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RISK MANAGEMENT IN SUPPLY NETWORKS FOR HYBRID VALUE BUNDLES
A Risk Assessment Framework

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Abstract: In the market for tangible goods there is increasingly a trend from the production of single individual products towards individualized mass customization. In contrast to this, so-called hybrid value bundles are getting more and more importance in achieving market share und make a differentation to the competitors. Hybrid value bundles are integrated solutions combined of tangible and intangible goods. For these complex solutions, subparts are often delivered from different suppliers and have to be bundled by a focal supplier. These bundles will be delivered in form of a single solution to the customer. The large number of heterogeneous suppliers within the supplier network needs a complex supplier relationship management. Classic supply chain management techniques fail because of the specific requirements of hybrid value bundles. One major issue in the supplier management is risk management. For this, the focal supplier has to evaluate its suppliers according to risk characteristics and then choose to take those who have the lowest risk. In this paper a risk management model is presented, which takes care of the specific requirements of hybrid value bundles and complex supply networks. This risk management model may serve as a risk assessment framework for a focal supplier to identify optimal supply chains for a specific offering.

1 MOTIVATION

Hybrid value bundles are a special type of product bundle, which consists of well-coordinated, highly-integrated products and services with the goal to solve a specific customer problem (Hirschheim et al., 1995). This tight integration increases the customer value of hybrid value bundles which exceeds the sum of the values of the individual sub-services (Johansson, J. E. et al., 2003). With these integrated solutions in their product portfolio, companies are able to differentate from their market competitors to generate higher margins and promote the development of long-term, intense customer loyalty (Burr, 2002). In addition, the product efficiency can be increased by the individual adaptation to customer needs (Becker et al., 2008) and higher added value is generated for both the producer and the customer (Galbraith, 2002).

The development and provisioning of a hybrid value bundle usually not only involves a single company as a vendor company, but often an entire network of autonomous companies that make a contribution to the hybrid value bundle. Reiss and Präuer showed study that the most suitable form for the development and provisioning of value bundles are strategic value-add partnerships, networks and cross-company project-oriented cooperations (Reiss and Präuer, 2001).

Regardless of the origin of the network usually a large number of suppliers and subcontractors are involved. Each of these participants would engender a risk to the network, and it changes the risk assessment of individual supply chains. The larger and more branched the network is, the more complex is the associated risk. Classical risk management methods for supply chains are not suitable for the specific requirements of value bundles. The research question of this paper is: how can risk be assessed in order to ensure the customer a maximum safety during product delivery?

The paper is organized as follows: In Chapter 2 the foundations of hybrid value creation and risk are explaind. Chapter 3 deals with the methods of supplier evaluation and the positioning of a decision catalog. In Chapter 4, the modeling of risk assessment is

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explained and an exemplary application is conducted. Chapter 5 includes notes to the software program and the underlying data model. Chapter 6 summarizes the work and identifies additional research needs.

2 VALUE BUNDLES AND RISK IN SUPPLY NETWORKS

Basis of the model to be developed for risk assessment are specific requirements for hybrid value bundles in procurement processes, on the other hand existing approaches to risk assessment in procurement in general.

2.1 Hybrid Value Creation

The term ”hybrid value bundle” represents an integrated bundle of products and services with the goal to solve a customer problem (Böhmann and Krcmar, 2007) (Sawhney et al., 2006). This can be, for example service level agreements, availability guarantees, the output of a machine, performance / full service contracts, performance guarantees, finance, consulting, licenses or rights include. The level of integration of these different components may vary significantly (Fettke and Loos, 2007). On the one hand there are standarized physical products combined with services directly related to the physical product (e.g. a mobile phone with a corresponding telephone contract). On the other hand there is the business case of performance contracting where the offer of a value bundle consists of several service agreements to the customer with no tangible asset at all (e.g. the garanteed output of a printing unit in printing pages per day) (Corsten and Gössinger, 2008).
An example of a hybrid value bundle is the iPhone by Apple Inc.. Usually not only the product in form of a mobile phone will be sold, but also the contract, consulting and service. But also criteria like brand, network, and the software solutions offered by the manufacturer are part of the hybrid value bundle. However, services, rights or service level agreements may be involved in a hybrid value bundle.

2.2 Risk Management in Supply Networks for Hybrid Value Creation

The need for risk management in supply chains with a large amount of participiants is highly accepted (Braithwaite and Hall, 1999). For the concept of risk in supply chain management, there are several definitions (March and Shapira, 1987) (Svensson, 2002). For the following we adopt the definition of risk as ”risk of loss or damage [which] by the failure of services that can be attributed to not be influenced or anticipated events [arises]” (Götze et al., 2001). Risk can be seen as the probability that a particular adverse event occurs during a specified time or resulting from a challenge out.

In the case of supply networks this includes a non-limited number of risk factors relating to the supplying company. To rate this variety of criteria, it requires an appropriate method. In contrast to the above general case of risk assessment, the evaluation of suppliers and supply chains uses a number of criteria, which include some quantitative risk metrics such as delivery reliability, delivery quality or liquidity of the supplier, but also qualitative criteria like the corporate form or the location of the headquarters. The same applies to the criteria for hybrid value bundles.

Moreover (Burianek et al., 2007) could identify seven criteria which are characteristic for a hybrid value bundle and have an essential effect on the complexity of value provision: type of customer benefit, scope of services, amount and heterogenity of partial services, degree of technical integration, degree of integration into the value chain of the customer, degree of individualization and temporal dynamics and variability of value provision. Which criteria in detail are the best to serve as base for the calculation of risk is an individual decision of the focal supplier and can not be defined per se. Examples of such decision criteria can be found in (Heyder et al., 2009). Coupled with possible effects (Müssigmann, 2006), which can help to assess the criteria change with respect to individual suppliers, one can get a practical insight. Especially for hybrid value bundles there is another example of (Pousttchi et al., 2009). This is a classification of features for hybrid value bundles, which distinguishes the corresponding characteristics in three groups of features: strategic classification, components composition and value creation.

For the assessment of suppliers, especially in hybrid value bundles, we recommend a list of criteria with dimensions such as price, quality or reliability, and including a simultaneous classification of the product, which is to be the end product of the supply chain, morphological inside the box. This allows focus on the product features and corresponding criteria which can be selected and weighted.

3 SUPPLIER RATING

3.1 Methods for Risk Assesment for Suppliers

The risk assessment of suppliers for the physical goods market have a long tradition and many established methods. The method of scoring is a numerical representation method, which gives expression to the qualitative methods, (Beucker, 2005), is in the literature clearly dominant (Koppelmann, 2003) and also for the case of risk assessment in supply networks with hybrid value bundles the most appropriate. Scoring procedures in the scientific literature is divided again into 100-point rating method, percent assessment procedures and scoring models. For the model to be developed, the scoring model is used to achieve an optimal weighting of the factors (Janker, 2008).

3.2 Exemplary Calculation Basis of Decision Criteria

In order to assess the entire supply network, it is first necessary to evaluate the single node (Müssigmann, 2006). A node in our model corresponds to a supplier, subcontractor or the focal supplier itself.

3.2.1 Placing the Decision Catalogue

The focal supplier first provides a decision-catalog basis of decision-relevant criteria. These criteria may be, for example, delivery reliability, delivery quality, quality of workers or the nature and formulation of service contracts and agreements. This list of decision criteria must now be assessed with a scoring method. This means that each criterion is assigned a weighting point value, for example in the range of 1-20, which states how much the focal supplier's knowledge of this criterion from a vendor or supplier would be worth. An example of this decision catalogue would be the first two columns in table 1.

In this case, the focal supplier's knowledge in assessing the delivery performance of the suppliers would be very much worthy, knowing about the location of the headquarters, however, relatively little.

3.2.2 Assessment by the Suppliers

Now, this list will be filled with the appropriate information from suppliers, subcontractors and raw material manufacturers. A possible result is as in the third column of table 1 look like. However, the problem of the result is that not all values correspond to a numerical value (example: head office = Munich), but this

Table 1: Evaluation of decision criteria including coded and uncoded suppliers data.

criterium	weighting points	supplier data (uncoded)	supplier data (coded)
delivery reliability	20	0,9	0,9
delivery quality	17	-	-1
guarantee of outcome and availability	16	-	-1
service contracts	14	3 contracts, maintenance of several plants	0,85
workers quality	13	-	-1
solvency	13	0,8	0,8
number of employees	8	10.000	0,7
type of financing	6	Leasing	0,3
head office	3	Munich, Germany	0,9

is necessary for further calculations. Therefore, the values must be encoded and represented as a number between 0 and 1. 0 is considered here as the worst value and 1 as the optimal one. This means that information such as company head office or number of employees must be classified as far as Munich that represents a value of 0.9, 10,000 people a value of 0.7 or servicing various machines to a value of 0.85. The value 0.9 of the headquarters may be interpreted to that way, that the focal supplier itself has its corporate headquarter in Munich and therefore the transport distance is minimal, creating risk occuring during the transport is minimized. Furthermore, the value -1 will be taken as code for unspecified information.

3.2.3 Coding of the Table

Since the coding of the criteria strongly depends on the particular criteria and the priorities of the affected companies, there is no complete table shown here, but we provide a recommendation of a possible coding for a focal supplier. An exemplary coding of vendor data is in the fourth column of table 1. Such a table can contain hundreds of decision-making criteria and therefore it is important to create a framework on which criteria are to be specified by the supplier. One possibility would be a minimum number of fixed sum of weighting points for the criteria of the data to be evaluated, which suppliers need to be delivered. The focal supplier would determine this is to be done from any eligible supplier, which in total have at least 60 weighting points for example. This has the advantage that each supplier can provide either very much information on criteria which do not add much value to the focal supplier, but allow a total of a good assessment of the supplier, or the supplier provides only little information, but information to criteria highly relevant for the decision of the focal supplier. Now, if the focal supplier, for example, specify that it requires data of 60 weighting points, so this would be satisfied in the example above.

4 MODELING THE RISK ASSESMENT IN SUPPLY NETWORKS FOR HYBRID VALUE CREATION

The values generated by the weights of each node must now be calculated into a risk value, which represents the risk of a specific supply chain. In the following, the value will be calculated by a dedicated supply chain for the focal supplier.

4.1 Decision Criteria

The risk value of the supply chain will be denoted as Ω_{l_i} and ranges in the interval $[0;1]$. The best value is 1, the worst value is 0. Ω_{l_i} is dependent on both the above-mentioned weighting scores of the affected criteria and the explicit expressions of the supply chain to be considered relevant criteria.

4.2 Model Formulation

To calculate Ω_{l_i} several variables and indices are relevant. These will be defined in the following:

Variables
$\Omega_{l_i} \in [0:1]$: value of the supply chain l_i for the focal supplier
$l_i = \{m_k | m_k \in K, Kconfiguration\}$: i-th supply chain consisting of the knots which are able to fullfil a specific customer demand
$M = \{m_1, \ldots, m_z\}$: set of all suppliers in the supply network
m_{k,l_i}: supplier of the supply chain l_i with ID k
$C = \{c_1, \ldots, c_y\}$: set of all criteria in the supply network
$G = \{g_1, \ldots, g_y\}$: set of all weighting points of the focal supplier
$g_j \in \{1, 2, \ldots, o\}$: weighting point of a criterium c_j
a_{j,l_i}: frequency of the criterium c_j within the supply chain l_i
$w_{k,j} \in [0;1]$: value of a criterium c_j for the supplier m_k

Indices
y: amount of the criteria in the supply network
o: maximum sum of weighting points in the criteria list
z: number of suppliers in the supply network
k: ID of a supplier in the supply network
i: ID of a possible supply chain for a specific customer demand
j: ID of a criterium in the supply network

With this notation, there is the following formula to calculate the value of a supply chain:

$$\Omega_{l_i} = \frac{\sum_{k=1}^{m_z} \sum_{j=1}^{c_y} [f(w_{k,j} * g_j)]}{\sum_{j=1}^{c_y} [g_j * f(a_{j,l_i})]} \quad (1)$$

Calculation of the function $f(w_{k,j})$:

$$f(w_{k,j}) = \begin{cases} w_{k,j}, & \text{for } w_{k,j} \neq -1 \\ 0, & \text{else} \end{cases} \quad (2)$$

Calculation of the function $f(a_{j,l_i})$:

$$f(a_{j,l_i}) = \begin{cases} a_{j,l_i}, & \text{for } w_{k,j} \neq -1 \\ a_{j,l_i} - 1, & \text{else} \end{cases} \quad (3)$$

The value Ω_{l_i} of a certain supply chain l_i is combined from the product of every single value of the criteria $w_{k,j}$ and the corresponding weighting points g_j from every single supplier M in the supply chain and all published criteria c.
This value will be divided by the product from the weighting points g_j and the corresponding frequency of the criteria a_{j,l_i} to derive an average value. In addition, the variable $w_{k,j}$ can be -1 in cause there are no values stated for this variable in the table. In this case, the function $f(a_{j,l_i})$ decreases the denominator by -1 and the function $f(w_{k,j})$ sets the numerator for this criterium to 0. Otherwise the result would be falsified by the criteria not stated from the suppliers. The calculated value for Ω_{l_i} ranges betweeen 0 and 1, at which 1 is considered to be the best value.

4.3 Exemplary Application of the Model

For illustration purposes a scenario is presented, which is reduced in complexity, but covers all relevant aspects of the issue of risk management for the procurement of hybrid value bundles. Suppose the focal supplier possessed only a single supplier that is relevant for the considered hybrid product. This allows the summation of all suppliers and it results in the following simplified formula for calculating the value of a supply chain for the focal supplier:

$$\Omega_{l_i} = \frac{\sum_{j=1}^{c_y} [f(w_{k,j} * g_j)]}{\sum_{j=1}^{c_y} [g_j * f(a_{j,l_i})]} \quad (4)$$

The calculation for $f(w_{k,j})$ and $f(a_{j,l_i})$ remain unchanged.

The criteria for the example should have the following characteristics (see tabelle 2):

Table 2: Exemplary validation of decision criteria.

criterium	**weighting points**	**supplier data**
delivery reliability	20	0,9
delivery quality	17	-1
guarantee of outcome and availability	16	-1
service contracts	14	0,85
workers quality	13	-1
solvency	13	0,8
number of employees	8	0,7
type of financing	6	0,3
head office	3	0,9

The weighting points g_j are stated in the second column and the supplier data $w_{k,j}$ is stated in the third column. From these data the calculation for the risk value follows:

$$\Omega_l = \frac{0{,}9*20+0*17+0*16+0{,}85*14+0*13+0{,}8*13+0{,}7*8+0{,}3*6+0{,}9*3}{20*1+17*1-1+16*1-1+14*1+13*2-1+8*1+6*1+3*1} = \frac{50{,}4}{107} = 0{,}4710$$

If more than one supplier would be involved, the weighting scores should be added in the numerator and the sum of the weighted scores to share times the number of incidents. The result would be the case in a number between 0 and 1.

5 PROGRAM FOR THE SIMULATION OF THE RISK MODEL

To demonstrate the risk calculation of this model a software program as a prototyp evaluation is implemented. This program was implemented in a modular 3-tier architecture to allow maximum flexibility in the illustration of different risk scenarios. To generate an appropriate model for the representation of the hybrid value bundle and to achive a efficient implementation, the semantic data model of Schrödl (Schrödl et al., 2010) is used accordingly. The presented Java program offers both the functionality of the evaluation and selection of suppliers and graphic elements for managing the data on which the calculation is based. The calculation as core of the program is displayed in the visualizer (see figure 1), which selects the first node without outgoing edges, that is created normally the focal supplier, and from that of the network of accessible nodes. Unreachable nodes are neglected by the program. Results are shown in the graph in color. Left of the window there is a range of products produced by the focal supplier, and can be run on one of the calculation. Below the selection, the button is to start the calculation and a way to adjust the criteria forms for a particular node in the network. These adjustments will result in a rule also in a different calculation and presented in the graph in a different color.

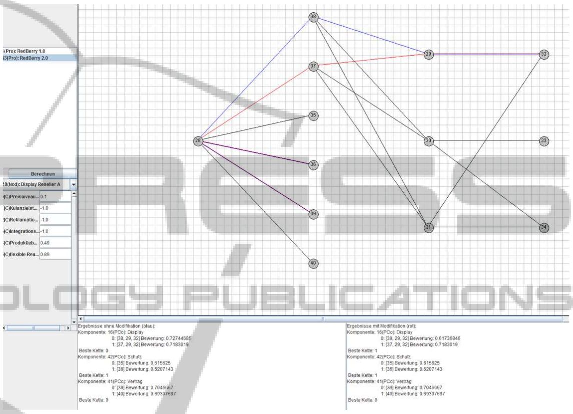

Figure 1: Visualizer.

6 CONCLUSIONS AND OUTLOOK

Aim of this paper was to develop a model for risk assessment of suppliers for hybrid value bundles. For this purpose, specific characteristics of hybrid value bundles were identified and different methods of risk assessment in supplier relationships were evaluated. Based on these findings, a new mathematical model for risk assessment of suppliers has been developed for supply networks for hybrid value bundles. This model is based on a scoring method with a decision catalog in addition to a moving average method. Advantage of this model in contrast to existing risk management models is the possibility to deal with inconsistent information from single suppliers but nevertheless giving a complete risk assesment of the whole supply chain for the focal supplier. To demonstrate this model, a software program was developed that demonstrates the different uses of the risk model.

It is shown that the model provides comprehensible and well interpretable results that allow sellers of hybrid value bundles to offer their solutions with a minimized risk in the market. The model presented is variable in the criteria and can therefore be used to identify an optimal supplier strategy for certain hybrid offerings. In addition, the model can be used to act in the operational procurement as a basis for decision, if one of the risks occurring in the procurement and the question of an optimal alternative variant arises. In summary, the presented model represents an optimization of supplier relations for supply chain management for hybrid value bundles.

The proposed model is a first step towards a comprehensive risk management as seen in the supply networks for hybrid value bundles. As further steps, several aspects are possible. First, the inclusion of the time factor and thus a widening in the direction of operational procurement. Another factor is the fact that may not all suppliers of the focal supplier deliver the required information. In the lead set out in this working model, this would indeed be a quite acceptable result in large variance values but could still complicate the interpretation from the perspective of the focal supplier. Thus the question remains of how to deal with incomplete information in such a model. The last major point is the fact that the focal supplier may have a different implementation of the criteria list than another supplier in the network.

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