

Supply Risk Assessment: A Utility Value Based Concept

Aiko Entchelmeier

Supply Management Institute SMI™, ebs European Business School
Soehnleinstr. 8, D-65201 Wiesbaden
Germany
a.entchelmeier.ebs@supplyinstitute.org

Dr. Evi Hartmann

Supply Management Institute SMI™, ebs European Business School

Dr. Michael Henke

Technical University Munich

Abstract

Increasing global competition has boosted the pressure on companies to raise corporate performance. To improve profitability more and more companies focus on core-competencies and tend to outsource non-core business activities (Pralhad & Hamel 1990). Following the trend to reduce the degree of value added and to purchase goods and services instead, companies gain competitive advantage by developing relations to other firms (Dyer & Singh 1998). The decision to source large volumes from suppliers however also implies an increasing dependency of the companies from their supply chains. Poor delivery performance, quality problems and insolvencies of suppliers are just a few threats that companies have to consider when they take purchase decisions. As a consequence companies do not only have to lever performance potentials of purchasing and supply, they also have to manage the risks that are related to their inbound supply through a proactive supply risk management (Smeltzer & Siferd 1998).

In order to understand which characteristics have the greatest effect on risk, supply managers have to focus their attention on reducing the effect that risk can have on their organization's success and profitability (Zsidisin 2003). Following the old saying "you can't manage what you can't measure" (House & Price 1991) a rigorous supply risk assessment is necessary to evaluate the effect of supply risk and to understand the necessity of managerial action. Today quantitative supply risk assessments are generally conducted by measuring risks as the product of maximum financial damage or loss and the probability of occurrence (e.g., Harland et al. 2003). An assessment of supply risks according to this formula, however, is not always capable to consider the managerial perception of risks (March & Shapira 1987) or to depict the impact of risks on a firm's intangible assets (Harland et al. 2003).

This paper proposes the incorporation of a supply risk utility value for the measurement of supply risks. The concept of the supply risk utility value is based on cardinal utility theory (von Neumann & Morgenstern 1947). Utility theory suggests that actors attempt to optimize the expected value of individual preferences defined as utility. It is analyzed how the incorporation of individual preferences into supply risk assessment can support the measurement of supply risks. Furthermore, it is investigated how supply risk portfolios can be set up with the utility value based supply risk assessment concept, how the concept can be used to enlarge the total cost of ownership concept and how utility value based supply risk metrics can be incorporated into the development of supply balanced scorecards. Finally, limitations of research and the fields of further research for the assessment of supply risks are indicated.

Keywords: Supply Risk Management, Supply Risk Assessment, Performance Measurement

Introduction and Problem Definition

Increasing global competition has boosted the pressure on companies to raise corporate performance. To improve profitability more and more companies focus on core competencies and tend to outsource non-core business activities (Pralhad & Hamel 1990). Following the trend to reduce the degree of value added and to purchase goods and services instead, companies gain competitive advantage by developing relations to other firms (Dyer & Singh 1998). Through the integration of other firms into their value chain companies begin to utilize the core competencies of their value chain partners. The decision to source large volumes from suppliers however, is not always advantageous for companies. It also implies an increasing dependency of the companies from their inbound supply. Poor delivery performance, quality problems and insolvencies of suppliers are just a few threats that companies have to consider when they take purchase decisions. As a consequence companies do not only have to leverage performance potentials of purchasing and supply, they also have to manage the risks that are related to their inbound supply through a proactive supply risk management (Smeltzer & Siferd 1998).

To demonstrate the necessity for the development of solutions for the management of supply risk an example from company practice shall be mentioned: Recently DaimlerChrysler had to stop its production for diesel vehicles for 18 days in the Sindelfingen plant due to a defective diesel fuel injector that has been delivered by its 1st-tier automotive supplier Bosch. As a consequence DaimlerChrysler had to face a collapse in sales because the vehicles could not be delivered to the customers. Daimler claimed that Bosch as the supplier for diesel fuel injectors has been responsible for the losses of the production stop. Bosch on its own stated that the company did not commit any mistakes in the production process and made its American supplier Federal Mogul responsible for delivering sockets with defective coatings for the fuel injector. Federal Mogul also neglected responsibility because it identified granulates for the coating of the sockets from its supplier DuPont as the source of the defective fuel injectors (Büschemann 2005).

This short example shows that the dependency of inbound supply and the related risks can be seen as an important issue for companies. Taking into consideration that in some industries like the computer industry and in some areas of the automotive industry the degree of value added has been lowered to less than 25% (Wildemann 2002) risks concerning inbound supply (e.g., price risks, currency risks, process interruption risks, fraud risks) become increasingly important (Zsidisin 2003) and should be managed through supply risk management. No matter which company in the value chain can be identified as the source of failure, every single participant is obliged to manage its supply risks in order to reduce the occurrence of hazardous events and thus avoid cutbacks of profits caused by individual supplier failures or the supply markets.

To cover all areas of supply risk management, a comprehensive supply risk management system should be implemented (Henke & Jahns 2005; Harland et al. 2003). The course of a risk management system can generally be depicted in the shape of a circle (figure 1). Identifying, analyzing, assessing and managing supply risks, however, does not mean to solely focus on the functional area of purchasing. Supply risk management has rather to be seen as one of the necessary support processes for the execution of an integral, cross functional supply process, starting at the source of demand to the fulfillment of the internal customers needs.

A comprehensive supply risk management can only contribute to competitive advantage, when all of its constituting process modules are put into action. One of these modules is supply risk assessment. Few purchasing organizations today perform rigorous supply risk assessments (Zsidisin & Ellram 1999). In literature several frameworks for supply risk assessment have been proposed, however, little research has been conducted on investigating the key constructs necessary for supply risk assessment (Zsidisin, 2004). Therefore the purpose of this paper is to investigate how supply risks can be assessed. Firstly lacks in current supply risk assessment practice are analyzed and a utility-value based measurement approach (supply risk value) is developed. Secondly the role of the supply risk value in supply portfolios, its role as an element of an extended total cost of ownership approach and its use as a key performance indicator (KPI) in supply balanced scorecards is discussed. Finally, limitations of research and the fields of further research are indicated.

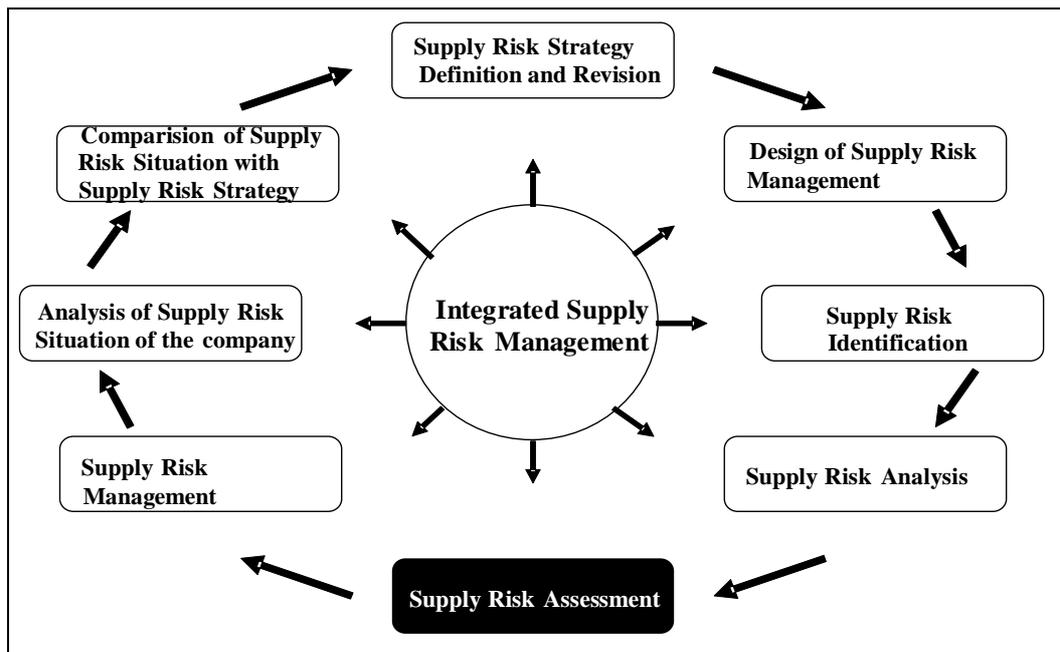


Figure 1: The integrated supply risk management process. (adapted from Henke & Jahns 2005)

Supply Risk Assessment – A Criticism in Current Assessment Practices

To understand which characteristics have the greatest effect on risk, supply managers have to focus their attention on reducing the effect that risk can have on their organization's success and profitability (Zsidisin 2003). Supply risk assessment evaluates the effect of risks on the companies' performance. Following the old saying "you can't manage what you can't measure" (House & Price, 1991) a rigorous supply risk assessment is necessary to evaluate the effects of supply risk and to indicate the necessity of managerial action. Supply risk assessment is a prerequisite for the management of supply risks. Decisions on the management of supply risks can only be taken when the impact of risks on the company's business can be evaluated.

Today quantitative supply risk assessments are generally conducted by measuring the average risk value (ARV) of a risk (i) as the product of the maximum financial damage or loss (l) and the probability of occurrence (p) (e.g. Harland et al. 2003):

$$ARV_i = l_i \times p_i \quad (1)$$

An assessment of supply risks according to Formula 1, however has been discussed in scholarly literature. Henke & Jahns (2005) argue that the calculation of the average risk value lacks of a strategic factor. As an example the authors refer to the risk calculation of the maximum credible accident in a nuclear power plant. Although the probability of an accident is very low, the damage would be severely high if the unlikely event of a hazardous incident would occur. They argue that the average risk value would not differentiate this event from events where the damage is very low but the corresponding risk of occurrence is very high (e.g., when a contract in the c-part delivery of a production line is broken). Henke & Jahns (2005) conclude that an average risk value for both events could be similar even though the consequences for management would be totally different. Therefore they propose to enlarge supply risk assessment by taking decisive measures (i.e. key performance indicators) into account.

The assessment of the average risk value with formula 1 can also be criticized in those cases where risks occur with a high standard deviation around the average risk value. In this case the calculation might be perceived as to vague by the supply manager. A reason for this can be seen in the divergence of the managerial perception of supply risks from the mathematical calculation of an average risk (March & Shapira 1987). In a nutshell this analysis leads to proposition 1.

Proposition 1: The product of the maximum financial damage and the probability of occurrence is not able to measure the managerial perception of supply risks.

Harland et al. (2003) criticize the average risk value (formula 1) from another perspective. They claim that risk has to be assessed from a broader perspective. Quantifiable assessments according to formula 1 can only be made, when risks refer to losses of a company's tangible assets. Assessing a risk is not simply a calculation that involves probabilities of loss of tangible quantifiable assets (Harland et al. 2003). Intangible assets like reputation, status and authority can also be damaged if a risk is realized. An assessment of the effect of risk on intangible assets, however, cannot be done properly with formula 1 because of the difficulties to evaluate the maximum financial damage or loss of intangible assets. Thus the observations of Harland et al. lead to the second proposition:

Proposition 2: Assessment of intangible risk differs from the assessment of tangible risks, intangible consequences and losses should be taken into account additionally.

Supply Utility Value – A Third Factor for the Assessment of Supply Risk

The criticism in current assessment practices has already been dealt with in literature. A third factor that should be included into the assessment of supply risk was already mentioned in the US in the middle of the 20th century and has been used in several industries including the military and the electronics industry. The failure modes and effective analysis (FMEA) process adds the probability of lack of detection as a third component to calculate the risk priority number (RPN). Each of the three factors of the formula (formula 2) is assessed on a 10-point scale resulting in a risk priority number from 1 to 1000 (Capurso 2003).

$$RPN_i = l_i \times p_i \times d_i \quad (2)$$

The FEMA process, however, can also be criticized because the probability of lack of detection is just another supply risk can be seen as another supply risk that could also be considered in the probability variable p_i . Nevertheless despite of the criticism the incorporation of another factor in supply risk assessment seems to be an interesting approach to assess supply risks more precisely and to overcome the criticism of Henke & Jahns (2005). To overcome the barriers in supply risk assessment and to take into consideration the managerial perception of actors, the authors propose the incorporation of a supply utility value (SUV) into risk assessment.

The concept of supply utility value bases on cardinal utility theory. Cardinal utility theory has been proposed first by John von Neumann and Oskar Morgenstern in their seminal work "Theory of Games and Economic Behavior" (von Neumann & Morgenstern 1947). The concept suggests that each individual attempts to optimize the expected value of something which is defined as utility, and that for each individual a relationship between utility and payout can be found (Swalm 1966). Utility is an important phenomenon in the decision theoretic research on risk management. Theory states that decision makers assign measurable preferences to risk situations in order to evaluate the trade off between risk and expected return. In this context three stereotypes of actors can be mentioned: a risk-averse actor prefers relatively low risks. He is willing to sacrifice some expected return in order to increase the variation. Risk seeking actors on the other hand prefer high risks. They are willing to sacrifice some expected return in order to increase the variation of the payout (March & Shapira 1987). Some actors react indifferently to risks. They do not change their behaviour when confronted with risks. According to utility theory, only for them the average risk value (formula 1) would be the appropriate formula for decision making under risks. As an example the flip of a fair coin can be mentioned. Most people would agree to gamble for 10 cents, but when they would be asked to play for 10.000 \$ most people would not participate. They calculate the average risk value (the mean payout of 0, when considering a probability of 50% and a maximum damage of 10 cents). In the latter case people are risk-averse, they perceive the possibility of loosing 10.000 \$ as more painful than the possibility of loosing 10 cents although the risk value or mean payout would be the same. Figure 2 visualizes the different stages of risk perception. For a specified amount of possible payout in case of risk aversiveness (a) a gain of the amount of payout increases the utility less than a loss of the same amount decreases the utility value, for the case of risk indifference (b) an increase or a decrease of possible payout cause the same amount of increase respectively decrease of the utility value and for

the case of risk seeking (c) a gain of any specified amount of possible payout would increase the utility value more than a loss of the same amount decreases the utility value (Gould et al. 1993).

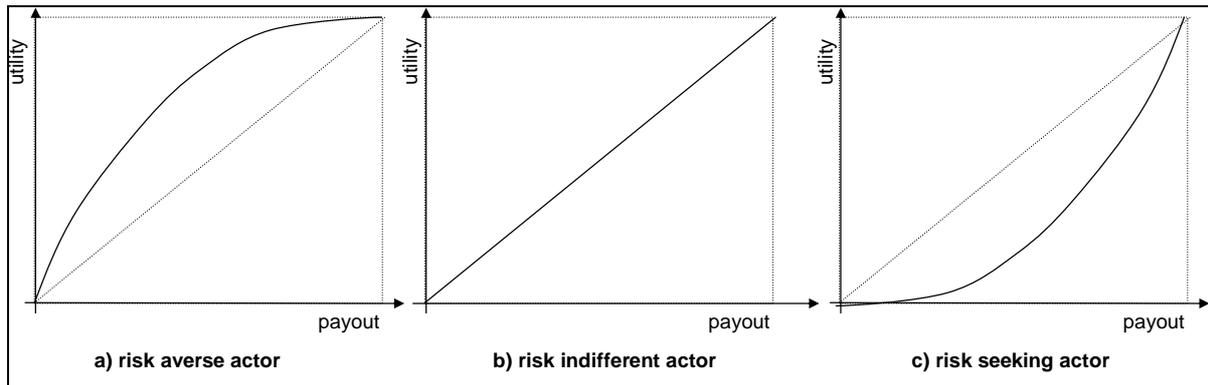


Figure 2: Prototypes of supply risk utility functions (adapted from Gould et al. 2003)

In supply risk management there can be many factors for the determination of the supply utility value. One determinant, as explained in the example before, can be the amount of expected damage or loss. The managerial perception of supply risk however can also be influenced by trust in the supply chain partner (Becket 2002) or by the strategic importance of a good or service for the value creation process (Sanderson et al. 2003, McQuiston 1989). The supply utility value is also able to consider the level of threat of a supply risk on a firms' intangible assets by considering it in the subjective decision making preferences (Zangemeister 1971) of the managerial actors. As it is not possible to measure the exact amount of threat on intangible assets, the supply utility value can take into account when a risk is able to critically influence the intangible resources and can weight the risk impact on intangible value creation accordingly. When considering the individual attitudes of decision makers on supply risk the following formula can be applied to evaluate the impact of supply risk:

$$SRV_i = l_i \times p_i \times SUV_i \quad (3)$$

Formula 3 thus explicitly incorporates the managerial perception on supply risk. Depending on their attitude towards a specific risk, the average expected damage is weighted by multiplication with the supply utility value as a third factor. Accordingly the supply utility value assures that the occurrence of supply risks is evaluated according to the perception of the manager towards it.

Supply Risk Assessment – An Enabler for the Comprehensive Management of Supply Risks

The assessment of supply risks is not an end in itself. Supply risk assessment is a prerequisite for the management of supply risks (figure 1). To enable supply managers to enhance efficiency and effectiveness of supply management through managerial actions, measures like the supply risk value have to be incorporated into the decision making process. In this chapter the incorporation of the supply risk value into management tools and concepts like the portfolio technique, the total cost of ownership concept and the supply balanced scorecard are described as managerial instruments to translate the assessed supply risks into action.

Supply Risk Management Using Supply Risk Portfolios

The basic idea of the portfolio analysis is the evaluation of strategic decisions in context with other decisions (Bea & Haas 2001). Portfolios are used widely to assess product-market-combinations from a corporate perspective. The use of portfolios can be traced back to Markowitz (1952). He introduced portfolio selection theory as an instrument for investment diversification. Since then the portfolio analysis has been established as a strategic planning tool in many areas. Well known portfolios are the product-market-portfolio (e.g., Roventa 1981), the technology-portfolio (Pfeiffer et al. 1991) and the purchasing portfolio (Kraljic 1983). In supply risk management portfolios can be used for the analysis of the strategic positioning of supply risks. In this context risks can be classified into three stages:

High risks: High risks have to be taken as a serious threat on the company. Management intervention is necessary to avert damage from the company and to shift them to a lower stage of risk assessment.

Medium risks: Medium risks are still critical and have to be taken seriously but they are not life-threatening for the future success. Nevertheless action should be taken to reduce them.

Low risks: Low risks have to be watched carefully since they can evolve to medium risks or even to high risk.

The supply risk portfolio (figure 3) visualizes the three-dimensional supply risk value construct. The portfolio is organized as a matrix. The x-axis is formed by the probability of occurrence. The y-axis is formed by the supply risk utility value. Every risk object is symbolized as a dot in the portfolio. The size of the dot symbolizes the maximum amount of damage.

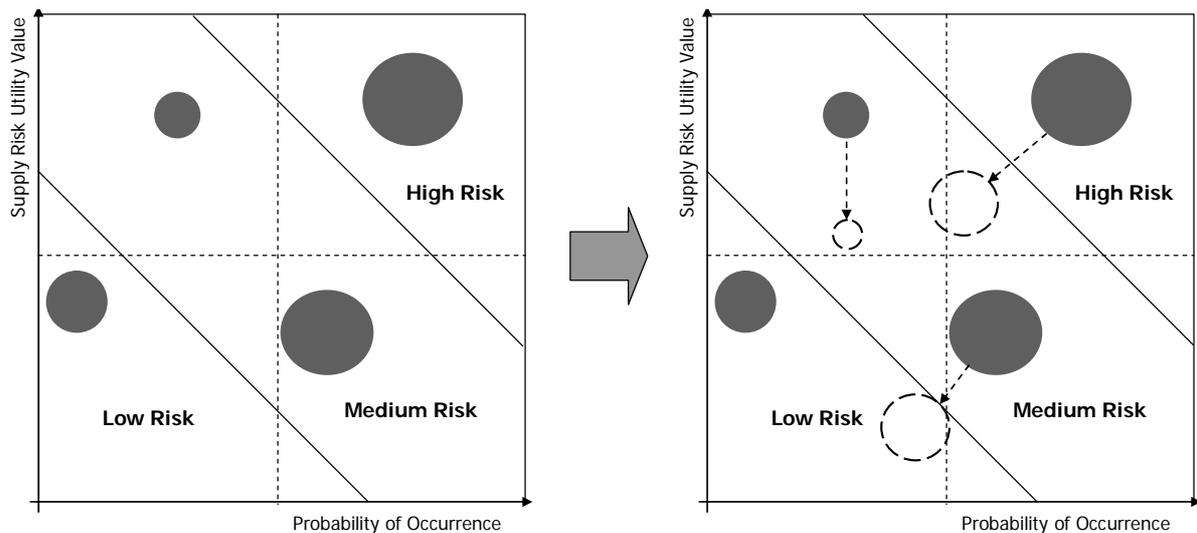


Figure 3: Supply risk management with supply risk portfolios

The visualization of supply risks in a supply risk portfolio can support the efficient and effective management of supply risks since it corresponds to the cognitive information needs of management. The supply risk portfolio enables the supply manager to cluster supply risks according to three stages (high risk, medium risk and low risk) and can support the decision-making process which risks to shift from higher risks to lower risks through managerial action. Table 1 lists different possibilities for managerial action in supply risk management.

Risk Avoidance	e.g., supplier selection, change management,
Risk Mitigation	e.g., multiple sourcing, risk and revenue sharing, continuous improvement process, early supplier involvement, quality control, buffer-oriented management,
Risk Compensation	e.g., acceptance of supply risks through reserves for contingencies
Risk Transfer	e.g., risk insurance, contract management

Table 1: Managerial action to shift supply risks

Integration of the risk value into the total cost of ownership concept

It has been investigated recently that purchase decisions should not be made on the purchase price solely but on total costs of ownership (Ellram 2002). The evaluation of the total cost of ownership in purchase decisions is advantageous to the company as it prevents from misleading conclusions that are based on single-sided evaluations that have been made on the purchase price only. As an example low-cost-country sourcing can be mentioned. In a purchase decision of a German company

between a supplier from Europe and a supplier from a low-cost-country the price cannot be the only criterion. The purchase price is an important component, but additionally e.g., logistics costs, costs for supplier selection and development have an impact on the total costs. Ellram (2002) has observed the importance of the total cost of ownership approach in detail. "Price is one element of total cost of ownership, and often the largest single element, but still only one piece of TCO. [...] Rather than simply buying based on price, the buyer should have a method for determining what a particular purchase really costs the organization – including more obvious issues such as transportation, duties, and on time delivery, and more subtle issues such as supplier responsiveness and technical support". To get an overview of the included costs (figure 4) Ellram differentiates between costs that occur prior to receiving of goods/performance of the service (pre-transaction costs); at the time of purchase (transaction costs) and after the purchase (post-transaction costs) (Ellram 2002).

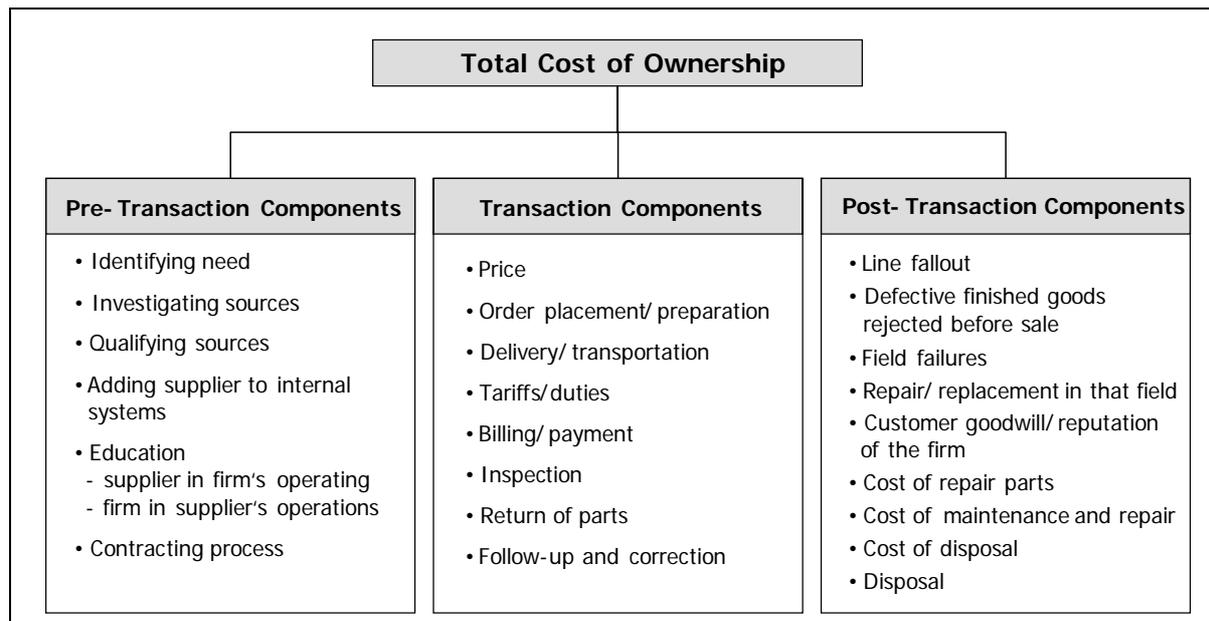


Figure 4: Decision making considering the total cost of ownership approach (adapted from Ellram (2002)).

Total cost however is not the only thing to consider when taking purchase decisions. Recently an enlargement of the total cost of ownership concept to a total value of ownership concept through the incorporation of "revenue enhancing" effects of buying items has been suggested (Wynstra & Hurkens 2005). In almost the same manner an enlargement of the total cost of ownership with the supply risk value for the evaluation of purchase decisions is suggested in this paper. A joined supply risk value has to be calculated by aggregation of all relevant supply risks. An aggregation, however has to be conducted under the constraint that all related risks are independent of each other to avoid double counting of risks that stem from the same sources or have overlapping impacts. An analysis of the interdependencies of supply risks requires a detailed analysis of the cause-and-effect relationships of the related risks. The formation of clusters of different supply risks that do not depend on each other is an approach that will be subject of further research.

To include an aggregated supply risk value into the decision making process the analyzed sum of is added to the calculation of the total cost of ownership value in order to make purchase decisions under consideration of supply risk. Mathematically the aggregated supply risk value is described in formula 4 and formula 5:

$$\sum_{i=1}^n SRV_i = \sum_{i=1}^n l_i \times p_i \times SUV_i \quad i \in N, n \in N \quad (4)$$

under the constraint that

$$SRV_i \not\subset SRV_j \quad j \in N \text{ and } j = \{1...n, n \neq i\} \quad (5)$$

Table 2 gives an example for a purchase decision between three suppliers: If the purchase decision would be based on the purchase price only, the company would source the purchase item from supplier C, who is significantly cheaper than supplier A because of the labor cost advantages in low cost countries. Considering additional costs that occur with the purchase decision however brings down the differences between the different suppliers. In this example a total cost of ownership decision would be in favor of supplier B. When risk is considered by summing up the monetary calculable supply risk value to the total costs a purchase decision can differ from a total cost decision. In the example the final decision is made in favor of supplier A.

Name of Supplier	Supplier A	Supplier B	Supplier C
Location	Local	Low Cost Country 1	Low Cost Country 2
PURCHASE PRICE	1,00 EUR/part	0,30 EUR/part	0,28 EUR/part
Logistics Cost	0,04 EUR/part	0,10 EUR/part	0,18 EUR/part
Administrative Costs	0,10 EUR/part	0,50 EUR/part	0,12 EUR/part
[...]	0,30 EUR/part	0,50 EUR/part	0,85 EUR/part
Σ (TOTAL COST)	1,42 EUR/part	1,40 EUR/part	1,43 EUR/part
Supply Risk Value	0,10 EUR/part	0,60 EUR/part	0,20 EUR/part
Σ (TOTAL COST INCL. RISK VALUE)	1,52 EUR/part	2,00 EUR/part	1,63 EUR/part

Table 2: Example for the calculation of the total cost of ownership under consideration of the aggregated supply risk value

Incorporation of Supply Risk Measurement into the Supply Balanced Scorecard

Performance measurement concepts have been emerged as a result of the perception that financial performance measures alone are insufficient to provide information for comprehensive management decisions. In this context it has been criticized that traditional accounting measures (1) are too historical and backward looking (e.g. Dixon et al. 1990), (2) encourage short-termism and thus lead to incorrect behavior (e.g. Hayes & Abernathy 1980) (3) are rarely integrated with one another or aligned to the business process (Lynch & Cross 1995). The balanced scorecard that has been developed by Kaplan and Norton (Kaplan & Norton 1992) has been acknowledged as one of the most efficient tools in performance measurement to overcome the perceived limitations of traditional management accounting systems (Gleich 2001).

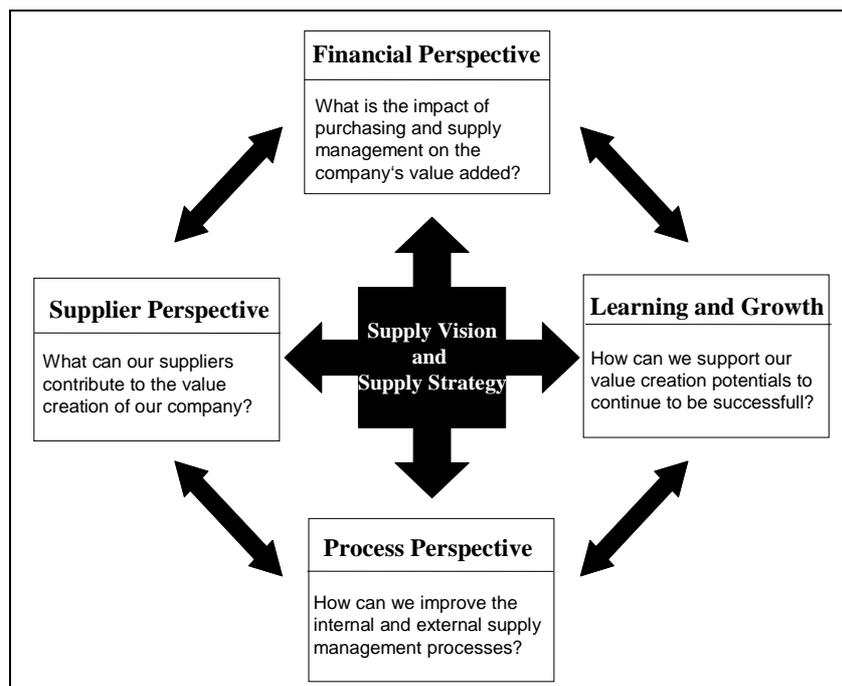


Figure 5: The supply balanced scorecard as a strategic management tool (adapted from Kaplan & Norton 1992).

With the shift of purchasing to supply management and its development to a strategic management function (e.g. Ellram & Carr 1994) the development of performance measurement systems to facilitate the coordination and alignment of purchasing and supply management activities with corporate strategy gains importance (Cousins & Spekman 2003). Even though many firms have started to utilize supply balanced scorecards (figure 5) for performance measurement nowadays, the academic and managerial publications on the topic are still scarce (Wagner & Kaufmann 2004). For that reason research on the design and implementation of supply balanced scorecards has to be intensified. An incorporation of supply risk metrics into the supply balanced scorecard seems to be the logical consequence of the fact that risks are an integral part of entrepreneurial decision making (Wurl & Mayer 2002).

Developments in risk assessment have to be incorporated into the translation of supply strategy to action to make influences of supply risks on value drivers transparent and controllable (Röhrig & Zinniker 2003). Risk metrics can either be financial indicators like the aggregated supply risk value that has been proposed in this paper or non-financial indicators that drive financial indicators (early warning function) like the number of contract violations of a supplier.

Further examples for supply risk indicators are:

- Percent of purchase spend in the area of high supply risk
- Number of suppliers in the area of high supply risk / total number of suppliers
- Number of categories in the area of high supply risk / total number of categories
- Aggregated financial losses resulting from negative events
- Country risk indicators of major sourcing markets
- Status of payment history of important suppliers or of the suppliers' suppliers.
- Degree of delivery reliability of suppliers
- Percentage of profit margin on sales of strategic suppliers
- Capacity restrictions of strategic suppliers

Figure 6 gives an example for a supply balanced scorecard with integrated risk management.

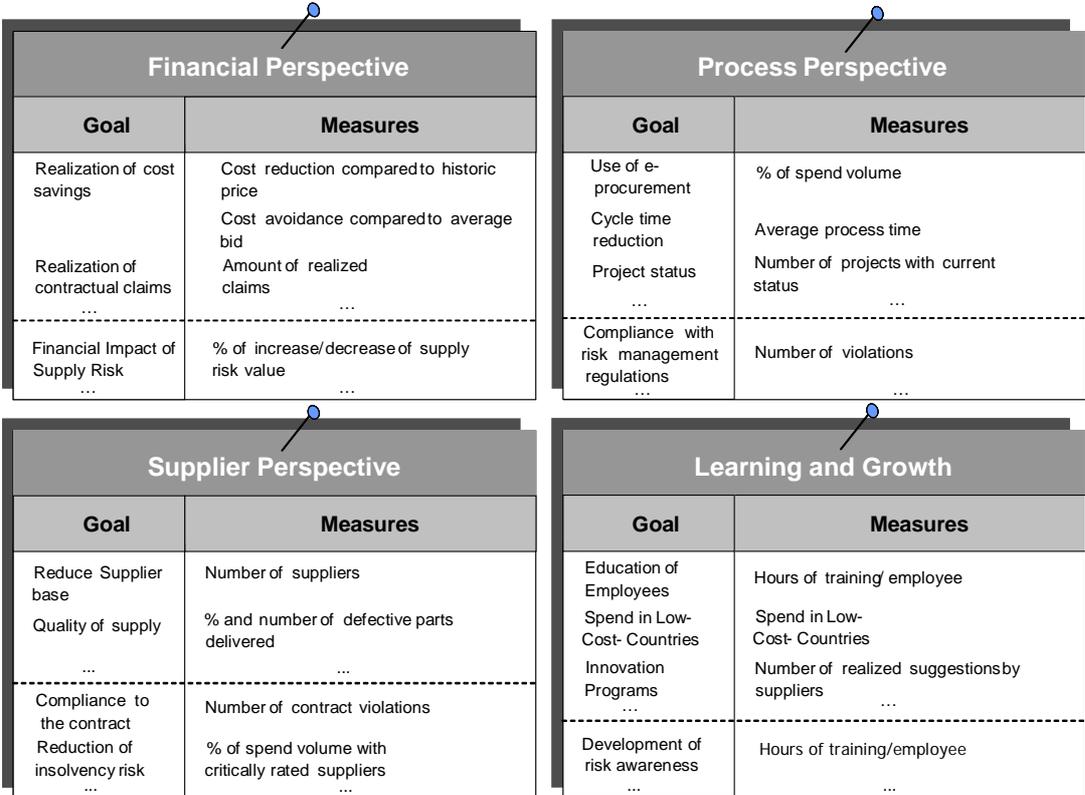


Figure 6: Example for a supply balanced scorecard with integrated supply risk management

Summary and Conclusion: Need for Further Research in Supply Risk Assessment

In this paper supply risk assessment has been recognized as an important topic for the effective and efficient management of supply risks. It has been analyzed that the quantification of supply risks in current assessment practice is not always capable to consider the managerial perception or to depict the impact of risks on a firm's intangible assets. As a consequence a new metric called supply risk value has been developed for the measurement of supply risks. The supply risk value is calculated as the product of the maximum financial damage, the probability of occurrence and the supply utility value as a third factor. Based on cardinal utility theory the supply utility value enlarges the traditional risk assessment concept by considering the managerial perception on supply risk (i.e., risk aversiveness, risk indifference and risk seeking). The involvement of the supply utility value thus allows the consideration of soft factors like trust in the supply chain, impact of risk on intangible assets and strategic importance of risk on a product in the evaluation of supply risk. It has also been investigated how the suggested supply risk value can be used for supply risk management analyses with supply risk portfolios. In supply risk portfolios the three-dimensional supply risk value can be visualized and classified into high, medium and low risks to support managerial actions. Moreover, it has been conceptualized how the supply risk value can be used to enlarge the total cost of ownership concept. It has been identified that an aggregated supply risk value needs to be added to the total costs of ownership for the consideration of supply risk in purchasing decisions. Additionally, it has been suggested to incorporate the supply risk value among other risk metrics into supply balanced scorecards.

Conducted research that has been documented in this paper can be seen as part of the ambitions to fruitfully develop the research field of supply risk management and supply risk assessment. Especially in the field of supply risk assessment further research has to be conducted. One field of research in this context will be the evaluation of intangible risks related to inbound supply. Though the proposed supply risk value is able to consider intangible risks such as the loss of reputation, status and authority through the integration of the supply utility value into the supply risk assessment concept, a precise evaluation of the impact of such risks is still subject to research. Another problem to be solved is the double-counting of risks when aggregating an overall supply risk value. The formation of supply risk clusters that group supply risks according to the source of origin of the related risk is a promising approach that will be in the focus of further investigations. For the measurement of supply risks with supply balanced scorecards multidimensional measures will have to be developed to better understand and integrate risk management into purchasing and supply management.

In general supply risk management, will continue to be a subject to further research as companies still have an enormous need for a better identification, analysis, assessment and management of supply risks. Impulses for future research in supply risk management will be given through the regulations of the Sarbanes-Oxley Act of 2002 that demands sustainable management including a company-wide risk management system and through the Enterprise Risk Management (ERM) Framework that has been introduced by the Committee of Sponsoring Organizations of the Treadway Commission (COSO) in 2004. The enterprise risk management framework supports the implementation of the directives set forth in the Sarbanes-Oxley Act and enhances the necessity for companies to assess and to improve their enterprise risk management processes including the supply risk management processes.

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