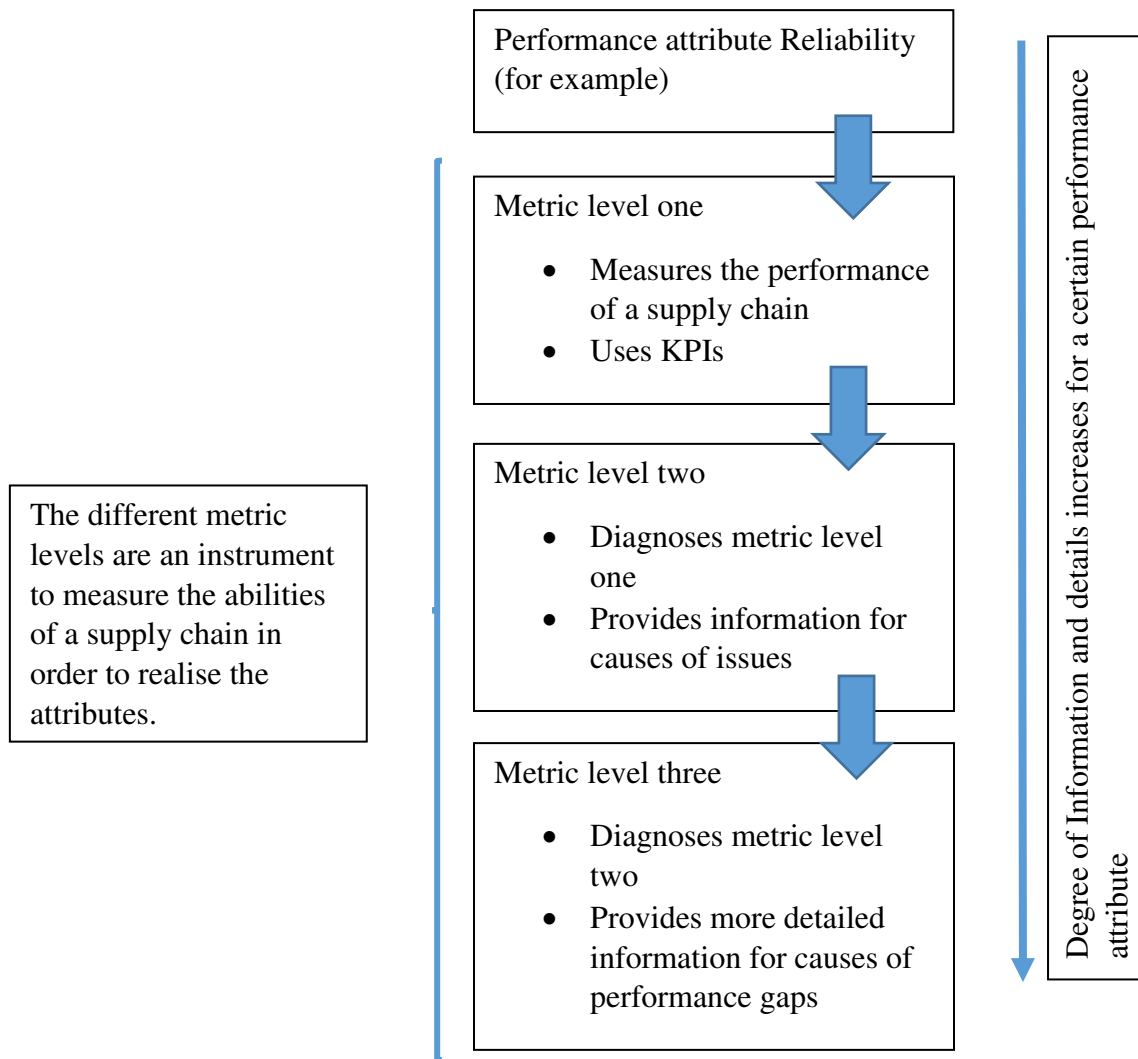


Figure 9: The diagnostic metric of SCOR - Illustration at own construction.

The second part of the SCOR model is the topic of processes. SCOR identifies four processes that are required by a supply chain to meet the customer needs. The first three levels are not depended on the industry whereby the forth level is industry specific. These processes are determined in levels. The first level describes the scope of a supply chain in five processes that are:

1. Plan
2. Source
3. Make
4. Deliver
5. Return

The second level process identifies processes that help to distinguish the level one strategies and determine the overall supply chain strategy. The second level categorises the

processes. The processes listed in the third level are the steps needed to actually execute the processes in the second level. This level decomposes the processes and identifies the strategic element in every process. However, the second level processes influence the first level processes and the third level processes influence the second level processes.⁷⁷

The processes in the fourth level are industry specific and influence the performance of level three processes. Therefore, the fourth level processes give a specific and detailed illustration how a firm should implement a process. These processes are individual for every firm and industry and thereby need to be developed by the particular firm that applies SCOR model.⁷⁸

The illustration below shows the structure of SCOR.



Figure 10: The SCOR structure⁷⁹

The third part of SCOR is called “best practice” and shows a unique way of setting one or more processes. However, there are four types of practices within any organisation that are discovered by SCOR. The four different types can be characterised by moderate and a high return. A high return symbolises best practice and leading practice whereas negative or low return refer to common practice and poor practice. The industry a business is participating in, classifies a practice. This means that not all “best practices” are really “best” for every industry. A common practice in one industry might be a best practice in a different industry. Therefore, the different practices vary from industry to industry. SCOR best

⁷⁷ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 11

⁷⁸ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 11

⁷⁹ Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 6

practice comprises among others like green supply chain management, supply chain risk management, general management practices as well as software solutions.⁸⁰

The fourth section of SCOR model is referred to people. SCOR says that talented people determine the effectiveness and efficiency of a supply chain. Nevertheless, people have different skills, knowledge and experience and need to be put in a position according to their expertise. SCOR provides a framework for management skills that helps managers to put perfectly matching supply chain teams together. The model consists of five competency levels of employees. The first level is called “Novice” which are people who do not have expertise and are untrained. The following level are “experienced beginners” who gained work experience but lack of situational perception. “Competent” are those that have full understanding of the work and can set priorities to reach goals. The fourth competency level is called “proficient” and those people have on the one hand the full understanding of their work as well as on the other hand are able to set priorities which are based on situational actions. The last level is “experts” who react intuitive in situations and fully internalised company processes and their work which gives them the possibility to transfer and dispose their knowledge even in new situations. Furthermore, the key elements which are used in SCOR to determine people are skills, experience, aptitude, training and competency. Basically, the better a person is in all these elements the nearer he/she comes to the point to be an expert.⁸¹

The SCOR model is therefore a tool that helps companies to improve their performance and to increase the transparency within a supply chain. The model includes all aspects that have influence on the supply chain, even supplier’s supplier, customer’s customer and employees who need to be trained and put into the right position to reach the optimum of productivity. These aspects might lead to higher profitability and reliability. However, it is necessary for a business to illustrate their process architecture to allocate causes that have negative influence to the firm’s performance and to develop solutions for these challenges.

3.5. Information technology (IT) and models of information sharing

Effective supply chain management should result in a decrease in lead times, reduced costs and an increase in service level. To reach these aims, it is important that information along

⁸⁰ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 17

⁸¹ Cf. Supply Chain Council Inc. (2010), Supply Chain Operations Reference (SCOR®) model Overview – Version 10.0, P. 19

the supply chain are shared. This is possible through information technology that enables the firm to manage information within the company and to share information with business partners and other facilities along the supply chain.

A study by the MIT, PRMT and SAP discovered that businesses need to invest in IT strategies and business processes simultaneously to have a positive effect on the supply chain performance. It says that companies that only focus on IT and don't put much effort in business processes have done business less respectable than those that invest in business processes mainly. Furthermore, businesses that invest only in IT and don't improve their business processes have negative impact on their performance and therefore a negative return.⁸²

The study tried to measure the level of maturity of processes in a business and the IT infrastructure which is applied in a business. However, they discovered different results. One result was that companies that have lower mature business processes also have lower inventory levels. Secondly, a firm that improves certain areas in their supply chain or in their business processes need to do investments in their IT section as well. Furthermore, companies that have mature processes also have an increase in their financial performance. As mentioned before, the study discovered that investments only in information technology infrastructure and not in business processes, lead to considerable inefficiency. However, a company's objectives determine the investments in IT. It depends on the maturity of a business and its processes to identify the best IT infrastructure because the study says that it is important to combine IT with business processes to increase efficiency. However, the study is inspired by the score model framework to identify the company's state of their supply chain and its business processes.⁸³

Furthermore, the study discovered four different types of business processes that are found in companies. The first level is called disconnected processes. Companies that apply these processes are organised functionally and the processes are independent. In addition, integration is not existent or at a low level and measurements are either not developed or

⁸² Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 408

⁸³ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 410

they do not fit the company's objectives. However, companies with these processes have a lack of supply chain management and its processes.⁸⁴

The second category of business processes are internal integration which means that companies that are at this level are also organised functionally like the first level but their integration is at a high level. The decisions are made in key functional areas in the company which are logistics, manufacturing and sales. Furthermore, the company applies forecasts, integrates functional information and key measurements at different departments to be more efficient and decrease inventory.⁸⁵

Companies at the third level are organised cross-functionally and key suppliers and customers are involved in processes and decisions. Nevertheless, all internal organisations are involved in processes and decision-making processes as well as the decisions themselves are optimised along the whole supply chain.⁸⁶

At the last level are companies that integrate their fully supply chain internal and external, thereby they apply multi-enterprise processes. Those companies have set objectives besides gathering information about their business environment as well as their customer's and supplier's business environment. Companies along the supply chain are linked to each other and can therefore act as one virtual business. However, company goals are linked to company objectives.⁸⁷

As the study discovered that processes go hand in hand with information technology it is necessary to apply at each level of business processes a different category of IT systems. The IT system for companies at the first level should have the architecture that there are different independent IT systems that gather a lot of data across the whole organisation. Data can be manipulated manually and decision are made on this base of information. The second level instead already uses planning tools and shares and applies information along

⁸⁴ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 408

⁸⁵ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 408-409

⁸⁶ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 409

⁸⁷ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 409

the supply chain. Companies that have the third level of business process also need a level of IT systems that share internal data completely. The company also allows key suppliers and customers to have access to some of the company's data. The IT system at the fourth level should share all processes and data internally and externally in order to gain synergies and act as one virtual business.⁸⁸

Furthermore, a company's aim should be to be as efficient and less costly as possible. To reach this aim transparency and information sharing are alternatives. In order to share information in an appropriate way, business processes need to be adjusted between business partners. In addition, the companies need to have a working IT infrastructure that complement the business processes in order to generate success.

However, IT should basically enhance a company's performance and help to improve inventory information gathering, storage and analysing as well as speeding product design and shortens lead times. Furthermore, IT should enhance supply chain activities and its coordination. A collaborative IT infrastructure should encourage transparency and therefore sharing information both within a company and with business partners.⁸⁹

3.6. Information quality and how to measure it

Information quality (IQ) needs to be defined and regarding to information consumers, its meaning in this paper is: Information quality is the satisfaction, value and importance of the consumer's needs. Furthermore, information quality in its second definition regarding delivering is described in the chapter interorganisational information sharing.

However, the definition based in information consumer expectations means that information and shared information within a supply chain should be exchanged under the purpose of meeting or exceeding consumer needs and expectations. Nevertheless, it is difficult to measure information quality because consumer expectations and needs might change within a certain time period. The "product and service performance model for information quality" (PSP/IQ) divides information quality into four quadrants which are

⁸⁸ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 409

⁸⁹ Cf. Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter, M. W. (2007). Information sharing and supply chain performance: the role of connectivity and willingness. *Supply Chain Management: An International Journal*, 12(5), 358-368

determined by product and service quality on the left side and on the upper side it is determined if the information conforms to specifications and if it meets or exceeds consumer expectations. The first quadrant is called “sound information” and these IQ dimensions specify database information which meet a certain standard of completeness, accuracy and that they are error-free. For example, a database for inventory information with a high accuracy is considered with high quality. The second quadrant is called “dependable information” and need to be timeliness and secured. This quadrant represents information that is necessary for information consumers so that the task can be supported forthcoming. One example for this manner could be that business partners acquire information about inventory so that the service specification is encountered. Furthermore, the third quarter indicates that information should be useful for the information consumer. For instance, if an information consumer needs information about inventory according to all warehouses than the information is only useful if they fulfil this requirement. This quadrant is called “useful information”. The last quadrant refers to the requirement that information can be easily manipulated and obtained. Information consumer need to be able to use the information for decision making processes.⁹⁰

Aspects of the PSP/IQ are illustrated below:

	Conforms to Specifications	Meets or Exceeds Consumer Expectations
Product Quality	<u>Sound Information</u> The characteristics of the information supplied meet IQ standards.	<u>Useful Information</u> The information supplied meets information consumer task needs.
Service Quality	<u>Dependable Information</u> The process of converting data into information meets standards.	<u>Usable Information</u> The process of converting data into information exceeds information consumer needs.

Figure 11: The product and service performance model for information quality⁹¹

Companies can use the PSP/IQ model to analyse and assess their information quality and the delivering process of IQ. This can help companies in their decision making process to

⁹⁰ Cf. Kahn, B. K., Strong, D. M., & Wang, R. Y. (2002). Information quality benchmarks: product and service performance. *Communications of the ACM*, 45(4), 184-192

⁹¹ Kahn, B. K., Strong, D. M., & Wang, R. Y. (2002). Information quality benchmarks: product and service performance. *Communications of the ACM*, 45(4), 184-192

improve their information quality.⁹² Furthermore, this model refers to the concept of total quality management which is explained in previous chapters. However, PSP/IQ model is the basis for companies to develop useful, sound, dependable and useable information for their information customer. It is necessary to coordinate among information custodian, consumer and producer so that a certain information quality is ensured.⁹³

3.7. Information sharing within companies and teams

SCOR already recognised the importance of people and included it in its model, beside the right positioning according to skills and knowledge, it is also important that employees in an organisation communicate in an appropriate way. This communication should be based on the idea of information sharing and that the more information is shared the better is every employee informed and can increase the efficiency because miscommunication and misunderstandings are prevented. Shared information in a team or a company help to make better decisions because the foundation on which the decisions are made are better prepared and based on a bigger amount of available data. According to Mesmer-Magnus and DeChurch, teams often use a lot of time discussing shared information but leave unshared information out of the discussion. Businesses and employees need to be aware of this inefficiency so that they can develop an information process that include new information instead of discussing over and over again the same information pool.⁹⁴

There are three dimensions that influence information sharing within a team. The first dimension is task demonstrability which means that group members should be able to demonstrate their task and solutions so that the group can response. Secondly, structured discussions encourage group members to share their information. A certain structure inspires people to share new information instead of wasting time discussing only one shared information. If times are set for each aspect of the meeting, people are more likely to discuss new information instead of sticking to one topic because time is pressures at this point. Cooperative discussions also motivate groups to share information. If group

⁹² Cf. Lee, Y. W., Strong, D. M., Kahn, B. K., & Wang, R. Y. (2002). AIMQ: a methodology for information quality assessment. *Information & management*, 40(2), 133-146

⁹³ Cf. Kahn, B. K., Strong, D. M., & Wang, R. Y. (2002). Information quality benchmarks: product and service performance. *Communications of the ACM*, 45(4), 184-192

⁹⁴ Cf. Mesmer-Magnus, J. R., & DeChurch, L. A. (2009). Information sharing and team performance: a meta-analysis. *Journal of Applied Psychology*, 94(2), 535

members cooperate with each other, they are more willing to share information as if they work against each other.⁹⁵

Companies need to be aware that certain circumstances encourage or discourage employees to share information and to fully commit to discussions. This can also be put on a different level. If we see teams as a system just like supply chain systems, we can refer this application to business-relationships. Business partners can be more encouraged to share information when tasks are demonstrable and discussions are structured and cooperative. Interorganisational discussions need to be on the one hand structured so that time can be used more efficient and on the other hand should the relationship between business partners be cooperative because both parties have the aim to gain advantages out of the linkage.

3.8. Interorganisational information sharing

Shared information, not only within a company but also with business partners, should have a certain quality so that the receiver of the information is on the one hand able to read and understand it and on the other hand is the right addressee. Therefore, information design and information architecture are crucial aspects in terms of developing an information process.

Perceived information quality correlate with perceived risk and therefore it is linked to trust and belief and has a direct relation to the willingness of information exchange between companies. Perceived information quality consists of three parts. The first part includes the accuracy, completeness and timeliness of the information. These dimensions make information reliable and relevant which is essential for interorganisational information exchange.⁹⁶ Secondly, data quality is relevant and therefore the data should beside accuracy, completeness, timeliness and contextually include accessibility.⁹⁷ Not only the data should have a certain quality, also the information shared should fulfil criteria like integrity, reliability, validity and relevance.⁹⁸ However, it is necessary that the

⁹⁵ Cf. Mesmer-Magnus, J. R., & DeChurch, L. A. (2009). Information sharing and team performance: a meta-analysis. *Journal of Applied Psychology*, 94(2), 535

⁹⁶ Cf. Nicolaou, A. I., & McKnight, D. H. (2006). Perceived information quality in data exchanges: Effects on risk, trust, and intention to use. *Information systems research*, 17(4), 332-351

⁹⁷ Cf. Lee, Y. W., Strong, D. M., Kahn, B. K., & Wang, R. Y. (2002). AIMQ: a methodology for information quality assessment. *Information & management*, 40(2), 133-146

⁹⁸ Cf. Nicolaou, A. I., & McKnight, D. H. (2006). Perceived information quality in data exchanges: Effects on risk, trust, and intention to use. *Information systems research*, 17(4), 332-35.

transparency is somehow controlled so that the information exchange is adequate. Control transparency can help to determine information quality and to increase its level of value. The higher the control the more assured are business partners about the data and information quality. Furthermore, accurate and relevant information methods support decision making processes. These methods have to be understood by employees and consist of a certain architecture which helps to easily access and work with the data.⁹⁹

Nevertheless, there are two requirements for interorganisational information sharing, which are on the one hand the capability in form of IT infrastructure and on the other hand the willingness of both parties to commit to the partnership and transparency. Therefore, the IT infrastructure creates the basis and capability for transparency. The other very important factor is that both firms need to be willing to share information because information are very valuable and many firms are afraid of data abuse and therefore only share as little information with their business partners as possible. The more information a company has, the better they can make decisions and the better they can work on their strategic decisions. Corporate culture determines the willingness of sharing information. Every firm's culture is different and, therefore, the willingness of sharing information at every business is influenced in a different way.¹⁰⁰

However, there are different incentives and driving forces for companies to share information like an increase in demand and the global extension of the company or a change in technological possibilities. Once there is an established information sharing process, it might have positive impact on the performance outcomes because it might increase quality or develop a new unique selling point. One aspect, which was explained earlier is the decrease in the bullwhip effect. The drivers and benefits are illustrated at the graphic below:

⁹⁹ Cf. Nicolaou, A. I., & McKnight, D. H. (2006). Perceived information quality in data exchanges: Effects on risk, trust, and intention to use. *Information systems research*, 17(4), 332-351

¹⁰⁰ Cf. Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter, M. W. (2007). Information sharing and supply chain performance: the role of connectivity and willingness. *Supply Chain Management: An International Journal*, 12(5), 358-368



Figure 12: The driving forces and performance outcomes of information sharing capability¹⁰¹

Trusting beliefs between business partners is essential because they need to be able to rely on each other and on each other's information. The perceived information quality with all its dimensions included has therefore an impact on trusting beliefs regarding interorganisational information sharing and the willingness of business partners to share information. The more one company can rely on its business partner's information the more they can trust the exchange process. This trust construct is important for a successful business relationship because decisions can be made based on the available and received data due to reliability. The higher the perceived information quality the higher is the trusting belief between business partners. This knowledge is essential for companies to develop information processes which are reliable, trustworthy, accessible and understandable. Trusting beliefs are very important for the intention to determine perceived risks. The higher the trust between business partners the more information might be shared and the more communication is between them so that risks and other changes could be discussed in short-time notice. Furthermore, it is more likely that risk prevention methods can be applied and introduced in the exchange process when there is trusting beliefs between business partners. Nevertheless, trust beliefs reduce uncertainty and uncertainty can be seen equal to risks. The increase in trust beliefs could lead to a decrease in risks and

¹⁰¹ Fawcett, S. E., Osterhaus, P., Magnan, G. M., Brau, J. C., & McCarter, M. W. (2007). Information sharing and supply chain performance: the role of connectivity and willingness. *Supply Chain Management: An International Journal*, 12(5), 358-368

an increase in profit because risks are cost-consuming and less risks result in less expenditures.¹⁰²

However, information sharing is essential for business relationships but the design should be clear. Information and data quality as well as transparency control and trust beliefs should be included in the information method architecture. Business partners need to be able to rely on the one hand on the IT as well as on the accuracy of the data and information itself. The intention to use the information exchange is based on trust and control. If the information sharing process is not reliable, business partners will not use the data and might not intervene with the particular company anymore. Therefore, transparency control and information quality influence the company's business performance.¹⁰³

However, there are superordinate influences on IQ of an organisation. One factor is, that firms use IT to gather, store and analyse data which result in information that are at one point shared either within a company or with external businesses. Nevertheless, IT infrastructure capability highly influences IQ. If firms use IT that does not fit to their business process or their information needed it might have a bad outcome which was already discussed previously. This correlation indicates the influence of IT on IQ. Another factor that has impact on IQ overall is the top management. The top management of a business needs to support information and IQ in order to ensure a certain satisfaction between information producer and information consumer. If the top management decides to establish a not suitable IT infrastructure, the result might be that the information gathering is not appropriate and therefore the overall IQ might decrease which can result in misunderstandings and communication failures. Not well established communication between business partners has negative impact on the operational supply chain performance which will result in negative influence of the overall business performance. The correlation between IT infrastructure, top management, IQ, supply chain and business performance is shown below:

¹⁰² Cf. Nicolaou, A. I., & McKnight, D. H. (2006). Perceived information quality in data exchanges: Effects on risk, trust, and intention to use. *Information systems research*, 17(4), 332-351

¹⁰³ Cf. Nicolaou, A. I., & McKnight, D. H. (2006). Perceived information quality in data exchanges: Effects on risk, trust, and intention to use. *Information systems research*, 17(4), 332-351

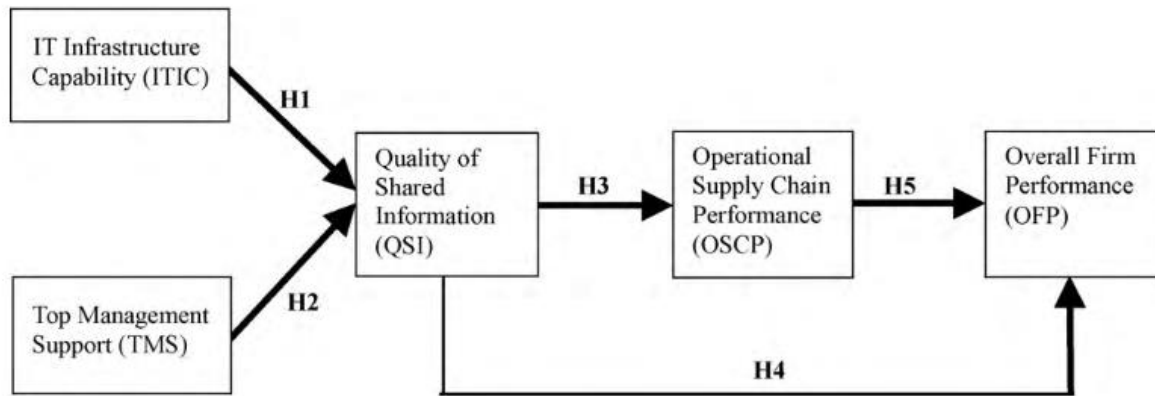


Figure 13: The correlation between IT infrastructure, top management, IQ, supply chain and business performance¹⁰⁴

Generally, information producer need to ensure a certain standard of IQ so that information consumer can use the information for a particular purpose. If businesses are not able to guarantee this standard it will have negative impact on the overall supply chain performance. However, information that are shared either within a company or with business partners have to have, thus, a certain quality because IQ stands in a relationship with the overall business performance.¹⁰⁵ Supply chain management need to be aware of this challenge and establish a certain control system to ensure IQ.

3.9. Controlling of transparency

Once a company gained trust and implemented processes and structures for a continuous information sharing, the business need to implement controlling and maintenance standards. There are different possibilities a firm has to maintain these processes and to gain control over these. Every possibility is recommended for different circumstances because they are different in costs and time-consuming aspects.¹⁰⁶

1. Strategic Alliances
2. Vertical Integration
3. Contracts

¹⁰⁴ Hartono, E., Li, X., Na, K. S., & Simpson, J. T. (2010). The role of the quality of shared information in interorganizational systems use. *International Journal of Information Management*, 30(5), 399-407

¹⁰⁵ Cf. Hartono, E., Li, X., Na, K. S., & Simpson, J. T. (2010). The role of the quality of shared information in interorganizational systems use. *International Journal of Information Management*, 30(5), 399-407.

¹⁰⁶ Cf. Craighead, C. W., Hult, G. T. M., & Ketchen, D. J. (2009). The effects of innovation–cost strategy, knowledge, and action in the supply chain on firm performance. *Journal of Operations Management*, 27(5), 405-421

4. Relationships

As mentioned before, transparency along supply chains can be improved in different ways. We explained earlier how vertical integration can be used for this and now we are going to analyse how strategic alliances can be beneficial in this regards. Besides the advantages, we also investigate the risks and drawbacks which alliances involve.

From our point of view, the term alliance implies that someone is doing something together with someone else in order to achieve something that all parties of the alliance need, want or desire. According to Frynas and Mellahi, a strategic alliance refers to a cooperative agreement made by two or more organisations to accomplish up-front set strategic goals.¹⁰⁷ They also add that once the alliance involves companies from two different countries, it has become an international strategic alliance due to the change in the geographical scope. The essential point in alliances is that even though companies work closely together and share resources and/or capabilities, they stay independent. We think that this is the key advantage of an alliance over mergers and acquisitions.

Basically, alliances can be divided into two main categories. The first category of strategic alliances includes those that are made between competing firms. Therefore, the second category includes those alliances that are formed between non-competing firms. For each category we have identified three different types of strategic alliances which have been commonly used. In terms of non-competing firms, there is for example the international expansion alliance with which companies want to enter new geographical areas. Actually, this alliance can be made between any two companies as the most important good they share is specific knowledge about the country they are doing business in. This knowledge, for example, includes cultural specialties, local behaviour or buying patterns. The second type of alliances between non competing firms is a vertical integration alliance which is made between a buyer and supplier. The vertical integration alliance should increase the quality of goods and the efficiency of supply chains by sharing knowledge, capabilities and capacities. The last type of alliance between non competing companies is called diversification alliance and is formed between two or more organisations from totally different fields of business. This alliance can also be described as a way to spread risks by entering completely new markets. This type of alliance should enable companies from

¹⁰⁷ Cf. Frynas, J.G. & Mellahi, K. (2011) *Global Strategic Management*. 2nd Edition. New York, USA: Oxford University Press: 187

different industries to combine knowledge, skills and capabilities from their individual fields in order to gain a strategic competitive advantage.

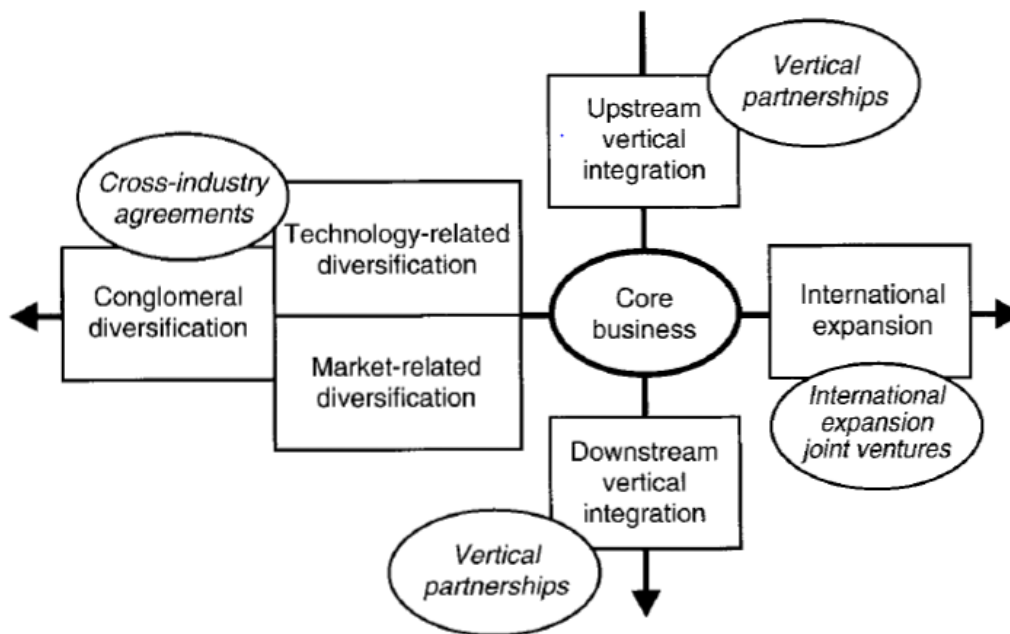


Figure 14: Competing through strategic alliances¹⁰⁸

In terms of alliances between competing firms, companies tend to think that forming a partnership with someone who is actually trying to convince their customer to buy his products is risky. On the one hand they think that the competitor might take advantage of important knowledge about processes or production methods and on the other hand organisations are afraid that they cannot be better than their competitors if they form alliances because then they would do things in the same way. However, also strategic alliances between companies that in some sense compete can be very beneficial. There is, for example, the so called complementary alliance which is formed between organisations from the same industry. Even though, the companies in this type of alliance are from the same industry, they contribute different skills and capabilities. For instance, this type of alliance is appropriate if there are two firms that have high skills in certain fields but lack something essential. Let's assume that there is a small company with special skills in cloud computing and data security but without access to large distribution channels. On the other hand, there is a large multi-national IT company with access to the European, American and Asian market that looks for solutions in this field as they lack knowledge about it. These two companies could easily form an alliance in order to complement their skills. The

¹⁰⁸ Dussauge, P. & Garrette, B. (1999) Cooperative Strategy: Competing Successfully Through Strategic Alliances. P. 51. Chichester, UK: John Wiley & Sons Ltd

second type of alliances between competing firms is limited to upstream activities such as research and development. This type of alliance is called shared supply alliance and is commonly used in many industries. Lastly, there is the quasi-concentration alliance in which companies want to create a product together by contributing similar capabilities, skills and assets from all points of the value chain.

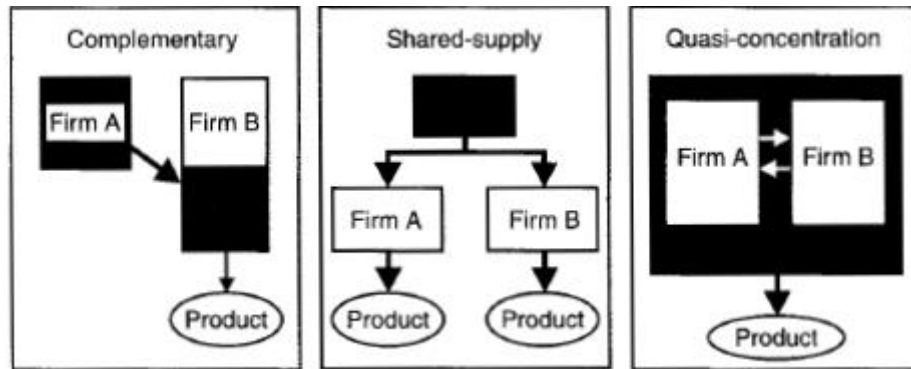


Figure 15: Strategic alliances between competing firms¹⁰⁹

Out of the alliances explained before, the only appropriate alliance to ensure transparency of a supply chain is the vertical integration alliance which is formed between a buyer and a supplier. The key objectives of a vertical integration alliance are to improve the overall efficiency and quality of a supply chain as well as to improve certain processes along the supply chain. The main target of every firm should be to improve and sustainably maintain the transparency of a supply chain. Thinking of a vertical integration alliance a company needs to follow certain steps.

1. Network Analysis
2. Identification of key suppliers (direct and indirect)
3. Analysing where to target the alliance and to which extend
4. Creation of a transparency/alliance concept
5. Contact appropriate partners

The first step of our vertical integration process includes a comprehensive analysis of the entire supply chain network. The network analysis should give a clear understanding of how many suppliers are involved and where are they located. In the next step, a company needs to identify key suppliers. Firstly, a company must know their direct key suppliers but also their second tier and if existing their third or deep-tier suppliers as well. This analysis

¹⁰⁹ Dussauge, P. & Garrette, B. (1999) Cooperative Strategy: Competing Successfully Through Strategic Alliances. P. 58. Chichester, UK: John Wiley & Sons Ltd

is required and essential for the evaluation of the next step which focuses on where to target the alliance. As explained before, it might be rather easy to maintain the transparency of a supply chain if a company only depends on direct suppliers but if second, third or even deep-tier suppliers are involved, maintaining transparency becomes much more difficult. Therefore, companies must understand their network of suppliers in order to make a decision where to intervene by using an alliance. If a company only uses direct suppliers, there might be no need for an alliance because the company can ensure transparency more efficiently by using supplier audits or other rules agreed on in contracts. In a network that consists of more than just one supplier level, a company can form alliances at different stages of a supply chain depended on where the effect on the overall transparency would be the highest. For example, a company can form an alliance with one of their direct key suppliers. This would enable the company to get access to the audits or monitoring process of third level suppliers. But the company could also form an alliance with a key supplier of their second level suppliers. As they can audit first tier suppliers directly, this would be ensured transparency until the third level. Because by forming an alliance with a level two supplier, the company can influence the process and product quality of the second tier supply directly and can get access to the third level suppliers' audit criteria. The key disadvantages of forming an alliance with a level two-tier supplier is that the belonging first tier supplier might feel offended by the alliance because if the company monitors second and third tier suppliers, it might be an indicator that the company does not trust their first tier supplier. Another disadvantage or risk is that the direct supplier could change its supplier. This would make the alliance worthless. Nevertheless, alliances require a lot of time and human resources which are usually cost-intensive. Therefore, forming alliances would be costly. Every company needs to do a cost-value analysis in order to know if and to which extend they want to form vertical integration alliances. Before a company contacts different suppliers, they need to create transparency or an alliance concept which includes the objectives the company wants to achieve with the alliance as well as the rules and requirements they want to include in the alliance. Once a company defined a concrete concept, they can contact potential partners. From our point of view, suppliers should be interested in those alliances because the asking company is either a direct customer or is in the position to create demand for the supplier because if a company wants to form an alliance with a second tier supplier, the company is the customer of the supplier's customer. Therefore, without the demand of the company, the profit for the second level supplier might be lower.

The concept of vertical integration, which is a part of supply chain management, deals mainly with the question of make or buy. According to Grant, vertical integration refers to an organisation's ownership of activities which are vertically related to the activities of the organisation.¹¹⁰ Basically, vertical integration strategies are driven by four key advantages.¹¹¹ Firstly, as supply chains nowadays often involve more than just one country, transaction costs play a major role in designing supply chains. Therefore, the first reason for a vertical integration strategy is lower transaction costs. Secondly, companies use vertical integration because it might be beneficial in terms of strategy. An ownership of vertically related activities can lead to sustainable strategic advantages because the company has more control over processes and the entire supply chain. This leads to the third advantage which is a higher control over input and output prices. Due to differences in terms of taxes, an efficient cost-allocation of intercompany processes can improve the profits of the whole group. Lastly, vertical integration is also a method to avoid or decrease uncertainties (e.g. price, cost, quality). Overall, vertical integration can lead to a stronger market position. Compared to vertical strategic alliances, vertical integration is more capital intensive. The degree of transparency would be higher as the company has fully control over more direct buyers and suppliers. Let's assume an organisation integrates a second level supplier, they have full control over the second level, and access to more third level suppliers via audits. Whether buying this part of the supply chain makes sense or not depends on how profitable this business is. Some companies would consider a vertical integration even though it brings some losses because the full control they get over their supply chain is a stronger and more sustainable argument for them than the costs. Once they own vertically related activities, they might become a supplier for competitors of the parent organisation which give them a certain power over competitors. The key disadvantages of vertical integration are the highly required financial means and the company might lack necessary knowledge of how to lead the integrated business. Furthermore, a highly vertically integrated business is less able to react on short-term changes and is therefore less agile respectively flexible. All in all, vertical integration can be used as a way to increase and maintain transparency along a supply chain but companies must be aware of high investments. Therefore, they need to do comprehensive

¹¹⁰ Cf. Grant, R.M. (2010) *Contemporary Strategy Analysis*. 7th Edition. P. 234. Chichester, UK: John & Wiley & Sons Ltd

¹¹¹ Cf. Mahoney, J. T. (1992). The choice of organizational form: vertical financial ownership versus other methods of vertical integration. *Strategic Management Journal*, 13(8), 559-584

calculations whether the investment is reasonable or not. Vertical integration definitely offers the highest degree of transparency due to the increasing control over a supply chain.

Thirdly, there is the aspect of contracts. Besides, the regular terms of the product, price and quality, firms need to clarify transparency and information sharing concepts in their contracts with suppliers. In these conditions firms could implement strategies for transparency for deep-tier suppliers so that the impact of risks in deep-tier supply systems can be limited. One possibility might be that the supplier adopts the risk management and CSR policy of the focal firm.¹¹² Within this possibility, firms could develop a list of questions which could be asked to their supplier on a regular basis to ensure the business continuity plan and a better risk assessment and prevention. Firms can take this list in their contracts so that the supplier has to answer certain questions. Furthermore, the contract could include that the suppliers have to make their suppliers apply the same risk analysis and give the answers of the questionnaire to them. This might decrease the appearance of uncertain risks and their impact on the business performance. One possible list of questions was given in the chapter “assessment of supplier risks”. The list increases the level of information shared and transparency between business partners without spending much money and time in building deep relationships.

Most of the times, in the early stages of business transactions with other firms, businesses don't know exactly which information they are going to need for the relationship. This fact need to be considered in the contract negotiations and firms should rewrite the contract after a certain time (e.g. after six months) so that the practice could show which information are generally needed and that this can become manifest in the contract.¹¹³ The following list shows aspects that could be included in contracts regarding the theme of transparency:

- Regular audits (e.g monthly, quarterly)
 - Additional audits in case of abnormalities (e.g. complaints)
- Questionnaire
- Support in the case of risk occurrence (e.g. natural disasters)
- CSR and corporate governance policy

¹¹² Cf. Sahin, F., & Robinson, E. P. (2002). Flow coordination and information sharing in supply chains: review, implications, and directions for future research. *Decision sciences*, 33(4), 505-536

¹¹³ Cf. Cachon, G. P. (2003). Supply chain coordination with contracts. *Handbooks in operations research and management science*, 11, 227-339

- Information needed including IQ and time, place and content of the information
 - Adaption after a certain period of time (e.g. semi-annual or annual)

Nevertheless, information sharing contributes value to the supply chain and every firm needs to identify their best way of approaching and controlling transparency.¹¹⁴ One significant criticism of the approach of contracts is that the buyer needs to be in a powerful position to be able to place requirements in contracts. Small firms might use a different approach to ensure control of transparency like building deep relationships.

However, as mentioned, the fourth aspect of gaining control over these complex processes is the buyer-supplier-relationship itself. As explained earlier, it is a very complex and time-consuming procedure to gain trust and build a sustainable relationship with a key supplier. Therefore, companies need to carefully choose and assess the supplier with whom they want to build a deep relationship. Within the process of the supplier-partnering hierarchy, firms could use this tool to implement control strategies for ensuring transparency. The aspect of “share information intensively but selectively” could also imply that businesses develop a risk assessment tool and corporate social responsible which both firms have to apply.¹¹⁵ This is at this stage possible because the basis for a deep relationship is already set and trust is gained. Furthermore, both parties could agree to a contract or informal regulation where all aspects of this topic are agreed like IQ, time, place and agenda. Control systems could be developed and implemented because information about the way how the supplier works is gained and a certain understanding is transferred. One control system could be that both firms agree on limits and if the received data is beyond the limit, an alert system steps in and therefore actions can be undertaken.

The graphic below illustrates the different methods which can be used to maintain and improve transparency along a supply chain. Out of the four concepts, vertical integration offers both, the highest level of transparency as well as the highest degree of control over the supply chain. This is caused by the legal ownership a company gets if they buy vertically related businesses. On the one hand, a company has full control over processes and product quality and on the other hand, a company has more control over input and output prices. Vertical integration alliances also offer high level of control over the supply

¹¹⁴ Cf. Ha, A. Y., & Tong, S. (2008). Contracting and information sharing under supply chain competition. *Management science*, 54(4), 701-715

¹¹⁵ Cf. Liker, J. K., & Choi, T. Y. (2004). Building deep supplier relationships. *Harvard business review*, 82(12), 104-113

chain and transparency because the company also gets access to processes and the supplier’s relationships with other suppliers but only to a certain extent. A medium level of transparency and control over the supply chain is offered by relationships. Relationships are usually based on experience and trust. Once companies work together for a long time, they have higher interest to maintain and improve the relationship as it has proven to be successful in the past. The key disadvantage is, that the focal firm has no right to intervene as it would be the case in an alliance or vertical integration. It can only suggest changes and hope, due to the strong relationship, that the supplier is willing to adopt the suggestions. The lowest level of transparency and control over the supply chain can be gained by the most formal approach. Of course, contracts pledge suppliers to work accordingly to what has been agreed but besides auditing, the focal company has no other instrument to monitor whether the supplier works as he is supposed to. Another disadvantage of contracts is that the focal firm does not get access to its supplier’s suppliers. Again, from a legal point of view, they can agree to audits of deep tier suppliers but the possibilities to monitor these are very little. All in all, the approach depends on how important transparency is to a company and how much time and money they are willing and able to spend as well as if the supplier contributes significant value to the supply chain or not.

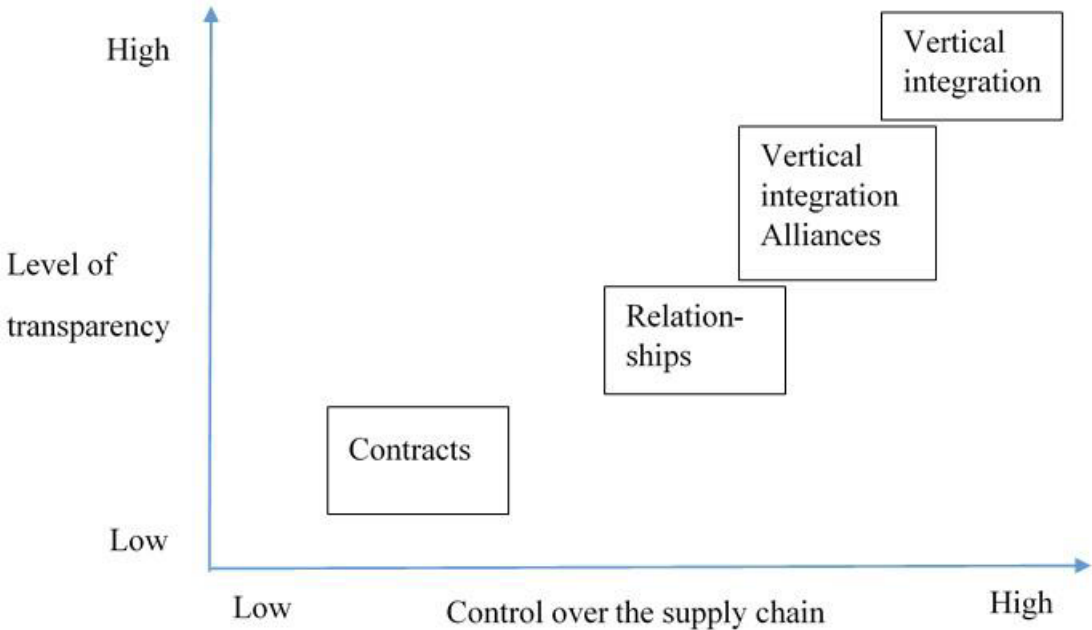


Figure 16: Different methods to maintain and improve transparency along supply chains- Illustration at own construction.

4. Supply chain risk management

4.1. Risk management

4.1.1. Definition risk management

Risk management can be defined as the classification, identification, analysis, treatment and continuous monitoring of potential harms to a firm. According to Douglas W. Hubbard (2009) risk management is “the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor and control the probability and/or impact of unfortunate events”.¹¹⁶ Structurally, risk management should have an independent position within an organisation and the risk management should be reporting to the management board directly. If the risk management belongs to a certain department, for instance the finance, there might be a focus towards the department the risk management belongs to. This could lead to a lacking attention on other important parts of the organisation. If it is possible that the risk management department transforms a risk into a benefit for the company, a sustainable competitive advantage can be achieved. So the management of risks can also become the creation of opportunities. Another possibility is that every department itself is outperforming risk management in terms of the content of their department. This ensures that risk management is spread in all sections of a firm.

In many daily situations, people use the term risky or describe something as a risk but what does risk mean? In ISO 31000:2009, a risk is defined as the “effect of uncertainty on objectives”.¹¹⁷ Looking at this definition in detail, it implies that this definition consists of two parts. On the one hand the effect of uncertainty and on the other hand the objectives. Objectives are something we want to achieve in future. Objectives might differ in time dimensions as they could be short-, mid- or long-term oriented. The other part of the definition is the effect of uncertainty which means that there are things that can occur which are not expected and lead to ambiguity. Uncertainty is seen in form of harming or keep a business in achieving its objectives. A risk is therefore a potential threat that could

¹¹⁶ Cf. Douglas W. Hubbard (2009) *The Failure of Risk Management: Why It's Broken and How to Fix It*. New Jersey, USA: John Wiley & Sons, P.10

¹¹⁷ ISO 31000:2009, Clause 2.1

have negative impact on achieving goals. Risk management should be implemented in any kind of company because not only large and complex organisations need to be aware of risks, even a one-man company should analyse potential threats. Analysing risks is very difficult, because often risks become a problem without knowing that they actually exist. Usually, unforeseeable risks are external factors on which the company has no or very limited influence. This is the reason why companies often get negatively surprised by those risks as people tend to put their attention on what they can influence or monitor easily.

Risk management is essential to ensure the survival of a company. A comprehensive risk management is helpful to prevent disruptions along the supply chain. The key problem is to identify major risks and to find tools to measure and monitor these. One potential threat to enterprises is not that they don't do risk management but that they don't focus on the most important risks. As mentioned before, one reason might be the fact that companies are not always aware of their risks. Another key issue of risk management is to implement it within an organisation. It is not only necessary to identify risks but also to find, implement and control tools to measure and evaluate the identified risks. An appropriate tool must enable the company to classify risks in their degree of impact on the company's success and their occurrence probability but even if the probability of occurrence is low, companies must not neglect those in case the impact on the company would be significant. One of the main challenges of risk management is to transform a potential threat into a benefit for the company. Normally, risks are associated with negativity as they can harm a company's objectives according to the ISO 31000:2009 definition but transforming a risk to an opportunity can lead to competitive advantages. Especially, when it is a risk that could affect not only one company of an industry but several competitors.

In the first step, it was important to analyse what a risk really is before we can define risk management with its objectives and functions. In the second step, it is necessary to define risk management in order to make clear why companies should implement a risk management system. Basically, an optimal risk management is a department that identifies, analyses, measures, assess and monitors risks as well as a risk management department should be able to transform a risk, a potential harm, into a potential benefit for the company. Identifying risks requires a detailed analysis of the internal environment as well as the micro and macro environment of an enterprise. Especially, external factors need be to analysed carefully because of their complexity. These factors tend to be more difficult to monitor or measure and therefore harder to evaluate. The problem is that an evaluation is

essential in order to determine the degree of how the company could be affected by an occurrence. Generally, the higher the complexity of a supply chain, the more risks could occur. The most important point in this regard is that the more risks companies have, the higher is the probability that there are risks that can't be controlled or influenced as well as there might be more risks that have side effects. The problem often is that companies are fully aware of their external problems but not of potential side effects because many firms don't put their supply chain as well as risks in an appropriate cause and effect context where side effects might occur that in turn have negative influence on the business' performance. Therefore, it is necessary that a company builds up a risk management department that is able to create a risk management system that is aware of complex causality changes. Only if this complexity is managed well within a risk management system, a company can work successfully in the long-term.

4.1.2. ISO 31000:2009

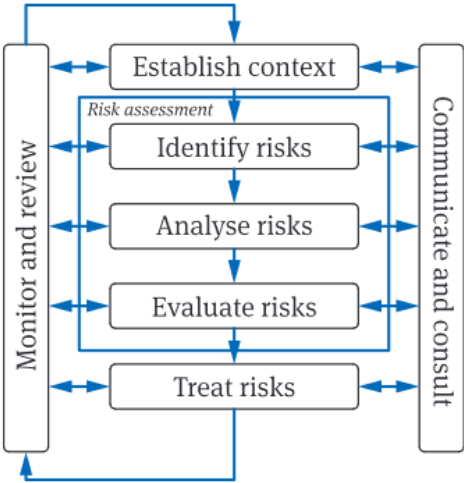


Figure 2 – The ISO 31000:2009 risk management process

Figure 17: The ISO 31000:2009 risk management process¹¹⁸

The illustration above shows the risk management process according to ISO 31000:2009. According to this graphic, risk management is a continuous cycle without a beginning or an end. At all stages of the process, it is essential to monitor and review the risk as well as it is necessary to continuously communicate and consult in order to deal with the risk appropriately. Besides the monitoring and reviewing and the communication and

¹¹⁸ ISO 31000: Risk management – A practical guide for SMEs. P.14, Figure 2 – The ISO 31000:2009 risk management process

consulting, the first step of the risk management process contains the establishment of the risk context. At this stage, a company could establish different risk categories such as supply chain or financial risks. In a comprehensive risk assessment, a company needs to identify certain risks for all contexts. In the next step, the identified risks need to be analysed. How realistic is an occurrence? What would be the impact on the company and how strong would be the impact? Does it have positive or negative consequences? Is there any side effect? After the analysis of risks, the company needs to somehow evaluate or measure the risks in order to formulate appropriate actions and activities to deal with the risks. After treating the risks, the undertaken actions need to be monitored and controlled so that managers can evaluate if the actions are successful.

4.1.3. Measuring risks

After companies decided what groups of risks they want to put attention on, they need to clearly analyse and define what risks they might face. For instance, company A offers online financial services and decided to focus mainly on two groups of risks. These should be risks that are related to the macro environment as their business heavily depends on what happens on capital markets as well as they want to focus on IT security because company A offers its services only online. As company A does not want to miss out any important risk, they want to monitor another group of risks which they call general business risks. In order to be able to measure risks, it is essential to clearly define the risks that might occur. Otherwise, companies would try to measure something but they don't really know what they are trying to measure and develop measuring tools without understanding the results. That is the reason why the stage of identification is so important. This is similar to the question of how to solve a problem. One can only solve a problem if the cause of the problem is known. Nonetheless, the problem could not be solved. This implies that companies can only measure and treat a risk properly when they know what their risks are. Not rarely, companies struggle to measure risks as they consider risks as intangible. Many risk management models consider the probability of occurrence as an indicator to measure risks. For instance, what is the probability of occurrence for earthquakes? If we assume that there is a company located in an area where earthquakes are a common phenomenon, a scenario could be like the following: There have been 4 earthquakes 3 years ago, 7 earthquakes 2 years ago and 10 earthquakes last year. Some people would say that the probability of occurrence is equal to the arithmetic mean – 21

earthquakes/3 years = 7 earthquakes/year. Therefore, the monthly probability of occurrence would be 7/12 months = 58,33%. The question at this point is if the arithmetic mean is a representative number. Taking a look at the development of earthquakes in this example, we can see that the amount of earthquakes/year has constantly increased over the last three years. The question is, does the trend of increasing earthquakes continue or not? Therefore, it is necessary to find appropriate measurement tools and KPIs to properly deal with risks.

In order to find an appropriate method to measure something intangible like a risk, Douglas W. Hubbard, inventor of Applied Information Economics (AIE) methods and an expert in measuring risks, suggests to ask five questions before measuring something.¹¹⁹ These five questions should help to understand what to measure.

1. What is the decision this is supposed to support?
2. What really is the thing being measured?
3. Why does this thing matter to the decision being asked?
4. What do we know about it now?
5. What is the value to measuring it further?

After being clear about what to measure, Hubbard suggests to six other questions in order to be sure about how to measure, so that a proper measurement tool can be chosen.¹²⁰

1. What are the parts of the thing we're uncertain about?
2. How has this (or its decomposed parts) been measured by others?
3. How do the "observables" identified lend themselves to measurement?
4. How much do we really need to measure it?
5. What are the sources of error?
6. What instrument do we select?

Often things or risks consist of several parts, therefore it is necessary to understand which part of the whole is a risk for the company. This refers to the identification stage of the risk management process because only if one exactly knows the risk, one is able to deal with it. Besides that, it can be useful to observe competitors or other companies. As explained earlier, there are many risks that could affect all kinds of companies not just one firm or a single industry. The probability is high that those risks have been measured by other

¹¹⁹ Cf. Douglas W. Hubbard (2007) How to Measure Anything – Finding the Value of "Intangibles" in Business. New Jersey, USA: John Wiley & Sons. P.43

¹²⁰ Cf. Douglas W. Hubbard (2007) How to Measure Anything – Finding the Value of "Intangibles" in Business. New Jersey, USA: John Wiley & Sons. P.104-105

companies before. Even though other companies don't have the perfect solution, gaining information about how they measure the risks definitely helps to find a solution that is appropriate. Important in this regard is to analyse and understand how others have measured, why they have measured it that way in the first place and thirdly can we apply the same measurement tool. The fourth question refers to nature of the risk and how much could the risk affect the company. Based on the concept of systems thinking, a risk should be monitored more careful if an occurrence would affect many subsystems as the degree of interdependence is an indicator for importance. For instance, two companies measure and monitor the same risk. In company A, the risk has only consequences for one department while in company B the risk has consequences for several departments. The total impact for both companies is the same but based on systems thinking, the impact on company B is worse. The reason is because in company A, there is only one department that undertakes activities to fix the consequences caused by the risk. These activities have no impact on other departments as there is no relation within the system. In company B, several departments undertake actions to fix the consequences but these departments are interrelated so their activities have also impact on other departments which means that one activity of department A can impact department B negatively and vice versa. However, the higher the degree of interdependence within the whole system, the more detailed the risk should be observed. However, it is not only important to find a way to measure but also to analyse possible sources of error. Lastly, we need to develop or choose the tool to measure.

4.1.3.1. Matrix models

As mentioned before, measuring risks is not easy. That's most probably the reason why many companies do not try to measure risks by calculating something but by putting risks into a matrix. Usually, those matrix-based models consider two aspects. The probability of occurrence and the impact on the company.

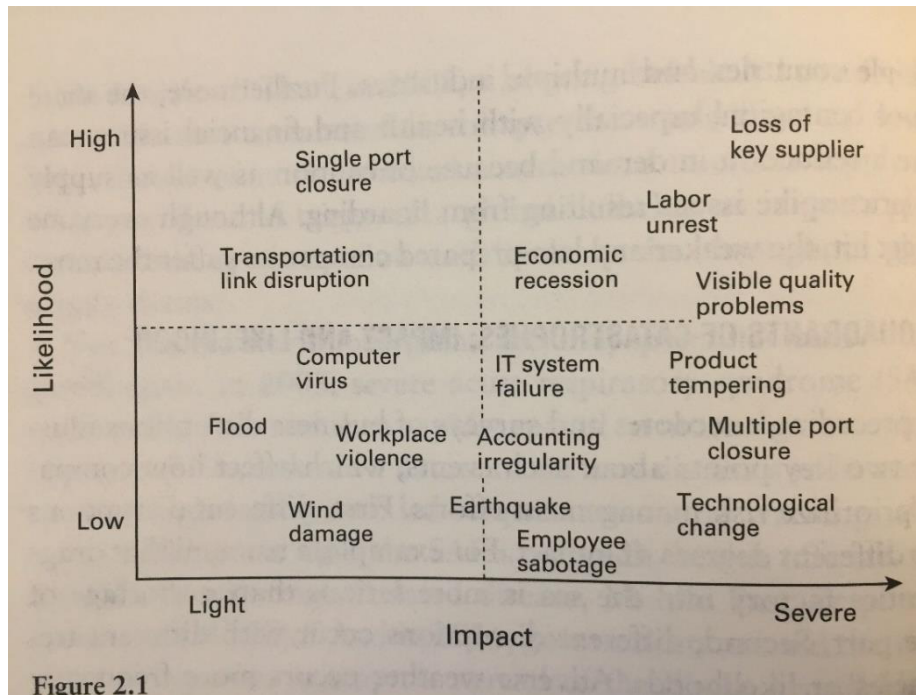


Figure 18: Typical supply chain risk matrix¹²¹

This example is a two-dimensional matrix created by Yossi Sheffi, director of the MIT's Center for Transportation and logistics, prioritizing risks from a supply chain management point of view. The axes illustrate the likelihood and the impact of events divided into two classes: High and low for the probability of occurrence and light and severe for the impact. In this case, risks have not been calculated mathematically but prioritized. A prioritizing of risks in a matrix is therefore an estimation of how could risks impact the company and how likely are they going to happen. According to Sheffi, a prioritization can be based on historical data, analytic or subjective measures. At the same moment, he suggests terms that could stand for the impact such as a potential loss in sales, a reduction of operating income or a decreasing share price.¹²² Besides the provided examples by Sheffi, there are other terms to express the impact such as the potential image damage of a company. Actually, the amount of impact that one risk has to a company is individually. While one firm might be affected badly, another firm might be affected rather not as bad by the same risk. In some cases, it might make sense to prioritize the same risks with different but relevant terms of impact. This would enable a company to compare different scenarios in order to have a better understanding of risks. The likelihood or probability of occurrence can be estimated either on historical data or other probability models. As mentioned

¹²¹ Cf. Yossi Sheffi (2015) *The Power of Resilience*. Massachusetts, USA: MIT Press. P. 34, Figure 2 – Prioritizing possible events

¹²² Cf. Yossi Sheffi (2015) *The Power of Resilience*. Massachusetts, USA: MIT Press. P. 33

before, companies need to be aware of changes if they choose historical data (see measuring risks). This model is a very simple one where risks have been aggregated. Of course, there might be significant differences in terms of risk, for example, for earthquakes. For instance, 9 out of 10 earthquakes had only a small impact on the firm's performance but the tenth earthquake had led to a standstill in the production facility of almost a month. How should a company aggregate these kind of risks? Does it make sense to use an arithmetic mean, a weighted average or a median? Nevertheless, there is no perfect solution and companies need to value those risks individually. But, it is recommendable to put a special attention on risks that could have highly deviated impacts. Perhaps, this could be in form of an automatically generated note. Let's assume company A measures their risks with Microsoft Excel, which would make it easy to cluster risks into groups. For instance, one group could be natural disasters. In the next step, the risk manager could include a formula that informs of high variances. For example, the formula could display high variances possible, if this risk is a natural disaster and if it belongs to another risk group, the formula could display nothing but an empty cell.

The screenshot shows an Excel spreadsheet with the following data:

	A	B	C	D	E
1	Risk	Risk group	Note		
2	Earthquakes	Natural disaster	High Variances Possible		
3	Computer viruses	Information Technology			
4	IT security	Information Technology			
5	Floods	Natural disaster	High Variances Possible		
6	Loss of key supplier	SCM			
7	Labor unrest	Employees			

The formula bar at the top shows the formula: `=WENN(B2="Natural disaster","High Variances Possible", "")`

Figure 19: How to create effective risk matrices in Microsoft Excel - Illustration at own construction.

The next matrix is slightly different to the first one with a couple of similarities. First of all, the next matrix does not come from someone who deals with logistics and transportation but from the healthcare industry. It shows different diseases such as HIV or Hepatitis B and categorizes those diseases based on their frequency and their severity. Another difference to the first matrix is the matrix itself. While Sheffi's matrix is a 2x2 matrix, this one is 6x5 matrix. Basically, the more columns and rows a matrix has, the more detailed the categorisation. An appropriate question in this regard is: Does it make sense to use a matrix with 30 boxes when only 10 boxes are used? As there is nothing with

medium or low frequency, we recommend to change the amount of rows in order to compress the matrix logically. We would use a classification as follows: very high frequency, medium-high frequency, very low frequency and extremely low frequency. From our point of view, there is another aspect in this matrix that is not illustrated well. One example for this situation could be HIV in the matrix below. As HIV leads to death after a certain time, the severity of consequences is very high but because of the very low frequency, HIV is categorised as a low risk. A low risk usually implies that it is to neglect but once someone has HIV, it is a sentence of death if the right medication is not available. In this case, it would be appropriate to either separate a deathly disease from the non-deathly disease ones or to mark them in another colour. Otherwise, there is a potential risk that the information gathered by the risks management is misleading or not representative.

Colored Cells are the Risk Categories		Low Risk	Medium Risk	High Risk	Very High Risk	
Frequency of Infection	Severity of Consequences					
	Very Low Severity	Low Severity	Medium Severity	High Severity	Very High Severity	
	Very High Frequency	TT virus *Obs 3 *Est 10	Cytomegalovirus *Obs 35 *Est 13 Epstein-Barr virus *Obs 90 *Est 79			
	High Frequency	SEN virus *Obs 0.1 *Est 0.19 Hepatitis G *Obs 0.11 *Est 0.10				
	Medium Frequency					
	Low Frequency					
	Very Low Frequency		Bacterial contamination *Obs 0.003 *Est 0.007	Hepatitis B *Obs 0.01 *Est 0.01		
Extremely Low Frequency		Hepatitis C *Obs 0.004 *Est 0.014	Syphilis *Obs 0.00 *Est 0.01 HTLV *Obs 0.01 *Est 0.05	HIV *Obs 0.13 *Est 0.03 CJD/vCJD *Obs 0.1 *Est 0.04		

Figure 20: A risk matrix with healthcare content¹²³

4.1.3.2. Risk score system

As illustrated above prioritizing risks in matrices is not a perfect solution, this chapter is going to show a mathematical risk assessment which tries to calculate the value of risks. A risk score system requires two things. Firstly, a company needs to define the factors that have impact on the risk score and secondly, the defined factors need to be weighted. In

¹²³ Shabnam Vatanpour, Steve E. Hruddy & Irina Dinu (2015). Can Public Health Risk Assessment Using Risk Matrices Be Misleading? International Journal of Environmental Research and Public Health 12(8) P. 9575-9588

practice, a model like this could be easily created with Microsoft Excel. The illustration below shows a small case where a company has identified five specific risks and defined factors that should be included in calculating the risk score as well as a weighting of those.

	A	B	C	D	E	F
1	Risk Score					
2						
4	Factors					
5			Likelihood	Severity	Interrelations	Total
6		Weighting	0,25	0,35	0,4	1
8	Risk					
9						
10	Loss of a key supplier		1	5	5	4,00
11	Labor unrest		3	4	5	4,15
12	Delayed deliveries of raw materials		2	2	3	2,40
13	Earthquake		1	4	5	3,65
14	IT-Network breakdown		2	3	3	2,75
15						

Legend	Likelihood	Severity	Interrelations
1	most probably not going to happen	Very low impact	Almost no interrelations
2	Probably not going to happen	Low impact	Low amount of interrelations
3	Not sure what's going to happen	Impact	Medium amount of interrelations
4	Probably going to happen	Strong impact	High degree of interrelations
5	Most probably going to happen	Very strong impact	Very high degree of interrelations

Risk Score Table	
1,00 - 2,50 =	Low Risk
2,51 - 4,00 =	Medium Risk
4,01 - 5,00 =	High Risk

Figure 21: How to measure risk score in Microsoft Excel - Illustration at own construction.

In this example, the company has used Microsoft Excel, a software which most organisations use, in order to prioritize risks with a score system. The factors that are considered as being indicators for measuring risks are the likelihood, severity and interrelation within the organisation. Every factor has a certain weighting, depending on the importance of the factor. Actually, a company can choose as many factors as they want as long as the sum of all weighting is one. In this case, the company has decided that interrelations are the most crucial criteria with a factor of 0,4 (40%), followed by severity with a factor of 0,35 (35%) and likelihood with a factor of 0,25 (25%). Now, the company needs to rate every factor from 1 to 5 according to the legend shown above:

Likelihood stands for the probably of occurrence of a risk. Basically, how realistic is it that this risk is going to occur? In terms of severity, the company measures the degree of consequences of a risk. How strong would be the impact on the company, if the risk occurs? Interrelations, in this case, deals with the question of to which degree would the

company be affected? Would an occurrence be a risk only for one or maybe two departments or would it be affecting the whole organisation? Again, the chosen scale is not a perfect solution that fits all companies and should be analysed individually based on what's necessary for the company. As a next step, all values of one risk need to be added and multiplied with their weightings. For instance, the calculation of the risk of the loss of a key supplier would be as follows:

$$(5) \text{ Loss of a key supplier risk score} = 1 \times 0,25 + 5 \times 0,35 + 5 \times 0,4 = 4$$

As risks have been divided into low, medium and high risks depending on the risk score shown in the risk score table, the loss of a key supplier would be a medium risk. Furthermore, this shows the disadvantage of a risk score system which is similar to the key disadvantage of a risk matrix. From a calculative point of view, the loss of a key supplier is a medium risk but actually it is one of the worse things that could happen for many companies. Mathematically, it is not categorised as a high risk because the probability of occurrence is very low. Even though the weighting of likelihood is comparably low, it still causes that the loss of a key supplier is only a medium risk. Our solution for this case is similar to the approach we suggested for the matrix based system. Companies can divide risks into low, medium and high but there should be a fourth category which includes all risks that have a value of 5 for one of the considered factors. In this case, it would be the loss of a key supplier, labour unrest and earthquakes. Basically, this risk group includes all risks that are not likely to happen but if they occur, they are going to have a massive impact on either one part of the company or the whole organisation as well as it includes risks which are very likely to happen. This is also important even if the impact is not so severe but if they are going to happen and a company knows about it before, they can initiate activities that try to prevent any impact. Including the idea of a category for risks that need special attention, the same example would look as shown below.

	A	B	C	D	E	F
1	Risk Score					
2						
4	Factors					
5			Likelihood	Severity	Interrelations	Total
6		Weighting	0,25	0,35	0,4	1
8	Risk					
9						
10	Loss of a key supplier		1	5	5	4,00
11	Labor unrest		3	4	5	4,15
12	Delayed deliveries of raw materials		2	2	3	2,40
13	Earthquake		1	5	5	4,00
14	IT-Network breakdown		2	3	3	2,75
15						

Risk Score Table		
1,00 - 2,50 =	Low Risk	
2,51 - 4,00 =	Medium Risk	Risks with special attention
4,01 - 5,00 =	High Risk	if any factor = 5

Figure 22: How to treat risks which require special attention - Illustration at own construction.

4.2. Definition supply chain risk management

The development of efficient and cost reducing supply chains around the world has influenced companies and their systems. The timely delivery of products or services is essential for every business around the world. The increasing interest in supply chain management and different cost reducing tools and techniques like lean management, just-in-time systems or total quality management has many benefits like cost reduction but on the other side they tend to increase risks because of the extend of complexity. A timely bound supply chain cannot take the risk of disruptions because it might affect the whole supply chain negatively. However, businesses need to develop plans in which risks and disruptions are anticipated so that happenings do not intervene the production flow especially when the business works in an international environment.¹²⁴ So the definition of supply chain risk management (SCRM) used in this paper is:

Supply chain risk management is the implementation of plans and strategies to manage risks, which could occur on a daily or even exceptional basis, along a supply chain in order to fulfil the objectives of reducing vulnerability and to ensure continuous production flow

¹²⁴ Cf. Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. International journal of physical distribution & logistics management, 34(5), 388-396

under the assumption of using continuous risk assessment. Furthermore, it includes the identification, assessment and regulation of supply chain risks.

This definition approaches that businesses that implement SCRM want to decrease their vulnerability to ensure continuity in their business. Prevention of risks and disruptions secure the company's financial performance because their risk strategy contains different back-up possibilities to run the company and ensure delivery to their customer.¹²⁵ Furthermore, risks can not only disrupt the supply chain flow but they can lead to a total supply-chain breakdown. There exist different supply-chain risks with different characteristics like natural disasters or labour disruptions, supplier problems, changes in legislative or politics or even war and terrorism. These potential risks might have negative impact on material or information flow and even on the company's cash flow which might result in decreasing sales and increasing costs.¹²⁶

Nevertheless, the term risk respective to SCRM need to be defined for further explanations in this paper. There are several definitions of risks. One understanding of risks is the uncertainty within a company and from external influences that might occur in supply chain operations and disrupt the production flow. Another interpretation is that uncertain and unreliable resources might cause supply chain interruptions. However, it is important for a firm to determine outcome, impact and expectations of risks and risk sources.¹²⁷

Risk pooling is a concept for companies to address variability and disruptions in the supply chain. Basically, risk pooling means that the effect of risks is reduced when it is spread across locations. However, risk pooling allows companies to reduce safety stock because other locations cover the deficit of supply.¹²⁸ The concept of risk pooling means that flexible systems are less exposed to risks than specialised systems. The possibility to produce different products at the same location or that other distribution centre can cover a risk that occurred at another one, are only two examples of risk pooling. The concept of risk pooling is strongly related to flexibility because flexibility is somehow the base for

¹²⁵ Cf. Lee, T. Y. S. (2008). Supply chain risk management. *International Journal of Information and Decision Sciences*, 1(1), 98-114

¹²⁶ Cf. Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. *MIT Sloan management review*, 46(1), 53-61

¹²⁷ Cf. Tang, O., & Musa, S. N. (2011). Identifying risk issues and research advancements in supply chain risk management. *International journal of production economics*, 133(1), 25-34

¹²⁸ Cf. Simchi-Levi, D., Kaminsky, P. & Simchi-Levi, E., (2009). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies*. Third Edition. International Edition. Mc Graw Hill Education, New York. P. 48

risk pooling. If a company doesn't imply flexibility in their supply chain, the company is hardly able to spread risks across different locations which basically means the concept of risk pooling. However, risk pooling is an essential concept for supply chain risk management to ensure the material, information and money flow of a supply chain at least until a certain extend. Risk pooling helps companies to reduce the effect of risks on the business performance.¹²⁹

4.3. Categorisation of risks and risk drivers in SCRM

Before companies can effectively implement SCRM and reduce or prevent supply-chain risks, they need to know which kind of risks might occur. For a better understanding of risks and what their sources are it is necessary to categorise them and analyse their drivers. However, companies that gained knowledge about supply-chain risks, need to assess them and develop an appropriate and most effective strategy for each of the risks. The table below is from Chopra and Sodhi (2004) shown in the MIT Sloan management and illustrates one way of categorisation of risks and their driver:¹³⁰

Category of Risk	Drivers of Risk
Disruptions	<ul style="list-style-type: none"> • Natural disaster • Labour dispute • Supplier bankruptcy • War and terrorism • Dependency on a single source of supplier • Dependency on capacity and responsiveness of alternative suppliers
Delays	<ul style="list-style-type: none"> • High capacity utilisation at supply source • Inflexibility of supply source • Poor quality or yield at supply

¹²⁹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.140-141

¹³⁰ Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. MIT Sloan management review, 46(1), 53-61

	<ul style="list-style-type: none"> source Excessive handling due to border crossings or to change in transportation
Systems	<ul style="list-style-type: none"> Information infrastructure breakdown System integration or extensive systems networking E-commerce
Forecast	<ul style="list-style-type: none"> Inaccurate forecasts Bullwhip-Effect
Intellectual property	<ul style="list-style-type: none"> Vertical integration of supply chain Global outsourcing
Procurement	<ul style="list-style-type: none"> Exchange rate risk Percentage of a key component or raw material procured from a single source Industrywide capacity utilisation Long-term vs. short-term contracts
Receivables	<ul style="list-style-type: none"> Number of customers Financial strength of customers
Inventory	<ul style="list-style-type: none"> Rate of product obsolescence Inventory holding cost Product value Demand and supply uncertainty
Capacity	<ul style="list-style-type: none"> Cost of capacity Capacity flexibility

Table 4: Supply chain risk categories and their risk drivers

Because of the complexity of a supply chain, the complexity of supply chain risks is also very high. The occurrence of a risk might have the effect that other risks appear, as well. If there is an increase in demand, the company will need to have more products from their

supplier and if they are dependent on only one supplier, this firm might not be able to react in a short-term on demand changes. In this example, it is shown that inventory and disruptions are linked to each other and therefore it is likely that a domino effect of risks might occur. However, companies need to look at the whole supply chain as one system. That means that if there occurred a risk at one stage of the supply chain it might have negative impact on business partners. One example is if a supplier goes bankrupt and is not able anymore to fulfil the contract and deliver material, it will have impact on the buyer because the production flow might stagnate. Furthermore, the buyer need to be able to resolve the disruption and delay and have to source their material through other suppliers or use a multiple supplier sourcing strategy from the beginning.¹³¹

Disruptions in a supply chain are hard to predict but cause a lot of damage as described above. Natural disasters are almost unpredictable but on the other hand have a large impact because taking the example of an earthquake, it can destroy a whole factory. Business should assess the location for their factories carefully so that the buildings are not set in an earthquake-prone area if possible. However, firms can develop different strategies to prevent certain disruptions. One example is to have different supplier to reduce the dependency on only one supplier. Delays occur because supplier are not able to react to demand changes due to different reasons like inflexibility or high utilisation. The bigger the system and the more companies contribute to one value chain, the more likely it is that anywhere in the system occur failures which might have impact on every company. Forecast risk is for example that the company's prediction and the actual demand do not fit together. An intellectual property risk is for example if companies due to outsourcing use the same supplier like competitors. The competitor might receive knowledge from the supplier and gain a competitive advantage. Procurement risks might occur if changes in acquisition costs are not anticipated. Receivable risk is when a company cannot collect their receivables and this should be prevented by filtering customers and ensure their creditability. Inventory risk is the decision of a company on what extend they hold inventory. Inventory is dependent on three aspects: uncertainty of demand and supply, product value and its rate of obsolescence. Capacity risk takes time to adjust because it can only be increased or decreased over time. One example for capacity risk is hiring new employees or building a new factory which is time and cost-intensive. However,

¹³¹ Cf. Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. MIT Sloan management review, 46(1), 53-61

businesses need to make their capacity more flexible so that they can adjust towards the demand and therefore reduce costs when demand is low.¹³²

However, every company need to identify their risk drivers in their supply chain network. Every supply chain system is individual and therefore needs to be analysed individually. Different aspects like globalisation, outsourcing, different distribution channels and supplier base influence the identification and assessment of risk drivers.¹³³

4.4. Stages of supply chains and their risks

It is necessary to understand the different parts of a supply chain and how they interact as an entire system. In a today's economy it is likely that the supply chain of one product goes around the world and incidents in one of these stages might lead to several risks in other subsystems of the chain. Generally, a supply chain can be divided in five different stages. The first stage describes the different parts of a product and how they are related to each other. Companies can create a bill of materials (BOM) to illustrate all necessary parts to build the final product. One part of the product might require several other parts in order to perform the final action. A company with a high product variety has also a high variety of BOMs. These BOMs are hierarchical arranged and show all parts required for a product. Many companies use IT like material requirement planning (MRP) to manage the amount of material required. This tool helps to organise production and purchasing schedules and refers to lead times for each material. Furthermore, if a supply chain is not fully vertically integrated, many organisations are involved in the supply chain of one product. The echelons of supplier, which are numbered from Tier 1 which is the first supplier over Tier 2 which is the supplier's supplier to Tier 3 etc., often equals the BOM. Supply chain influencers like organisations might vary in their geographical location. The choice of supplier of a company determines the structure of their supply chain. Companies need to take different aspects into consideration like quality, costs and environmental aspects. The distribution channel of a product determines the location of distribution centres and warehouses. Companies also have the possibility to outsource distribution which could increase the variation of locations in a supply chain.¹³⁴ However, every location and

¹³² Cf. Chopra, S., & Sodhi, M. S. (2004). Managing risk to avoid supply-chain breakdown. MIT Sloan management review, 46(1), 53-61

¹³³ Cf. Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. International Journal of Logistics: Research and Applications, 6(4), 197-210

¹³⁴ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.16-21

organisation of the supply chain need to be connected through different kinds of flows. There are three types of flow within a supply chain: information, material and money flow. These flows are affected by the uncertain types of disruptions.¹³⁵ There are different options for companies available in order to move material: trucks, ships, airplanes and pipelines. The way of transportation depends on the sort of product and its condition.¹³⁶

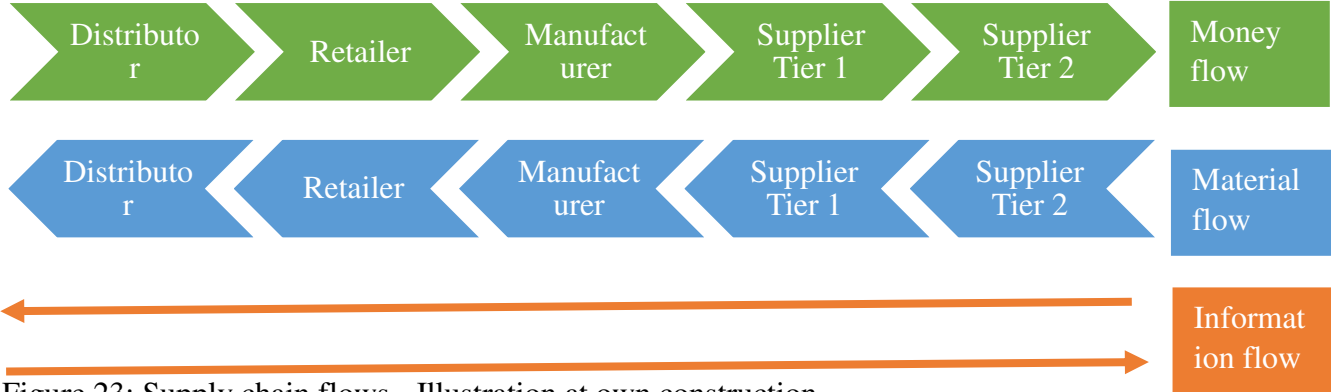


Figure 23: Supply chain flows - Illustration at own construction.

The illustration above shows that money flow goes up the supply chain and material down the supply chain. When we consider recycling, remanufacturing, returning and disposal, it might also be the fact that both flows are the other way around but this should not be the normality because those incidents, except recycling, indicate failure within the supply chain. Information flow should be continuous and flow in both directions which symbolises the exchange of information along the supply chain.

The last stage to consider in a supply chain is inventory of finished goods, parts and materials. Storage and handling of these goods need to be organised at various stages. Inventory is in various aspects costly. It needs space to be stored as well as man power to be managed and maintained.¹³⁷ Companies try to reduce inventory with different tools and techniques which are described in the chapter of supply chain management.

Each of the five aspects, which are described above, are potential risk taker in different ways. One part reflects the risks concerning handling the material in a supply chain. Organisations and locations are associated with risks like disruptions. Furthermore, these organisations are responsible for SSCM and ecological footprints. The further away the

¹³⁵ Cf. Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics: Research and Applications*, 6(4), 197-210

¹³⁶ Cf. Sheffi, Y. (2015). *The power of resilience: how the best companies manage the unexpected*. MIT Press, Massachusetts. P.16-21

¹³⁷ Cf. Sheffi, Y. (2015). *The power of resilience: how the best companies manage the unexpected*. MIT Press, Massachusetts. P.21-22

companies are, the larger is the ecological footprint because of different factors like transportation. The different flows of a supply chain offer risks regarding financial, logistical and informational aspects. Timeliness regarding logistics and the prevention of potential disruptions during the transportation is essential to assume. The information flow is mainly dependent on IT and therefore shows the vulnerability of technology risks. The money flow is connected with financial risks like bankruptcy, financial crises and exchange rates.¹³⁸ However, inventory risks are also a high risk taker in the material flow. The different drivers for this risk are shown in the table at the chapter of risk categorisation.

As described earlier, a supply chain has three different flows and one of them is the money flow or money supply chain. In contrast to the material and informational flow, which affect the supply when disruptions occur, disruptions in the money supply chain and also the appearance of financial crises affect the demand. When a financial crisis occurs, the origin of this incident lays way in the past. The effects of not well managed debts have their origin in the past and might occur after a long period of time. However, if there are disruptions in the money flow, it will have negative impact on the purchase ability of customers and also the purchase ability of manufacturers for needed material for production. This circumstance influences the supplier's business performance negatively. Furthermore, if there is a financial crisis, it will affect the exchange rates and money supply. This change in exchange rates might make purchasing in other countries too expensive so that the company goes bankrupt because they cannot effort material for production. This bankrupting might be a disruption for other companies in the supply chain.¹³⁹

Therefore, manufacturers should be aware of the fast changing financial situation of their supplier. To manage the risk of bankruptcy of suppliers, manufacturer should assess their supplier on a regular basis and adjust the time between two assessments towards external and internal circumstances like financial crises. However, looking at the other side of a supply chain, customer insolvency can also occur. The risk in this situation is that the supplier gets either paid with an indefinite delay or not at all. To mitigate the negative

¹³⁸ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.22-23

¹³⁹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.105-107

financial impact on the supplier’s business, the firm could offer payment motivations like discounts for early payments.¹⁴⁰

However, customer purchasing power might decline and less goods might be demanded when a financial crisis arises. Nonetheless, this could impact the bullwhip effect in a supply chain’s orders. If we consider that a retailer foresees a decline in demand and sales, he might also want to reduce inventory. Therefore, the retailer need to cut orders by the wholesaler by for example two percent. Whereas, the wholesaler reacts to the declining sales as well and cuts order by the distributor by for example four percent. This effect can go through the whole supply chain and have the impact that the further the bullwhip effect goes down the supply chain, the less is the amount of orders.¹⁴¹



Figure 24: The bullwhip effect regarding order declines - Illustration at own construction.

This decline in orders might lead to bankruptcies along the supply chain. If a supplier is not anymore able to supply goods because of too less orders, the company cannot survive in the long-term because of a shortfall of profit. Therefore, it is important for companies to think about the financial situation of their supplier when they cut orders because at some point it is not affordable anymore to produce.¹⁴² However, this shows that financial crises influences forecasting because most forecasts are based on historical data and when there

¹⁴⁰ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.118-119
¹⁴¹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.108-110
¹⁴² Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.108-110

is a significant drop in demand the data cannot be used for forecasts.¹⁴³ Furthermore, the bullwhip effect is also recognised when demand is going to recover. This time the orders increase from supply chain station to supply chain station as described in the chapter of the bullwhip effect.¹⁴⁴

However, financial crises are considered as very uncertain because companies can hardly predict the impact on demand and supply. Financial uncertainty for business and their consumer lead to drop in consumer demand. Whereas the amount of impact is unpredictable. Retailer are the first stage of the money that is entering the supply chain. Therefore, retailer notice at first the effect of disruptions in money supply and declining customer demand.¹⁴⁵

However, financial crises have the effect that customer demand is shifting towards products in the low-price segment. Companies that supply products in this segment might benefit from the financial crises because they face an increase in demand and sales and therefore higher profit. Other companies need to adjust to disruptions and new situation and offer different products for a lower price to stay competitive or even to save the business. Furthermore, supply shortages might occur because suppliers are not willing to purchase material for orders that might be cancelled. Supplier tend to cut inventories in those situations and implement up-front payments to ensure money flow.¹⁴⁶

Companies need to be aware of the risks in money flow and financial crises. In order to prevent bigger effects on a company's supply chain, the business could use vertical integration towards upstream and down-streaming parts of the supply chain so that purchase and supply is secured. Even though when one part of the supply chain is not profitable but supplies a profitable part or product of the supply chain, companies should think about keeping it because they prevent risks along all three of the supply chain flows.

¹⁴³ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.112

¹⁴⁴ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.121

¹⁴⁵ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.110-111

¹⁴⁶ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.111-112

However, this type of risk allocation is one possibility for companies to adjust risks in the money supply chain.¹⁴⁷

4.5. The importance of preparation

Businesses need to be prepared for different kind of risks that might occur in their supply chain. Therefore, risk managers need to develop options that can be used by crisis managers. Companies have to be resilient in order to stay competitive and overcome risks. There are two categories of options to build resilience. The first option is that companies should build redundancy and the second option is building flexibility of their supply chain processes and assets.¹⁴⁸

However, most businesses have tangible assets that refer to real options and managers have the right to use them but not the obligation. If due to the shortage of demand, the inventory is declining, managers could use the capacity for other purposes. Furthermore, firms should develop business plans for different types of disruptions so that the company is able to continue the production. Preparation in general need to consider a portfolio of options that include different aspects like additional capacity and inventory as well as sources of supply and flexibility in both production schedules and material input as well as transportation. The supply chain should involve redundancy and flexibility so that reacting to certain circumstances is easier. Furthermore, it is relevant to develop different disruption tools for the management so that the company can increase their resilience. Disruption management tools can help to reduce the time which is needed for recovery as well as both preventing negative long-term consequences and mitigate customer risks.¹⁴⁹

Crises lead to a drop in inventory, capacity and unused facilities. These redundant supply chain assets can be used by managers to mitigate effects of a disruption. However, these assets do not require any qualitative changes or expertise to be invested in. Managers only need to take the chance of maintaining spare assets in a crisis.¹⁵⁰

¹⁴⁷ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.114-115

¹⁴⁸ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.129

¹⁴⁹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.130-131

¹⁵⁰ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.132

Extra inventory could be useful when a plant or warehouse is in a region where disruptions that might interrupt the operations of a company are common. If a disruption takes place, the company is still able to produce and sell until a certain amount is reached. However, this type of preparation gives managers time to react on the disruption for example in form of gathering information from customer and supplier. There are different mathematical options to choose the right amount of cycle and safety stock so that the costs are not higher than the profit. Additional, the work-in-process inventory needs to be considered and calculated, as well, because this are parts and products which are currently in some processes along the supply chain which can help to buffer the effect of disruptions by securing the supply.¹⁵¹

However, as already mentioned supply chains should be designed flexible. Flexibility increases the amount of practices for given assets. One example is that production lines should be designed to be able to produce different kinds of products as well as employees should be trained to be able to work in different product sections for different products. This helps managers to better react to risks so that the company can still fulfil customer demand to a certain extend. This implicates that flexibility supports resilience and mitigates risks.¹⁵² Furthermore, redundancy and flexibility complement each other because when there is extra inventory available and another plant is flexible enough to produce another product, the production flow is to a certain extent ensured. Furthermore, there is also the possibility that the distribution channel of a company is disrupted. To prevent a deficit in sales, the company could use other distribution centres for backups.¹⁵³ Nevertheless, redundancy and flexibility are strategies to fill the gap between the risk occurred and the beginning of recovering the company's processes. On the other hand, both strategies are somehow cost-intensive because extra inventory requires more money. Furthermore, the modification of plants in order to be able to produce different products is also very cost-intensive regarding for example machinery equipment.¹⁵⁴

Next to financial crises are also market risks, which need to be estimated by companies. Businesses need to be able to recognise market changes at an early stage so that they can

¹⁵¹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.132-134

¹⁵² Cf. Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics: Research and Applications*, 6(4), 197-210

¹⁵³ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.136-140

¹⁵⁴ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.138-139

implement new products or react to the changes in an appropriate way. One risk could be that the company misses market opportunities because it is not flexible enough in its production lines and supplies to meet the new demand. Another aspect is lead times which need to be considered because companies should be able to also meet customer demand which is recognised on short notice.¹⁵⁵

4.6. Assessment of supplier risks

As briefly mentioned earlier, supplier can represent risks in another business' supply chain. A disruption at one supplier might lead to a domino effect and affects the whole supply chain.¹⁵⁶ Due to globalisation, suppliers can be located all over the world which increases the complexity of risks in supply chain operations. Companies have to assess procurement risks and they have to implement processes and strategies to manage them.¹⁵⁷

Supplier risk assessment consists of three aspects which are already explained in the chapter of risk management: detectability, impact and likelihood. The triplet focuses on the supplier's input to the company. Some companies have so many suppliers which supply different subassemblies and material that they only focus on key supplier. To determine key supplier, many companies use metrics that could include the importance of the material, availability of alternatives, amount of time for change in supplier or material, location, money as well as the supplier's financial situation and contribution to the firm's performance.¹⁵⁸

When a deep-tier supplier faces a disruption, it takes some time until the company and the company's customer realise the effect. It takes much more time for a supply chain to drain than to fill during recovery. However, companies should try to detect disruptions in their first tier supplier system, but also create processes or situations to control deep-tier disruptions because those might have influence on the company's performance. The benefits of dedicating disruptions in the supplier system at an early stage are that the company has some time to find alternatives of material or supplier or even help the

¹⁵⁵ Cf. Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International journal of physical distribution & logistics management*, 34(5), 388-396

¹⁵⁶ Cf. Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics: Research and Applications*, 6(4), 197-210

¹⁵⁷ Cf. Sheffi, Y. (2015). *The power of resilience: how the best companies manage the unexpected*. MIT Press, Massachusetts. P.159

¹⁵⁸ Cf. Sheffi, Y. (2015). *The power of resilience: how the best companies manage the unexpected*. MIT Press, Massachusetts. P.159-160

supplier or deep-tier supplier in their recovery process. The implementation of those dedication techniques might give the business a competitive advantage regarding securing procurement. The likelihood of a supplier risk should be represented by the aggregation of the likelihood of all risks.¹⁵⁹ Companies can also create a supplier score card to assess the supplier risk. It is up to the company and industry which risk factors are considered in the supplier score card. However, it is helpful for companies to describe the risk probability of their key supplier and if necessary deep-tier supplier.¹⁶⁰

Intel developed five questions which are asked to their supplier to ensure their business continuity plan. This approach includes deep-tier risk assessment so that businesses can ensure the flow of their supply chain even at a deep-tier stage. The five questions are listed below:¹⁶¹

- “Have you discussed business continuity with your critical supplier?”
- Do you have contingency plans in place if they cannot deliver to you?
- Are secondary sources available for critical suppliers? How quickly could these be activated during an emergency?
- Do your inventory and spare parts strategies allow sufficient buffer to ensure operations are not disrupted?
- Are engineering workarounds an option for extended supplier outages?”

These questions help companies to ensure the mitigation of supplier risks. Supplier should answer these questions on a regular base so that the company can ensure their business continuity plan. When supplier use these questions for their supplier, the continuous supply chain performance could then be even ensured to deep-tier supplier.

When for example a subassembly of a product is defective, the earlier it is recognised, the earlier the supplier can react and mitigate the supply risk as well as costs. Therefore, communication and shared information is also in SCRM a very important factor.¹⁶² Furthermore, strategies like just-in-time and lean production support the detection of failures at an early stage. A company measure the reaction time of their supplier when a

¹⁵⁹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.161

¹⁶⁰ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.164-165

¹⁶¹ Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.177-178

¹⁶² Cf. Jüttner, U. (2005). Supply chain risk management: Understanding the business requirements from a practitioner perspective. The International Journal of Logistics Management, 16(1), 120-141

risk occurs and how long it's going to take the supplier to fix the disruption. When a disruption occurred, all participants who are affected mostly don't measure the disruption itself but the time of reaction and the time until solutions come into actions and the supply chain is able to recover.¹⁶³

Nevertheless, even when the likelihood of appearance of a supplier risk for a particular supplier is low, the supplier might negatively affect the company in another way. One way is when a supplier doesn't take its corporate social responsibility serious and this might affect the brand image of the focal firm negatively.¹⁶⁴

One possibility to prioritise a supplier risk assessment is to use a spend/risk procurement matrix. It helps to assess the supply risk and procurement strategies. Furthermore, this matrix is an instrument for companies to better understand the importance of different subassemblies, materials and supplier.¹⁶⁵ On this basis, companies can develop plans and procurement strategies for different parts and suppliers. Firms can use this approach to identify and develop their strategic positioning. Furthermore, it creates the possibility to identify opportunities or areas of vulnerability. The matrix shows the company's buying strength and the supply market strength.¹⁶⁶

The horizontal axis shows "spend" which represents how much a company spend, for example, on a given subassembly at a given time. There are parts that are easy to replace but there are also parts that are easy to replace but have a large impact on the whole production flow, if missing. A company's costs and procurement strategies are effected by spend. There are two factors that need to be considered in this approach. One is that spend represents on the one hand the cost of inventory and on the other hand it reflects the importance of a company to its supplier. A supplier is more willing to mitigate risks, adopt the buyer's corporate social responsibility guideline and implementation of risk-reducing

¹⁶³ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.185-187

¹⁶⁴ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.162

¹⁶⁵ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.162

¹⁶⁶ Cf. Kraljic, P. (1983). Purchasing must become supply management. Harvard business review, 61(5), 109-117

procedures, when the buyer is important to them. Mostly this is determined by the money exchange and the degree of capacity utilisation which is occupied by the buyer.¹⁶⁷

The vertical axis of the matrix shows the complexity of procurement. This dimension includes the coordination of suppliers because one material might be easy to buy from other suppliers because of standardisation, but other material might be customised so that it is hard to get the material on short notice. In this case, if a company faces risks, the procurement of the material will be critical.¹⁶⁸

The illustration below shows the spend/procurement matrix:

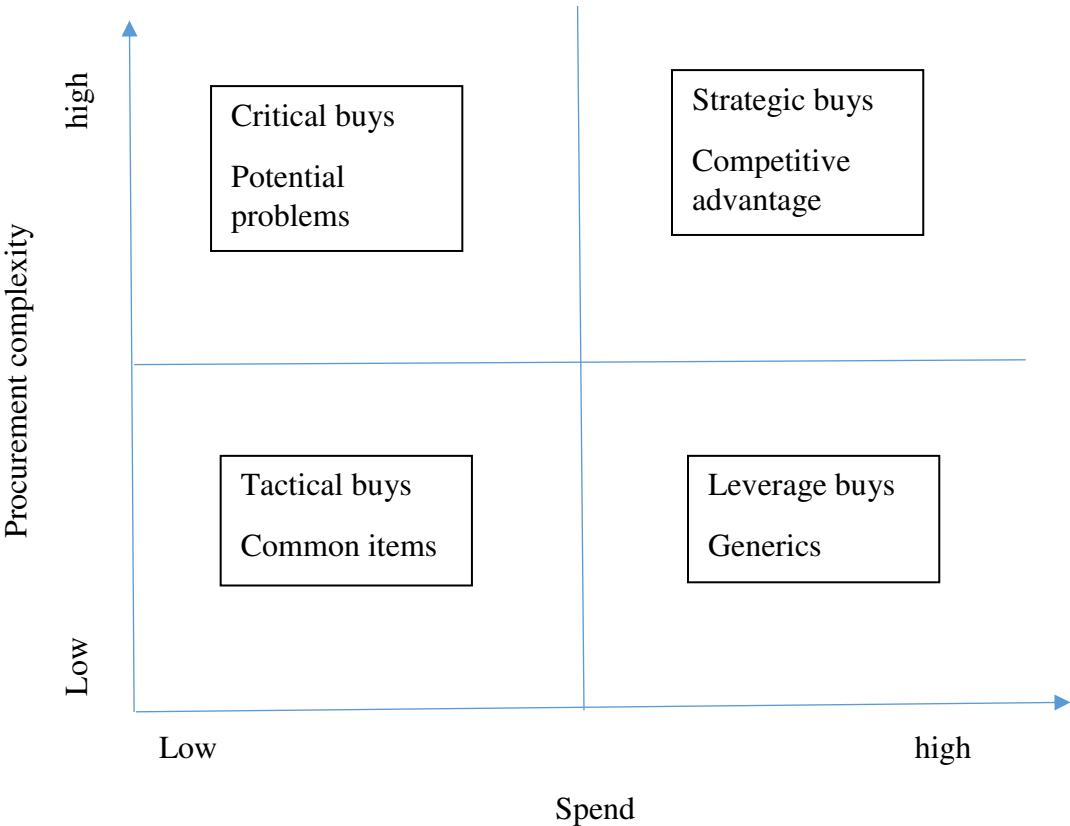


Figure 25: The spend/procurement matrix¹⁶⁹

However, the matrix shows four categories regarding the procurement conditions. One of the categories is “critical buys” which implies a complex procurement and a low spend. These items are basic parts of the product but very essential and critical for it as well. It is significant for companies to secure the flow of critical, hard-to-produce but low-spend

¹⁶⁷ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.166

¹⁶⁸ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.166-167

¹⁶⁹ Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.168

items even more when the buyer is no “key” buyer from the supplier. These items are the riskiest parts of a product and need to be cared for. One possibility for risk mitigation of this category is to keep a high inventory so that the supply is secured in case of a risk because multiple sourcing might not be possible due to the lack of alternatives.¹⁷⁰ Another category is “tactical buys” which consists of low procurement complexity and low spend. These items are parts which can be procured easily, are almost continuously available and have a low volume.¹⁷¹ “Leverage buys” are high-spend commodities. Companies try to leverage the costs of these items by allocating the volume of different locations to reduce transportation, administration and service costs. Both, “tactical buys” and “leverage buys” are items that are simple to procure.¹⁷² The fourth category is “strategic buys” which have a complex procurement and high spend. These items generally provide a competitive advantage. Furthermore, strategic items are produced from key supplier with whom the company has a deep relationship because of several reasons like price, planning, innovation or support from different plans.¹⁷³ The partnership includes collaborating in terms of supply chain performance, mitigating risks as well as innovation and efficiency.¹⁷⁴ The way of building deep business relationships is explained at an earlier stage of this paper.

4.7. The risk spiral

Next to tangible risks which are discussed before are also intangible risks in a supply chain. Intangible risks are the motivation, attitude, self-commitment and perceptions of participants in a supply chain including employees, customers and suppliers. If a supply chain lacks of confidence, risk managers are forced to intervene throughout the supply chain which could have risk exposure as a result. One example is when a buyer doesn't rely on the order fulfilment lead times, they might react with ordering stock in order to satisfy their customer's needs. This buffer stock is inefficient. Because of lack of visibility throughout the supply chain, businesses take decisions like building up buffer stock to

¹⁷⁰ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.170-171

¹⁷¹ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.168

¹⁷² Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.168

¹⁷³ Cf. Kraljic, P. (1983). Purchasing must become supply management. Harvard business review, 61(5), 109-117

¹⁷⁴ Cf. Sheffi, Y. (2015). The power of resilience: how the best companies manage the unexpected. MIT Press, Massachusetts. P.169

reduce the uncertainty and risks. Nevertheless, the buffer stock causes a longer pipeline which is boosted by the lack of visibility in the employee's actions because they don't react to the formal operating system and instead develop an informal system which is not accurately communicated and officially implemented. The concept of the risk spiral is illustrated below:¹⁷⁵

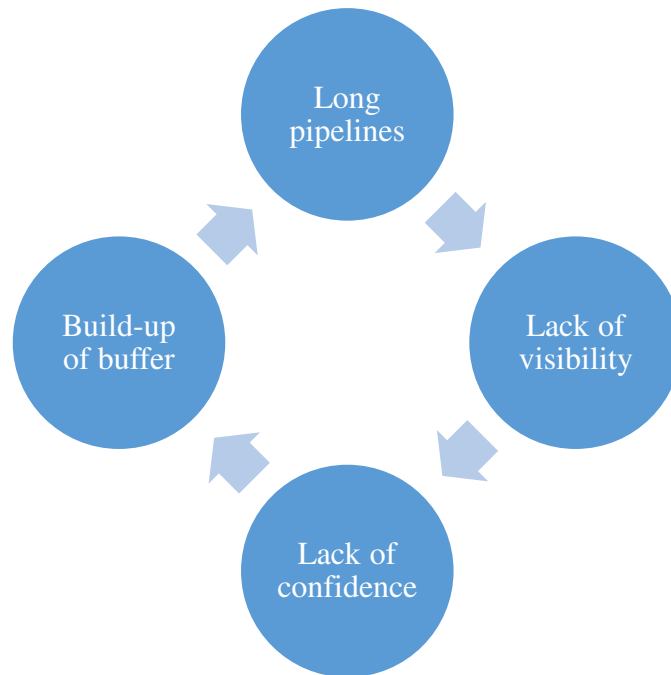


Figure 26: The risk spiral¹⁷⁶

However, the lack of supply chain confidence causes inefficiency and makes all businesses that act in the supply chain liable for supply chain risks, decision risks and thereby responsible for the concept of the risk spiral. Therefore, the aim in this case for SCRM is to decrease lack of confidence in the supply chain. There are two aspects that influence supply chain confidence which are visibility and control. Visibility is connected with time which takes the material in a supply chain to go through different stages until it actual reaches its destination. This means that business partners in a supply chain should have knowledge about inventory regarding material, finished goods, work-in-process as well as demand forecasts, capacity, lead times, production plans and statuses. This can be referred to the chapters of transparency along a supply chain because shared information improves visibility and transparency and reduces uncertainty along a supply chain which refers to an

¹⁷⁵ Cf. Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International journal of physical distribution & logistics management*, 34(5), 388-396

¹⁷⁶ Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International journal of physical distribution & logistics management*, 34(5), 388-396

increase in visibility and a decrease of lack of confidence. The second aspect is control which means that companies should be able to control their supply chain operations. Even though there is some kind of visibility in the supply chain including that managers have knowledge about the company's processes, it doesn't mean that they have control to make changes in a short time. If market changes are discovered and the manufacturer wants to react on it, it might be the case that the supply chain is too slow to react and the opportunity is missed.¹⁷⁷ Therefore, managers should be able to control variability in their supply chain. One possibility is that business partners work together to identify critical factors in a supply chain. At these factors and links, business partners agree to control limits and actions from which extend abnormalities are crucial. If one of the actions goes out of its limits, an alert system is generated and actions can be taken.¹⁷⁸

However, companies should try to break through the risk spiral in their supply chain by strengthen the supply chain confidence. The benefits of this are beside reducing costs, also reducing market risks which could lead to higher sales and market share.¹⁷⁹

5. Supply chain controlling

5.1. Definition controlling

During the last years, the need for comprehensive controlling has increased significantly due to the constantly growing level of complexity within organisations. Global supply chains require not only an efficient supply chain management but also someone who manages financial streams. Simply said, this is what controlling is about. Controlling manages financial streams as well as controlling measures the performance of a company.¹⁸⁰ As organisations not rarely consist of several legal entities, managing financial streams is a broad field and the functions and tasks can differ from organisation to organisation. For instance, one key function is to create periodical financial reports such as monthly, quarterly or annual profit- and loss statements. Besides periodical standard reporting, controlling departments create ad-hoc reports or analyses for certain situations in order to clarify financial anomalies. Main objective of these reports is to inform directors

¹⁷⁷ Cf. Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International journal of physical distribution & logistics management*, 34(5), 388-396

¹⁷⁸ Cf. Stiles, P. (2002), "Demystifying Supply Chain Event Management" in *Achieving Supply Chain Excellence Through Technology*, Vol 4, pp 262-264, Montgomery Research Inc

¹⁷⁹ Cf. Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. *International journal of physical distribution & logistics management*, 34(5), 388-396

¹⁸⁰ Cf. Garrison, R. H., Noreen, E. W., & Brewer, P. C. (2003). *Managerial accounting*. New York: McGraw-Hill/Irwin. P. 1-24

and managers so that they have appropriate data to make decisions. From a structural point of view, controlling often works closely together with the management and accounting. On the one hand, this should ensure an easy and fast communication between controlling and management but also a thematic orientation towards the needs of the management. A good relationship between controlling and accounting is necessary because both departments depend on each other. Controlling reports are often based on what accounting booked and accounting must rely on calculations made by controlling. All in all, controlling is an early warning system that monitors financial streams and informs management or other departments whenever anomalies occur in the business' performance. Nevertheless, controlling provides the management with periodical and ad-hoc reports that support the decision making process. These reports, especially periodical reports such as annual or monthly reports can also be used to provide investors, the public or legal authorities with financial information. Apart from these main functions, controlling also does cost center accounting, cost-unit accounting and cost-type accounting, product price calculations as well as break-even analyses and planning/budgeting. Furthermore, many organisations have started to use key performance indicators in order to measure the success or the development of success more efficiently.

5.2. Types of controlling

Usually, people relate growth with something positive but as explained before, simultaneously with the growth, the complexity of a company increases as well. In many large organisations, the controlling department is rather a centralized division that focuses on strategic aspects as well as it manages the financials of the whole group but it does not do much of operating controlling. From our point of view, it makes therefore sense to divide controlling into two categories: strategic and operative controlling, not only because of the complexity but also because of the distance in terms of contents that a centralized division has. For instance, the supply chain department wants to measure the efficiency of internal processes by using KPIs. Now there is two alternatives how the KPI system can be implemented. KPIs can be defined either by the controlling division or by the supply chain department itself. We think that it is better to locate those operating controlling processes to the departments because they know better how to measure their success or performance than a centralized division that has no clue about supply chain processes. If the supply chain department knows good indicators but can't really put them into mathematically

logical formulas, the controlling department can consult and support in transforming indicators into measurable equations.

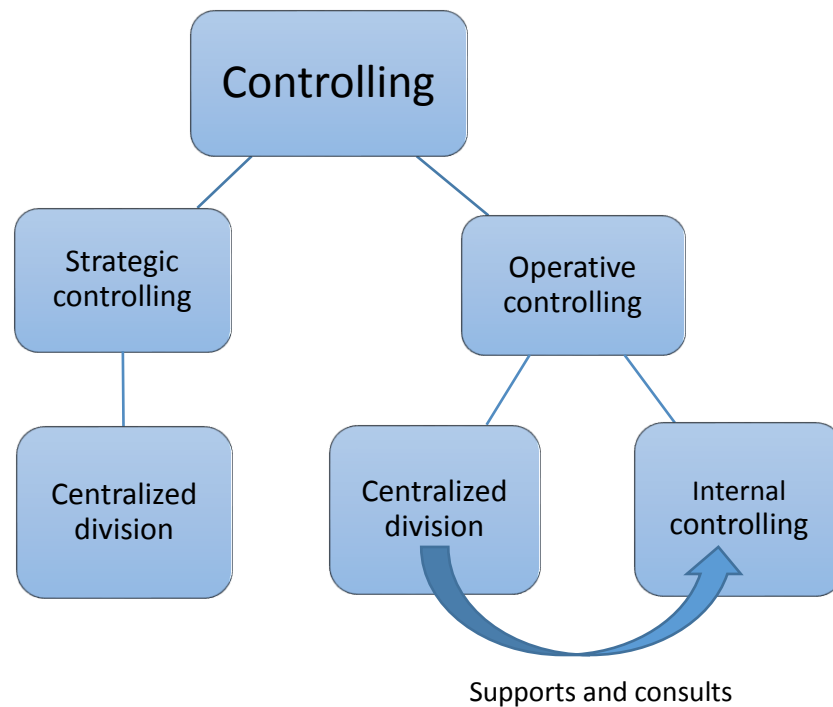


Figure 27: Types of controlling - Illustration at own construction.

The graphic above shows a classification of how an organisation’s controlling should be organised ideally. The centralized controlling is responsible for tasks like planning, budgeting and monitoring on a corporate scale. Besides, it creates financial reports and does managerial accounting. On the operative side, tasks should be divided. The particular department is responsible for defining indicators that could measure performance with the guidance of central controlling when there are problems in putting indicators into mathematical equations.

5.3. Key performance indicators

According to Parmenter, key performance indicators refer to different measures which focus on the most important aspects of a firm’s performance.¹⁸¹ In many cases, people want to measure the performance or success of an organisation by looking at numbers such as revenues, operating profit or net profit, but from our point of view, these numbers don’t measure the performance of a company. These numbers rather display the consequences of the performance of a company. Therefore, it makes more sense to measure performance at

¹⁸¹ Cf. Parmenter, D. (2010) Key Performance Indicators – Developing, Implementing, and Using Winning KPIs. 2nd Edition. P. 4. New Jersey, USA: John Wiley & Sons Ltd

earlier stages. For example, revenues are a consequence of the efficiency of many processes, so in order to measure performance, it would be more effective to measure the efficiency of key processes. KPIs can be absolute numbers, values between 0-1 and also percentages. Many companies lack to identify the crucial aspects of how the performance is driven in their company and how to really measure performance. Companies should determine their KPIs in order to identify potential causes of delays because the key function of a KPI is that managers can deviate actions out of the information of the KPI.

5.4. Definition supply chain controlling

If controlling is defined as managing financial streams and the performance of an organisation, supply chain controlling can be defined as managing the same but not on a corporate level. This means that the supply chain controlling manages financial activities and the performance of the supply chain management and refers therefore to internal controlling as illustrated in an earlier graphic. As innovative supply chain solutions can lead to sustainable competitive advantages and because of continuously changing conditions in the macro environment, it is essential to continuously monitor the performance of the supply chain.¹⁸² It is also necessary to check whether the currently used KPIs exactly measure the efficiency of supply chain processes. For instance, a manufacturer of metal cans relocates its production facilities from Germany to Eastern Europe. Before the change, the focus of the company was on monitoring contribution margins of products due to high unit costs caused by high labour costs. Since the production facility has been moved to Eastern Europe, contribution margins look better than ever but does this really reflect a better performance? Actually, it depends. If the changed unit costs are the only condition which has changed, then it does but what if it is not a *ceteris paribus* situation and other factors have changed, too? For example, labour costs in Germany were high because the company only employed skilled personnel. Now, labour costs have decreased but the employees might be not as good as before. As product quality highly depends on the skills of employees, the relocation might have led to lower quality. Lower quality then leads to a higher amount of complaints and complaints lead to costs or in the worst case to the loss of buyer. In total, the performance might be worse and contribution margins are not representative as an indicator for performance. This underpins

¹⁸² Cf. Miguel, M.R. (2004) Interactions between management accounting and supply chain management. *Supply Chain Management: An International Journal*, Vol. 9 Issue 2 pp. 134-138

that KPIs can be appropriate at a certain time but changes of internal processes or in the external environment can make a KPI predicting misleading information.

5.5. The supply chain performance matrix

This chapter illustrates one example of a supply chain performance matrix. Every company needs to consider their internal and external environment as well as their industries and products while developing their supply chain performance matrix. Businesses have to choose and identify carefully the key aspects and characteristics of their supply chain. The key aspects of the supply chain have to be monitored and controlled. If a company identified the crucial characteristics of their supply chain, they can start to develop factors that influence these. Those factors represent influencers that can have positive or negative effect on the supply chain performance. In order to manage the supply chain, the influencers have to be measured. The most effective way to control and measure different aspects of a supply chain is the use KPIs. The example below shows different key aspects of a simple manufacturing supply chain and some of their influencers. Companies, in practice, develop KPIs in order to monitor their supply chain performance. This example shows only two influencers per key supply chain characteristic. The two factors are indicators for improvements and failures in a business’ supply chain performance.

Key supply chain characteristics	Influencers (Key Performance Indicator)	
Customer satisfaction	Customer loyalty	Product dissatisfaction
Material flow (external)	Fulfilled lead times	Inventory deviation
Production operations (internal)	Product quality	IT matching business processes
Transparency	Communication with key supplier	IQ
Planning	Inventory turns	Production plan compliance (PPC)
Supplier	Reliability	Control of supplier’s supplier
Employees	Sickness	Fluctuation
CSR	Recycling	Illiteracy rate

Table 5: Key supply chain characteristics and their influencers - Table at own construction

The table above shows eight key supply chain characteristics and two influencers for each aspect. The characteristics are connected to the value chain of a manufacturing company. In this case we began with customer satisfaction because it is the superordinate aim of a company to meet customer needs. Overall, it is necessary to say that basically all KPIs indicate customer satisfaction because every aspect in a supply chain is based on meeting customer needs. Anyway, this matrix pointed customer satisfaction particularly out because in this context it refers to after sales services and customer loyalty. These two aspects including the amount of returns of one product illustrate how pleased a customer is with the product and services. Many companies use a KPI for customer loyalty when calculating revisits or rebuys on a firm's webpage. This is one possibility, but we like to go beyond the boundaries of a webpage but also calculate the rebuys and revisits of shops. To do so, companies could use the information from customers who paid with credit card. If one credit card is used more often in any shop during a certain period of time, this customer could be seen as loyal. For some industries this calculation is difficult to do because the product they sell is used for several years. In this case the after sales services could be consulted. However, if customers use the service or buy additional extras for their products, they can be seen as satisfied. Furthermore, the period of time in this case for calculating customer loyalty might extend to how long the product, in average, lasts. The less customers come back for another product, the less are they satisfied with the company. Another indicator for customer satisfaction is the product returns. Simply, when a customer is satisfied with the product, he/she won't return it. Therefore, the higher the rate of product returns, the less is customer satisfaction.

$$\text{customer loyalty} = \frac{\text{amount of retained customers}}{\text{total amount of customers}} * 100\%$$

$$\text{Product dissatisfaction} = \frac{\text{amount of product returns}}{\text{total amount of products sold}} * 100\%$$

Furthermore, the matrix divided the operational processes in material flow, production operations, supplier, employees and planning because the overall operational processes is too broad and if a company doesn't differentiate between the different aspects of operations, it might be that the KPIs don't help identifying the source of failure in business performance. In this context, material flow refers to the transportation of material outside the company which includes the inbound and outbound material flow but does not include the material within the company itself. The internal material flow is illustrated as the factor

of production operations. However, inventory refers to both, internal and external material flow. It is important to see the whole level of inventory which also includes work-in-process inventory. Otherwise results might not be representative. In addition, the failures which could occur at the supplier are determined under this aspect. However, it is very important for a firm to know if the planning of a production flow equals the actual operations. Companies need to know if they have to make adjustments in their planning process of their supply chain in order to guarantee a healthy supply chain performance. Furthermore, employees are a significant factor that can influence supply chain performance. It is necessary to know the source of employee failures so that solutions can be applied.

The lead times at the characteristic of material flow refer to the efficiency of inbound transportation of products and materials that are entering the company. It illustrates if the amount of time which was agreed is accomplished or not. If it is not, managers should think about alternatives so that the actual lead time can be achieved. In addition to that case, it is necessary to say that there might be disruptions which could not be anticipated like car accidents or natural influences like storms. To include these circumstances, managers should consider a certain deviation as acceptable. This means that the lead time itself should have a certain percentage of deviation which is considered as acceptable. One example is that a truck has six hours to go from the supplier to the manufacturer. On the road was an accident but the truck only lost 30 minutes. If a company considers 10% deviation, the truck is still fulfilling the lead time. If every delay, even a small period of time, is accounted, the KPI is not able to reach the optimum because unforeseen occurrence can always happen. Nevertheless, any deviation should be investigated so that the source of disruption can be located and at most eliminated.

$$(6) \quad \textit{Fulfilled lead times} = \frac{\textit{amount of achieved lead times}}{\textit{total amount of inbound transportation}} * 100\%$$

Another indicator for material flow is inventory. It is important for a company to know how much inventory they have available in their supply chain. The total inventory includes the base stock, safety stock and work-in-process inventory. It is important that the inventory level is not too high in order to not extend costs and not too low so that the company can still produce in case of a disruption. The level of inventory should never be under the average. To indicate a healthy material flow, a company could use the following equation.

$$(7) \quad \text{inventory deviation} = \left(\frac{\text{total inventory}}{\emptyset \text{ of total inventory}} - 1 \right) * 100\%$$

If the percentage is minus it means that the inventory is below the average and should be restocked by the particular percentage. If the percentage is positive, it means that the inventory level is too high and should be adjusted. The average itself could be calculated annually or monthly because sometimes industries have a volatile customer demand. Therefore, it might be that customer demand is higher at a certain time than at other time periods. In order to meet customer needs, the average needs to be adjusted so that enough inventory is available to produce. One exceptional case could be at Christmas when firms which produce toys face a higher customer demand.

The following key characteristic for supply chain performance is the internal production operations. Every production is based on business processes. As mentioned earlier, it is important for firms that their IT is matching their business processes. Therefore, firms need to somehow monitor this influence. One possibility to measure the compatibility of supporting IT and business processes is to measure the amount of time which was wasted in finding IT solutions. For instance, IT should be supportive in order to work efficiently but not rarely, employees can't work properly because their information technology is not working as it is supposed to. As wasted time is hard to measure, employees should try to be as objective and concrete as possible. Often, people tend to overreact to things that do not work which could be misleading. The following KPIs illustrate this approach by calculating either the time that was in order to make IT work or the average service desk requests per employee as they are an indicator that something is not working well in terms of software and hardware:

$$(1) \quad \text{inefficiency of IT} = \frac{\text{time used to find IT solutions}}{\text{actual working time with the IT}} * 100\%$$

$$(2) \quad \text{inefficiency of IT} = \frac{\text{IT service desk requests}}{\text{number of employees}}$$

This efficiency can be measured in certain time frequencies to see if the supporting IT has improved or if the situation has become even worse. The intention of the KPIs is to show that the more time is necessary for finding IT solutions, the less the IT is compatible with business processes. The lower the KPI, the better is the IT synchronised with internal business processes.

Another indicator to make IT work are the average service desk requests per employee as they are an indicator that something is not working well in terms of software and hardware.

In times of dynamic information spreading, companies can't afford many complaints because customers can use platforms such as Facebook or Instagram to make bad experiences with product quality public. This can have a massive impact on a brand's image. Therefore, firms should ensure a certain production quality within their own production lines so that they can better identify sources of product failures. Measuring product quality directly at production line level has the advantage that actions against identified quality problems can immediately be undertaken by line operators. In many cases, companies have strict rules about the amount or weight of components that should be added to the production process. Besides, firms must provide their line operators with trainings of how the final product should look like and how possible quality issues could look like so that operators are able to visually identify quality problems. For this in-line control, KPIs could be a production error rate where all line operators must count the amount of produced goods with errors they have identified during their shift. As production orders are usually integrated in electronic systems, the production error rate would be calculated automatically because the system knows the amount of products that should have been produced. Another possibility to measure quality at a production line level is to measure the weight of produced goods and compare the results with the planned weight of output. This would be an indicator of how much scrap a line has produced during a production run. As the production method highly depends on the products that are produced, appropriate quality ratios must be chosen by every company individually. A high error rate or a high amount of line scrap might be an indicator for many things such as bad raw materials, not well trained staff or inefficient production lines. The worse these ratios are, the higher is the negative influence on the supply chain performance.

$$(3) \quad \textit{Production error rate} = \frac{\textit{amount of faulty products}}{\textit{total amount of products}} * 100\%$$

$$(4) \quad \textit{Line scrap} = \frac{\textit{Actual weight of output}}{\textit{Planned weight of output}}$$

Transparency is also very important in a supply chain as explained in previous chapters. Companies need to be able to monitor and manage transparency in their supply chain because it is a significant factor for a company's performance. In terms of transparency, suppliers play an essential role. A good relationship with key suppliers is an indicator for a transparent supply because relationships require trust and trust is an indicator for how

much information someone is willing to share. This means that communication and information sharing are therefore indicators for transparency. Because of the fact that some companies have so many suppliers, it is almost impossible to manage all of them. Therefore, they should concentrate on key suppliers. However, the first KPI for transparency refers to the communication between manufacturers and suppliers. Buyers should be in continuous contact with their suppliers. The increase in communication between suppliers and buyers could have different causes. One cause could be that a failure occurred and an intensive analysis is necessary. Another cause could be that the business partners extend their partnership and increase the transparency. However, both causes are an indicator for an increase in communication, commitment and collaboration. The most difficult challenge in terms of communication is to measure it. We suggest that both companies should sit together in a workshop and come up with a survey that focuses on communication and relationship issues and which they have to provide to those employees that work together with employees from the other company. The questions should focus on how the people evaluate working together. Again, the questions must be worked out individually as every relationship requires a different set of requirements to work. A good example would be the question of how people evaluate the degree of communication. This question would indicate if there is too much or too less communication. An appropriate KPI to measure the relationship between two companies would be the average value of the survey. This would show how people evaluate the degree of communication. This question would indicate if there is too much or too less communication. An appropriate KPI to measure the relationship between two companies would be the average value of the survey (school grading system from 1-6 might be appropriate).

$$(5) \text{ Average survey value} = \frac{\text{Total sum of survey values}}{\text{total amount of survey}}$$

Another KPI which focuses on transparency is information quality. In a relationship between supplier and buyer, information is shared in order to increase efficiency and decrease costs. As mentioned earlier, information need to have a certain standard of quality so that the addressee is able to analyse and use the data. In order to control the standard of (IQ), companies should develop KPIs dealing with this topic. Low information quality leads to decisions that might negatively influence the supply chain performance. The amount of misleading information should be as low as possible. However, companies should develop a standard form of information needed and how they should be provided.

Nevertheless, it is important to have an overview if the received information quality as requested. Information quality can get a section in the survey mentioned before. This survey given to employees of both firms should include questions that focus on the quality of information provided by the other party. The recipients should evaluate aspects like:

- I usually receive correct information
- The communication flow between me and colleagues from the other company is good
- The information provided by the other company enable me to work efficiently

The mentioned aspect could be measured on scales (for example in a school grading system from 1-6) and the average value could be used as an indicator for information quality.

$$(6) \quad IQ = \frac{\text{total sum of survey values}}{\text{total number of recipients}}$$

Another supply chain performance characteristic is planning. Planning is essential in every business because all processes and procedures need to be planned before they are introduced so that the amount of occurring risks can be limited. Therefore, it is important for a company to know if their planning is good and meets the customer needs on the one hand and on the other hand if the plan itself could be implemented as organised. One possibility for businesses to control whether the planning is efficient and effective is to see if the production plan suits to the actual operation.

$$(7) \quad PPC = \frac{(\text{scheduled plan} - \text{actual plan})}{\text{scheduled plan}} * 100\%$$

The production plan compliance (PPC) KPI shows the variance between the planning and the actual production. Companies should keep this KPI low and if possible close to zero because this indicates that the production meets the planning and therefore the customer's needs. If a company produces too less or too much, the expenses will increase or the customer might be dissatisfied with the service and change supplier.

Another KPI regarding planning is the inventory turnover. Inventory turnover shows how often the company was able, in a given period of time, to sell their inventory. The higher the number, the better is planning. If the number is low, it means that the average inventory planning of a company was bad and stored too much inventory because the company wasn't able to sell those products.

$$(8) \quad \text{Inventory turnover} = \frac{\text{sales}}{\text{average inventory}}$$

Connected with production, transparency and a business' supply chain performance are the company's suppliers. Companies should be able to rely on their suppliers and be sure that they fulfil the contract as to delivering products and materials or offer services. Timeliness and the amount of how many products are delivered in contrast to how many have been ordered are two indicators for the reliability of suppliers. Timeliness is, in this example, covered with the lead times in the material flow. This circumstance shows that all actions and KPIs are somehow also an indicator for other characteristics because a supply chain is a composition of many subsystems that are interrelated. The second mentioned indicator for reliability shows how often the delivery was wrong. The KPI shows the variance between the amount of orders and the incorrect deliveries for one supplier in a percentage. Basically, it shows if the amount which was ordered by the buyer is according to the amount of delivered goods and therefore shows if there is any difference. Companies could include different factors in incorrect deliveries like the correct amount, time or product quality. However, the higher the KPI, the more reliable is the supplier because the less orders had failures in terms of quality or quantity.

$$(9) \text{ correct delivery rate} = \frac{(\text{total orders} - \text{amount of incorrect deliveries})}{\text{total orders}} * 100\%$$

Furthermore, suppliers need to be reliable in terms of CSR because the actions of a firm's suppliers also refer to the image of the focal firm. In order to control this aspect of reliability, focal firms need to assemble transparency and a good buyer-supplier relationship. Nevertheless, buyers should regularly visit their key suppliers to make sure that the working conditions and environmental footprint is acceptable. It is difficult for companies to ensure the reliability of CSR for deep-tier supplier. One possibility are the five questions mentioned in the chapter of assessment of supplier risk including questions like:

- Do the working conditions of your supplier suit the overall CSR of our firm?
- How often do you visit your supplier?

These questions show how intensive the relationship is between the supplier and second tier supplier. Companies, if they are in the position, should try to influence their supplier to implement the questions in every supplier and deep-tier supplier relationship to ensure business continuity and to ensure that CSR is thoughtful applied.

Employees are a significant factor for the supply chain performance. Firms need to know if the employees work efficient and if they feel comfortable at their workplace because the better employees feel at their workplace and the more they can identify themselves with the product and company, the better they work. One indicator that shows if the company created a good work atmosphere is the sickness rate of employees. The smaller this KPI, the better are the working conditions and the more comfortable are workers to stay at work. Furthermore, the company could differentiate between sickness and work accidents with outfall. A high rate of accidents is an indicator for either not well trained staff or dangerous working conditions or both. If this rate is constantly high, companies should provide trainings and implement additional security and safety measures.

$$(10) \quad \textit{Sickness rate} = \frac{\textit{amount of sick certificates}}{\textit{total amount of employees}} * 100\%$$

$$(11) \quad \textit{Injury rate} = \frac{\textit{amount of injuries in production}}{\textit{total amount of employees in production}} * 100\%$$

$$(12) \quad \textit{accidents with time loss} = \frac{\textit{accidents with time loss}}{\textit{total amount of accidents}} * 100\%$$

Another indicator is the fluctuation rate of a company which shows how many people left the company in a given period of time. Best is when the fluctuation rate is low because this indicates that the working conditions are suitable for the employees and they feel so comfortable that they don't think that they want to change their job. Basically, it means that the opportunity costs are too high for a change. Regarding to this aspect, the company should always offer so much for their employees that the opportunity costs for a job change are too high. The higher the percentage, the higher is the loss of knowledge and the higher is the cost for new hiring. This is an issue, especially for SMEs as they often struggle to find good employees because a lot of well-trained people rather work for the big brands which are publically known. This is caused by the general need for social acceptance.

$$(13) \quad \textit{Fluctutation rate} = \frac{\textit{amount of people left the company}}{\textit{average amount of employees}} * 100\%$$

As discussed earlier in this paper, CSR is a very important factor for companies and might have influence on their supply chain performance. One aspect of CSR is the ecological footprint. This indicator has different drivers like recycling or pollution. The KPI shown below indicates the recycling rate of a company. In order to work environmentally friendly and implement sustainable supply chain management, businesses should use material that

is able to be recycled. The more recyclable material a company uses, the better is their ecological footprint and SSCM. However, the ecological footprint is an indicator for sustainability and therefore indicates how responsible the company is doing business. The KPI indicates the percentage of recyclable material processed in a product. The higher the KPI, the better the ecological footprint and the better the firm fulfils CSR.

$$(14) \quad \text{Recycling rate} = \frac{\text{amount of recyclable material used}}{\text{total amount of material}} * 100\%$$

The second KPI which this example shows, is the illiteracy rate in the area the company is operating in. Illiteracy rate represents the standard of education in the particular area. The higher, the rate the lower the education. Companies can influence this rate and act beyond governmental and legal terms and support the local education. If it is possible for a company, they could build schools and educate children and also adults. This has two positive aspects which are on the one hand that the company gains a positive image and on the other hand that the company ensures the provision with potential employees in the future. The higher the KPI, the more educated people live in the area and might be capable of gaining a job at the company. We have chosen the illiteracy rate not only because it is an appropriate indicator for the educational level of an area but also because it is easy to get access to the illiteracy rate because it is usually published on a regular basis by most governments.

$$(15) \quad \text{Illiteracy rate} = \frac{\text{number of people who can read}}{\text{total amount of people living in the area}} * 100\%$$

5.6. The supply chain risk balanced scorecard

The balanced scorecard (BSC) is a strategic controlling instrument created by Kaplan and Norton in 1997.¹⁸³ Main objective of the BSC is to strengthen a company's market position by putting the company's interests into a balanced equilibrium. In the case of Kaplan and Norton, the key parts of a company are the financials, customers, internal business processes and learning and growth. The company's vision and strategy takes place in the middle of the model surrounded by the four key categories. The concept of the BSC targets the combinations of those key categories and the organisation's strategy and vision. For each category, the company needs to define objectives that should be addressed by the formulated strategy. However, it is necessary to define measurable indicators which can be

¹⁸³ Cf. Kaplan, R.S. & Norton, D.P. (1996) Using the Balanced Scorecard as a Strategic Management System. Harvard Business Review January-February

used to evaluate whether the company has reached the objective or not. In this regard, the balanced scorecard also recommends to give out target values for the measures. For instance, the financial objective of a company is to guarantee financial security to its stakeholders. Large investments are often paid with loans given by banks or private investors. Therefore, the company has decided to measure the financial security by using the times interest earned ratio which shows how many times a company could pay its interests. The equation looks as follows:

$$(16) \quad \textit{Times interest earned} = \frac{\textit{EBIT}}{\textit{Interest}}$$

According to Gitman and Zutter the times interest earned ratio should have at least a value of 3.0, a value close to 5.0 is considered as good (might differ from industry to industry).¹⁸⁴ Additionally, companies need to develop concrete initiatives and actions in order to improve the measures or to reach objectives.

The question that is asked regarding the aspect of financials is how the company wants to appear to its owners from a financial point of view. As companies need financial resources for investments and growth, the financial strategy should be well chosen in order to convince investors that it is worth investing in the particular action or asset.¹⁸⁵

In terms of customers, a company needs to define how they want to appear to their customers in order to achieve their strategy and vision. As most markets are characterized by fierce competition, it is essential, for any company, to find methods, tools and techniques that make customers come back and for the best turn them into happy loyal user. This highly dynamic competition has led to an increasing significance of customer relationship management.¹⁸⁶

The aspect of business processes in the balanced scorecard targets internal processes. The first question that needs to be asked is: Do the company's processes fit to the strategy and vision? Secondly, are there any conflicts along the different parts of the company regarding internal processes. It is important that processes of one department do not disturb other departments or processes of the company. If there is something that could be negative for

¹⁸⁴ Cf. Lawrence J. Gitman and Chad J. Zutter (2012) Principles of Managerial Finance. 13th edition. Boston, USA: Prentice Hall. P. 78

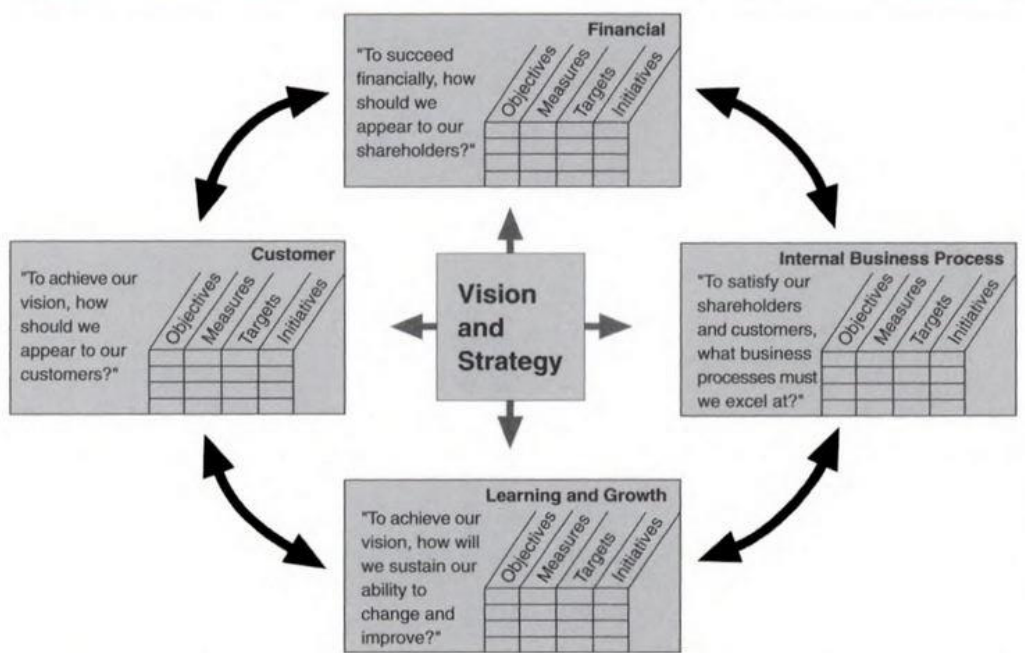
¹⁸⁵ Cf. Kaplan, R.S. & Norton, D.P. (1996) Using the Balanced Scorecard as a Strategic Management System. Harvard Business Review January-February

¹⁸⁶ Cf. Kaplan, R.S. & Norton, D.P. (1996) Using the Balanced Scorecard as a Strategic Management System. Harvard Business Review January-February

one division but very beneficial for the company as a whole, it makes sense to do it but it has to be communicated honestly and openly.¹⁸⁷

Learning and growth refers to a company's ability to change. Fierce competition forces, besides other influences of the external business environment, companies to be able to immediately react to new situations on a daily basis. This dynamic environment makes it very difficult for managers and other decision makers to find long-term oriented solutions. Ideally, organisations want to behave pro-actively so that they create changes that have either impact on the whole industry or provides internal improvements that lead to sustainable competitive advantages. The balanced scorecard targets on measures that can evaluate a firm's ability to continuously improve or being able to change. From our point of view, this part of the balanced scorecard goes hand in hand with the internal business processes. The main difference between these two categories is the scope. Learning and growth focuses only on a corporate level while business processes on the other hand targets individual activities within departments.¹⁸⁸

Figure 1-1 The Balanced Scorecard Provides a Framework to Translate a Strategy into Operational Terms



Source: Robert S. Kaplan and David P. Norton, "Using the Balanced Scorecard as a Strategic Management System," *Harvard Business Review* (January–February 1996): 76. Reprinted with permission.

¹⁸⁷ Cf. Kaplan, R.S. & Norton, D.P. (1996) Using the Balanced Scorecard as a Strategic Management System. *Harvard Business Review* January-February

¹⁸⁸ Cf. Kaplan, R.S. & Norton, D.P. (1996) Using the Balanced Scorecard as a Strategic Management System. *Harvard Business Review* January-February

Figure 28: The balanced scorecard¹⁸⁹

The balanced scorecard is a useful tool to create a clear overview of a company's strategy as well as appropriate objectives, measures, targets and concrete activities. Therefore, we recommend to create a supply chain risk balanced scorecard as a supply chain controlling tool that focuses on the vision and mission of the supply chain management and the four key categories of risks a company considers as the most important ones for their supply chain. This selection is individually for every firm because of factors like the industry the company is acting in as well as internal and external influences which differ from firm to firm. If a company did not define a strategy, mission or vision for single departments yet, they should start thinking about it because from our point of view, it is essential, for the successful development of a whole organisation, to have an efficient organisational structure which should be adjusted regularly due to external or internal environmental changes which might have a significant impact on the company. Furthermore, employees might have a better structure and understand certain actions better when department strategies are defined. In this regard, any department should be able to answer questions such as: why do we exist? What do we contribute to the success of the whole organisation? Where do we stand now and where do we want to stay in future? Any department should be able to answer these questions easily, otherwise this might be an indicator for an inefficient organisational structure and inefficient communication. In terms of supply chain risk management, it is required to create risk clusters. For instance, the supply chain risk matrix created by Yossi Sheffi (Figure 18) could be used as an initial situation for clustering supply chain risks. In this case, the illustrated risks could be clustered for example in the categories: Supplier, Natural disasters, Employees, Infrastructure, Economy and Information technology risks. Of course, this cluster does not cover all possible risks but it might be appropriate for a certain company. There is no perfect clustering as every company faces or identifies different risks. Therefore, risk clustering is a useful but individual solution. For example, if a supply chain involves many suppliers, not only first tier suppliers but also second or third tier suppliers, one risk group must be transparency because of the complexity of those networks and the imperfect availability of information. As mentioned before, first tier suppliers or direct suppliers can be audited and information can be gathered rather easily but even though there is never an information symmetry. This

¹⁸⁹ Kaplan, R.S. & Norton, D.P. (1996) Using the Balanced Scorecard as a Strategic Management System. Harvard Business Review January-February. Figure 1-1

asymmetry of information is increasing heavily if a supplier does not deliver directly but through others. However, this is a comparably reasonable argument to include supply chain transparency in any supply chain risk management system. Another method to cluster risks is to divide them by their characteristics. For instance, in the first case of how a clustering could look like, risks haven't been clustered by their function but risks could also be clustered by the type of their consequence (e.g. delay, disruption, capacity etc.). Structuring risks by the type of their consequence requires another hierarchy level in order to categorize risks correctly. If a company clusters by characteristics, there is always a one to one relation meaning that one risk can only be categorised to one risk group (an earthquake is always categorised as a natural disaster) but if a company clusters risks by the type of their consequence, a natural disaster, for example, can lead to different types of consequence at once. For instance, an earthquake could cause disruptions or delays but also system breakdowns. Let's assume that company A is located in Japan and exports most of their goods to Europe and the United States. Since at least the Fukushima nuclear disaster of 2011, everyone knows that Japan is located above the Pacific tectonic plate and the Okhotsk plate. The moment these two tectonic plates moved on March 11 in 2011, a massive earthquake was caused off the coast of Japan and led to an enormous Tsunami which then caused the nuclear disaster. Because of this incident, company A wants to include earthquakes and tsunamis in their risk assessment. In a characteristically organised clustering, both risks would be categorised as natural disasters. In a clustering by types of consequence, both would be clustered as natural disasters as well but natural disasters themselves could be categorised as disruptions, delays or system breakdowns. Overall, the different ways of clustering would be similar but the additional hierarchy level offers an opportunity to be even more specific. The question whether this additional level makes sense or not depends on the company. Generally, we think that the key points in assessing risks are to identify relevant risks and in the second step to find appropriate measures and activities in order to manage them. The illustration below shows an example of how a supply chain risk balanced scorecard could look like. As mentioned before, the supply chain strategy and vision are placed in the middle of the scorecard surrounded by the key risk groups or clusters that have been identified. In this case, we have decided to cluster risks functionally. Supplier risks refer to all risks that are related to suppliers. Typical supplier risks are: delayed deliveries, loss of a key supplier, bad quality and information sharing or compliance.



Figure 29: The supply chain risk balanced scorecard - Illustration at own construction.

Once a company defined its key risk groups, they need to distribute the risks they identified during the risk analysis accordingly. In the next step, companies need to define appropriate KPIs and other ratios in order to be able to measure the risks and compare the results with the up-front set targets as well as analyse a trend over a certain period of time. Once, a company defined and if existing especially the supply chain management department has defined measures, they need to identify and initiate appropriate actions and activities to support achieving the goals. As explained earlier, some risks cannot be influenced, so it is difficult to measure them and to set goals but it is not impossible. Taking the example of an earthquake again, the company can't influence the amount or the severity of them but the company can define as an action to monthly check entities' websites or publications about what is happening currently. As an approach, the company could use the date the employee should be done with a report about the findings of the current circumstances. Let's say the employee is supposed to have the report done on the fifth of every month, so the company can measure this. Taking the example of an earthquake again, the company can't influence the amount or the severity of them but the company can initiate undertaking like multiple supplier sourcing. This means that they could source crucial subassemblies through different suppliers so that if one supplier can deliver the product, the supply is still running and doesn't affect the production of the focal firm badly. Another opportunity is to take the risk of earthquake and to initiate activities that mitigate the consequences of an earthquake such as the construction or installation of earthquake-proof production facilities. An appropriate measure could be the degree of

completion. A goal for this can easily be defined by management according to the project schedule. Generally, the balanced scorecard is a useful controlling tool which helps to transform a strategy or vision into measurable actions that can be compared with set goals. Besides, the balanced scorecard can also be applied to supply chain management and supply chain risk management. Actually, risks and visions have in common that they are not rarely difficult to measure but using a supply chain risk balanced scorecard helps to support the supply chain strategy by analysing and monitoring the main risks of a company.

5.7. The supply chain risk management process

The graphic below shows the supply chain risk management process created by us in order to maintain, assess and control supply chain risks. First of all, a company needs to do a comprehensive risk analysis. Tools that could be used to perform an analysis are a PESTLE analysis to find risks in the external environment and internal auditing could be used to find internal risks. The PESTLE analysis is a commonly used management tool which helps to understand the external environment in which a company operates or wants to operate in future by analysing political, economic, social, technological, legal and ecological factors of a certain country at a certain time. It could also help to identify trends that are likely to happen in a relevant country. As many companies have global supply chains, it is necessary to analyse all countries that are involved individually or if possible by building country clusters. The second step regarding the external business environment is to see the bigger picture and analyse the interrelations of the different countries to prevent risks regarding transportation as well as cultural and legal differences. Internal auditing will help especially in analysing risks regarding internal processes. If an audit shows that certain processes are not efficient and tend to cause, for example, a delay in lead times, these processes have to be considered as supply chain risks. Besides the things a company can somehow analyse or measure, it also needs to analyse potential threats within the supply chain network that are not easy to monitor or control. This includes, for instance, activities and processes of second tier suppliers or suppliers of an even higher level. Of all the risks that have been identified during the analysis, a company has to identify which of these risks are really a potential threat for the company and which could be neglected. To be neglected does not mean that these risks are completely unimportant and no threat at all but they might have less negative affect on the business performance than others and therefore other risks have to be prioritised. After all relevant supply chain

risks have been identified, they need to be assessed and ordered. Businesses need to assess the relevant risks in order to prioritise them accurately. The possibilities of risk assessment were already mentioned before and one of these possibilities is using a matrix which determines risks in probability and impact, which is considered as qualitative risk assessment. Using this assessment approach, risks can be easily prioritised. Prioritizing risks can be done either in a supply chain risk matrix or with a risk score system. After risks have been prioritized, they need to be clustered in key groups. As mentioned before, the clustering process could be done in several ways. Risks can either be divided functionally or organisationally. Another way to do the clustering process is to divide the risks by their level using a risk score system as explained earlier (e.g. low, medium and high). The next step of our supply chain risk management process involves the creation of supply chain risk balanced scorecard. At this step, a company needs to transport the clusters into a balanced scorecard and distribute the belonging risks. Once this is done, measures, targets and concrete actions need to be defined in order to complete all requirements of a balanced scorecard. Lastly, it is very important to continuously monitor and control the scorecard because of the dynamic environment in which companies usually are doing business. Companies need to define after what time range they want to do their comprehensive risk analysis. This could be done monthly, quarterly or annually, depending on how important supply chain risk management is to the company and if changes of external or internal business environment are expected. Firms also need to be aware of the fact that some risks might occur a certain time ahead their next analysis. Therefore, it is necessary that employees are trained and educated to be able to observe their environment so that they can identify new risks that need to be added to the scorecard immediately. Furthermore, companies sometimes need to adjust their time schedule because occurred disruptions lead to the need that supplier or even internal processes have to have more attention and therefore more analysis to monitor, assess and control the exceptional circumstances.

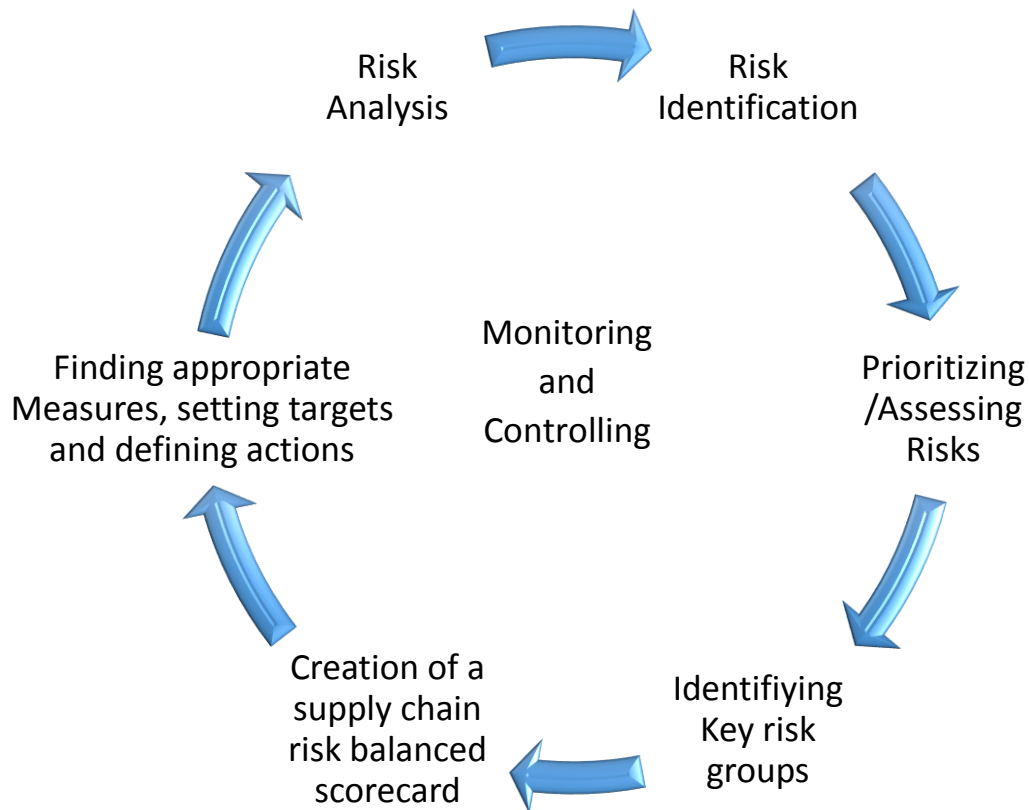


Figure 30: The supply chain risk management process - Illustration at own construction.

6. Conclusion

Fierce competition has forced global acting companies to continuously seek for improvement and economies of scale. This development has put attention on the field of supply chain management as the key management field in order to successfully overcome internal and external obstacles and create a profitable future. The need for SCM has increased so heavily because SCM ideally has an overview over the whole network of a firm. An efficient SCM understands an organisation as one system that consists of several interrelated subsystems. This includes not only different plants of a company but also suppliers, buyers, end customers and employees, basically the system includes every single individual and organisation that takes part in the system or is able to have impact on the system. This dynamic environment brings many opportunities but also several risks due to the growing complexity which comes along with globalisation and internationalisation. Therefore, supply chain risk management should be one of the key aspects in an effective supply chain management system. SCRM requires not only the observation of external factors but also internal business processes need to be monitored and improved continuously. In terms of supply chain risks, especially transparency plays a vital role. As illustrated before, even networks of SMEs often consist of many subsystems, individuals and organisations. However, these complex systems are difficult to manage and maintain. Therefore, firms need to address the topic of supply chain risks and interorganisational information sharing with a systematical approach. This is necessary because

companies need to be aware that many factors and actions can have impact on their supply chain performance. Even the actions of deep-tier suppliers or small changes in the external environment might influence a company's network.

However, this complexity makes it very difficult to keep supply chains transparent. Firms might be able to audit direct suppliers but they only have limited access to deep-tier suppliers. We suggest that companies should analyse the importance of every supplier and how every supplier gets its supplies. There are some alternatives to maintain and improve transparency such as vertical integration, strategic alliances or good supplier relationships. The appropriate method to address the issue of supply chain transparency depends on what the company wants to achieve, how important the supplier and how big the overall network is. Vertical integration would increase the transparency as the company gets deeper access to their own network as well as it would increase control over prices, product quality and processes. Besides the stated advantages, vertical integration would be beneficial in terms of corporate social responsibility and sustainable supply chain management as well because not rarely big companies were confronted with image issues because a deep tier supplier didn't follow the same CSR standards like the focal firm. On the other side, vertical integration requires large investments and might not be feasible for many suppliers or for SMEs with lower financial means. In many cases, it makes sense to combine certain actions like vertical integration and maintaining relationships to improve supply chain transparency.

Besides the actions to maintain transparency, effective supply chain systems should control general supply chain risks and their supply chain performance continuously. We recommend to use a supply chain risk balanced scorecard to get an overview about the most important harms a company need to be aware of, to formulate appropriate measures in order to assess the risk accordingly, and targets the company want to achieve in terms of every risk included in the scorecard. The controlling of the overall supply chain performance should be done in a supply chain performance matrix in which a company defines the most important supply chain aspects and key performance indicators to measure and manage these. KPIs help to identify fields and points where a company needs to define actions in order to become more successful. KPIs should not only focus on financial ratios as they are the result of many processes and actions. Instead, companies should rather focus on KPIs that measure the performance of what leads to revenues or profits.

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