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Assessment of dynamics and risks in supplier selection processes

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Abstract

Increasing competitive pressure in the production sector has led to considerable changes in the global competitive structure. Currently, companies attempt to counteract cost pressure by increasing their global outsourcing activities as well as focusing on their core competencies. Hence, global procurement has gained increasing importance among general purchasing activities of companies and is predicted to have an increasing influence on future cost development. Due to this development, companies are looking for new suppliers in low-wage countries. However, companies have to consider negative effects in the fields of quality, service level, and counterfeiting or plagiarising of merchandise. Therefore, cost savings in low-wage countries can only be achieved through major efforts during the planning and the realisation phase of the supplier selection process. Purchasing companies lack systematic assistance in analysing the procurement object and the economic environment of potential supplier candidates. This paper presents a two-step approach dealing with the issue of global procurement in low-wage countries and how this issue is faced taking business environment into account. In the first step, a method is described using the help of a requirement profile for suppliers and a cost structure analysis to select potential suppliers. In the second step, an approach for modelling and identifying potential dynamics and risks related to the acquisition of new suppliers in low-wage countries is developed.

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Keywords: Sustainable Procurement; Procurement Strategies; Low-Cost Country Sourcing

1. Introduction

Permanently increasing competitive pressure in the production sector has caused companies to refocus on their core competencies. This change of the global competitive structure has led to a fragmentation of the value-added chain [1]. It is shown in several studies that 60-70% of today's production costs originate from purchasing cost of supplies [2] [3] [4]. Due to this outsourcing trend, procurement will have an increasing influence on cost development as well as on maintaining the company's competitiveness in the future [5]. Recently, this trend has shifted the relevance of the purchasing department from an operative focus to a more strategic planning body. Global procurement has reached a higher status among general purchasing activities due to major cost saving potential of low-wage country sourcing [6]. Despite high importance purchasing companies attribute to low-wage countries at present, today's procurement volume originating from those countries is relatively low: For example, Western European countries only receive 6% of their procurement volume from China and only 2% from India [7].

Besides not achieving targets in the fields of costs and quality, supply difficulties, product piracy, and respectively knowledge drain are also negative results which pose an obstacle to a successful processing of low-wage country procurement activities [8]. Oftentimes, cost savings can only be achieved through large investments in planning and implementation of the supplier development when a certain level of quality is required [9]. Companies lack systematic assistance in analysing the procurement object and the corporate environment of potential supplier candidates to be able to economically and successfully shape global procurement activities, particularly in low-wage countries.

Existing approaches are already dealing with the monetarily evaluation of supplier customer relationships [10] [11] [12] [13] [14]. Supplier qualification can be considered as

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an investment project, which is influenced by several risks. In contrast to existing approaches, it is focused on a general framework for supplier qualification in this paper (e.g. development investments, risks and dynamics, decision flexibility).

2. Objective

The main objective of this paper is to analyse the procurement object and the corporate environment of potential supplier candidates. Existing approaches are providing monetary evaluation techniques for procurement related actions. However, they take dynamics, risks, and forecasting methodologies into account insufficiently. The presented approach overcomes this gap in two steps whereby decision alternatives may subsequently be considered when evaluating the acquisition of new suppliers in low-wage countries.

In a first step, the procurement object is defined and a catalogue of supplier requirements is elaborated. This catalogue contains a definition of the respective purchasing company's objectives as well as a comprehensive cost structure analysis of potential supplier candidates for the component specific production cost. In a second step, potential risks and dynamics related to the acquisition of new suppliers in low-wage countries are analysed and modelled. The consideration of flexibility of action in the acquisition of new suppliers in low-wage countries allows for responsiveness to dynamic developments and risks originating from the technical and economic environment.

3. Analysis of procurement object and corporate environment

The presented objectives are implemented using an innovative two-step methodology. As illustrated in Fig. 1, the first step deals with the analysis of the procurement object. Therefore, specific supplier requirements are determined for each individual procurement object and the cost structure for the respective procurement object is modelled and analysed, using a Total Cost of Ownership approach.

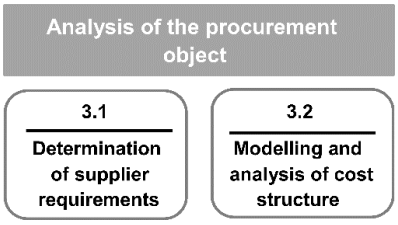

Fig. 1. Analysis of the procurement object.

Furthermore, the corporate environment of potential supplier candidates is analysed in the second step, which is illustrated in Fig 2. This analysis comprises the identification of dynamics and risks as well as their assessment.

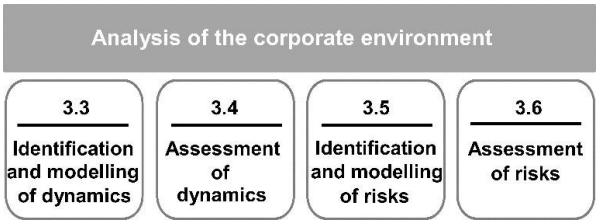

Fig. 2. Analysis of the corporate environment.

First, respective dynamic environmental factors are identified and modelled for each supplier candidate in chapter 3.3 as a basis for subsequent assessment in chapter 3.4. Analogously to the first two steps, risks are identified, classified, and modelled in chapter 3.5 that are relevant to procurement in a model-theoretic approach; these risks are also assessed in chapter 3.6.

Table 1. Product-specific profile of supplier requirements using the example of a machine park.

Question	Requirement	Degree of requirement in points [1-5]	Observation	Corrective action
What is your impression of the production facilities and machines? Are you in general satisfied with the age, flexibility, run times, and material flow?	Necessary production facilities	4.5		
Is it possible to manufacture the relevant product in the required nature and quantity using the existing machine park?	Capacity	3		
Are the means of production appropriately connected to one other?	Ensuring capacity and quality	1.5		
How is maintenance carried out? Is preventive maintenance according to a maintenance plan performed?	Preventive maintenance	4.5		
...	...	...		

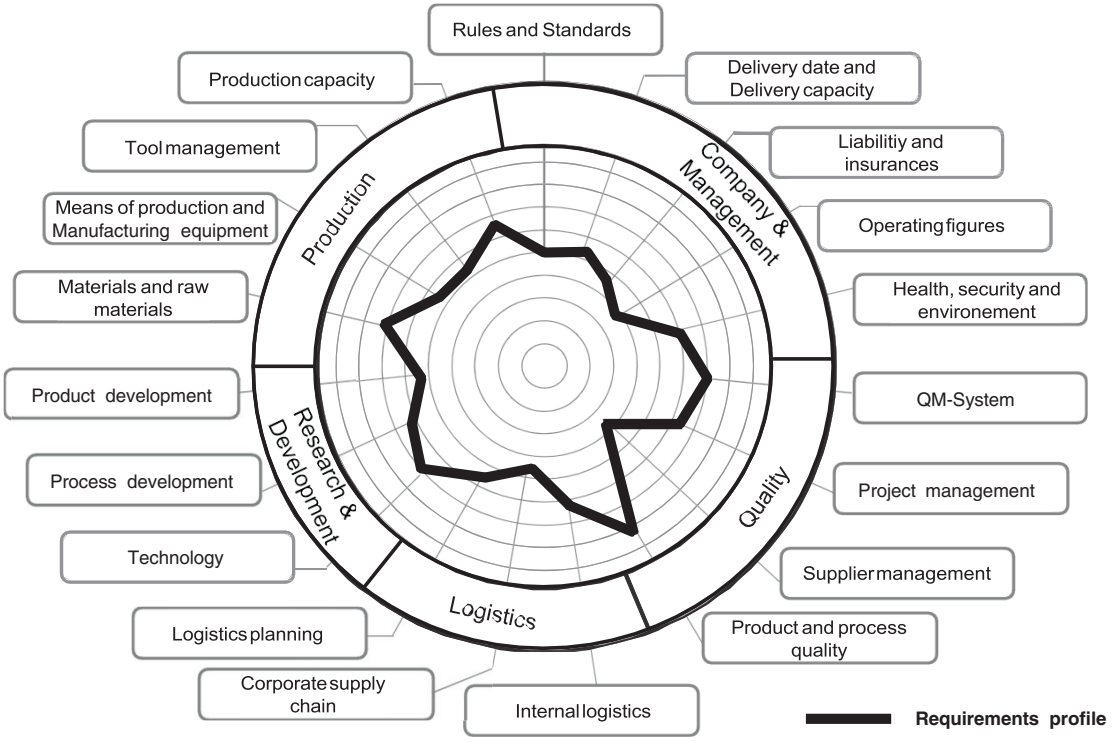

Fig. 3. Exemplary profile of supplier requirements [15].

3.1. Determination of supplier requirements

A successful determination of supplier requirements strongly depends on the precise description of the procurement object in terms of its technical and qualitative properties. This is ensured by the creation of a supplier requirements catalogue since it helps to systematically evaluate potential suppliers and also allows for deriving the resulting development needs for each evaluated supplier candidate. This catalogue is based on a questionnaire that is divided into sub-categories comprising the areas of production, research and development, company and management as well as quality and logistics. It is illustrated in Table 1 how such a questionnaire might look like, using the example of a machine park.

Each of the mentioned main criteria also comprises a large number of sub-criteria which as a whole create a comprehensive catalogue of questions for the assessment of potential supplier candidates. Subsequently, supplier-specific weaknesses may be identified by comparing the requirements and the observed actual situation. The profile of supplier requirements (illustrated in Fig. 3) serves as a basis for the systematic assessment and selection of potential supplier candidates since it creates transparency of supplier candidate's performance capability. After creating the profile, the procurement-specific supplier screening, the supplier audit and the supplier assessment are processed and submitted offers from supplier candidates are compared. A preliminary selection of the most promising supplier candidates in low-wage countries is resulting from this step. Hereby, the weight of each criteria and sub-criteria is determined qualitatively based on the experience of the employees performing the analysis.

Fig. 3 depicts an exemplary profile of supplier's requirements, containing the same requirement categories as the supplier requirement catalogue. Several requirement sub-criteria are allocated to the categories, which are to be evaluated.

3.2. Modelling and analysis of cost structure

Besides production requirements of the procurement object, the supplier-specific cost structure also has a major influence on the profitability of new supplier acquisitions. In the following, an approach for modelling and analysing a supplier's cost structure is presented. This approach facilitates capturing supplier-related cost structures for each procurement object so that various suppliers can be compared. First, a supplier-related assessment of individual cost elements is performed using the Total Cost of Ownership approach. Hereby, not only acquisition cost of a component are taken into account but also the aspects of subsequent use, for example procurement overhead cost, expenses for third-party works, and services related to logistic requirements such as tariffs, fees, increased stocks, and longer delivery times [16]. Consequently, all procurement related cost elements are included in the product- and supplier related modelling and the determination of the cost structure of the procurement object. Hereby, a theoretical price of the offer, which

represents a crucial control parameter in procurement, may be generated. For reasons of comparability, the cost elements and components are determined on the basis of the same incoterm "delivery duty paid" which ensures that no additional cost for the purchasing company will occur. Important cost elements of a product that are considered in the purchase price EP_t^L are [15]:

$$EP_t^L = MK_t^L + LK_t^L + MAK_t^L + FK_t^L + GmK_t^L + GA_t^L + TK_t^L \quad (1)$$

with

MK_t^L	material cost at point in time *t*
LK_t^L	labour cost at point in time *t*
MAK_t^L	machinery cost at point in time *t*
FK_t^L	add. manufacturing cost at point in time *t*
GmK_t^L	overhead cost at point in time *t*
GA_t^L	mark-up at point in time t
TK_t^L	logistics cost at point in time t
L	supplier, for example $L = \{LCC, HCC\}$
LCC	low-cost country
HCC	high-cost country

For example, additional manufacturing costs may be composed of setup costs, and quality cost. The machinery costs are composed of imputed depreciation, imputed interest, maintenance cost as well as premises and energy costs. It is to be noted that the exchange rate must be integrated in the purchase price when payments are made in a foreign currency.

Second, the procurement object costs are broken down into previously defined relevant cost elements. The supplier's production processes are thought trough virtually and the cost elements are identified for each work step on the basis of the manufacturing plan. Effective savings in low-wage countries are predominantly attributed to lower factor cost and material cost such as labour cost and energy cost. Furthermore, low factor cost may also be achieved by adapting a locally available manufacturing technology. The cost structure analysis results in a detailed overview of the cost structure which is illustrated in Fig. 4. The information sources vary from publicly available information, e.g. from the customs office, to supplier specific information sources such as financial statements. The significance of various inputs and factor cost on the purchase price as well as on the purchase price change in case of dynamic developments of the individual cost elements is illustrated in Fig. 5. The total absorption costing method is used as pricing approach since suppliers have to cover their fixed cost and variable cost in the long term. Finally, the purchase price, determined by the calculated cost structure, is compared to actual offers of the possibly existing suppliers and potential supplier candidates.

3.3. Identifying and modelling dynamics

Since configuring and developing a supplier network takes a long period of time, dynamic developments must be taken into consideration when to analyse the profitability of potential supplier candidates. Dynamism describes changes and variations of parameters over time. In the following, a

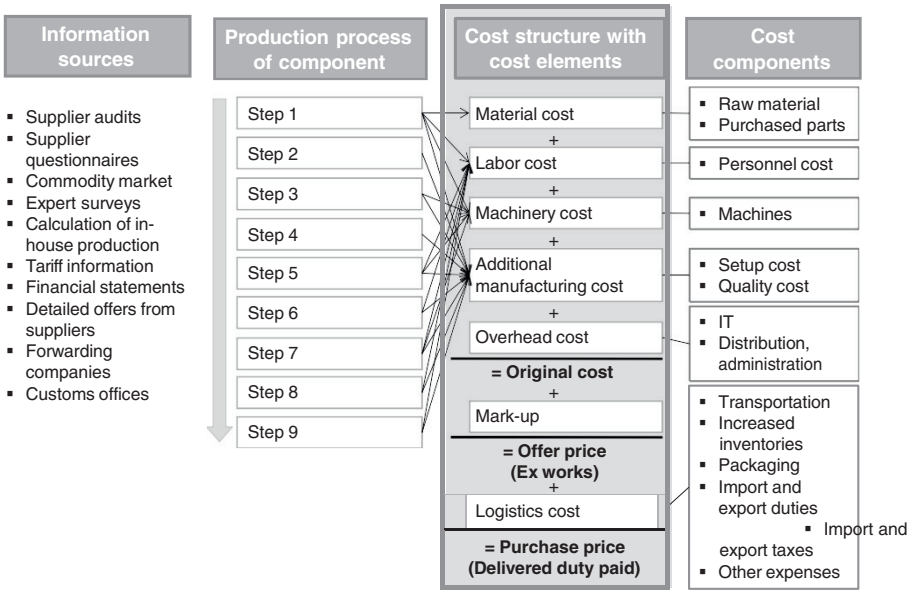

Fig. 4. Cost structure modelling [15].

new methodology is presented that shows how these dynamics can be identified and modelled. For the identification of dynamics, three fundamental factors are to be analysed: purchase price, exchange rate, and procurement quantity. Future changes of factor costs in low-wage countries may reduce initial production cost advantages. Especially low-wage countries with strong economic growth feature very high cost increases.

Dynamics of the procurement price have to be considered individually for each supplier since different economic zones develop at different rates over time. When concluding a contract in a foreign currency, future exchange rate developments may have a strong influence on procurement profitability. Hence, the unit quantity that needs to be procured will be analysed. The quantitative development of units to be purchased plays an important role for the investment projects due to changing market demands. For instance, a reduction of the unit quantity may lead to a reduction of overall savings due to high initial investments. Furthermore, it is of high importance to select dynamic variables and their developments adequately to be able to describe time-related dynamic aspect in the behavior of the variables. For this purpose, it is necessary to understand future prices and quantities not only as a fixed value but also as a process that is subject to variations and uncertainties over time [17].

This stochastic process can be modeled, for instance, using geometric Brownian motion [18]. The general differential equation of the geometric Brownian motion is stated as:

$$dX_t = \mu X_t dt + \sigma X_t dz_t \quad (2)$$

with

dX_t = Change of variable X in time period dt

μ = Expected drift rate of variable X

σ = Volatility of variable X

dz_t = Vienna process

The linearization of a discrete point of interest can be written as:

$$\Delta X_t = \mu X_t \Delta t + \sigma X_t \varepsilon \sqrt{\Delta t} \quad (3)$$

The following transitional equation can be concluded from equation (3):

$$X_{t+\Delta t} = X_t (1 + \mu \Delta t + \sigma \varepsilon \sqrt{\Delta t}) \quad (4)$$

with

ΔX_t = Change of variable X in time period Δt

μ = Expected drift rate per time unit

σ = Volatility of variable X

ε = Random value of the stand. normal distribution

Equations (3) and (4) contain the drift in the first term, which represents the expected average development per time unit. This corresponds to the expected increase or decrease or rather the expected value of dynamic variables.

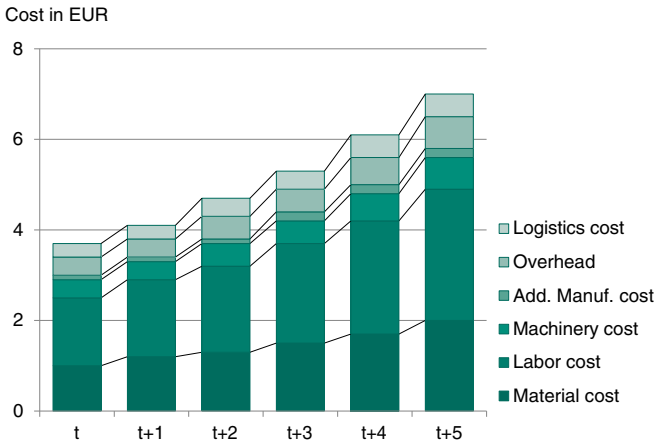

Fig. 5. Exemplary dynamic development of the cost structure [15].

Hence, equations (2) and (4) may depict stochastic processes whose trend has rather a tendency to decrease (μ<0), for instance, or rather a tendency to increase (μ>0). The geometric Brownian motion offers the advantage that the expected drift μX_t is formulated in a multiplicative way, so that it is depending on the value of the variable, in this case the time period or time unit. But on a percentage basis, the expected drift rate μ (quotient of the expected drift and the value of the variable) may remain constant [18]. Using this characteristic, the value change is always adjustable to the level at which a company currently performs. Under the assumption that the volatility is equal to zero, future expected developments of labour cost LK_t, for instance, could therefore be calculated by multiplying the value of the previous time period with the drift rate:

$$LK_{t+1} = LK_t + \mu LK_t = LK_t (1 + \mu) \quad (5)$$

Using a steady drift rate μ and a volatility of zero, the future value LK_T can be calculated based on the initial value LK_0:

$$LK_T = LK_0 e^{\mu T} \quad (6)$$

3.4. Estimation of dynamics

Equations (5) and (6) can also be applied to define purchase price, exchange rate and unit quantity. However, a forecast of the drift rate μ for the respective dynamic development is required. The drift rate can be forecasted either quantitatively based on mathematical models or qualitatively by falling back on expert knowledge and empirical values. Future changes in value (rate of increase or decrease) of dynamic input parameters are mostly estimated using historical data. A pattern may be derived using a time series that describes the historical development of an input parameter (e.g. development of commodity prices) which will be assumed as being valid in the future [19]. Given that the development of a dynamic input parameter observed in the past will also occur in the future, since a comparable economic environment is expected, the mean of annual growth rates of historical data may be used as estimator for expected annual growth rates. In addition, methods of econometrics and time series analysis may be useful, such as regression methods that explain historical observations by (linear) combinations of a variety of characteristics [20] [21] [22] [23]. Expert knowledge may also be integrated in order to refine the historical analysis (e.g. the unit quantity forecast on the basis of knowledge gained by experience) or to eliminate historical trends completely in case of other basic conditions or economic settings being expected for the future. With this presented methodology in particular, different scenarios can be run through, e.g. expected trend scenarios or even extreme scenarios. Especially monetary values, such as exchange rates [24], logistic costs [25] [26], wage costs [27] [28], and material prices [29] may be collected from official data bases and may then be analysed.

3.5. Identification and modelling of procurement-relevant risks

Several types of risks exist in all phases of the supplier-customer relation which endanger success and profitability of the supplier development project. As illustrated in Fig. 6, the presented approach distinguishes between exogenous risk category and endogenous risk category.

The illustrated risk criteria have been detected on the basis of supplier development projects in the past whereby experts in the field of purchasing and supplier development were interviewed [15]. Market risks and macroeconomic risks may be assigned to the exogenous risks category. Both are subject to constant external influences and therefore are not affected by company activities such as investing in the supplier. Success and profitability of a supplier-customer relationship are both influenced by currency risks, demand risks, and price risks during every transaction. Therefore, cost structure elements are to be seen as exposed to risks when analysed and modelled. Investments can be subject to country-specific risks; hence, these risks can be taken into account via the discount rate as part of a dynamic net present value calculation or a real options analysis.

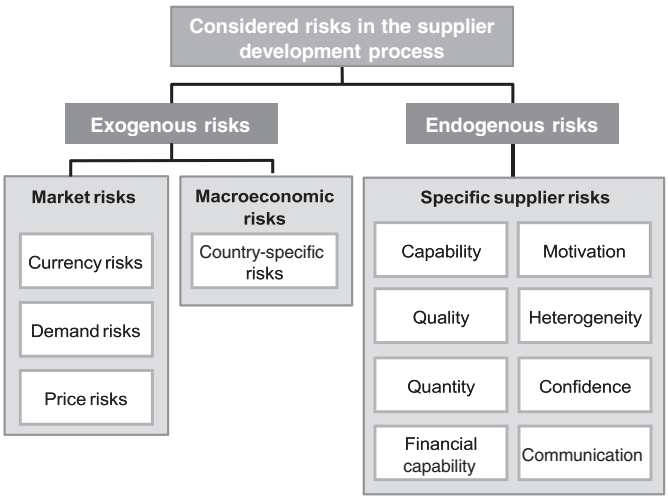

Fig. 6. Risks taken into account when developing a supplier [15].

When modelling dynamic market variables, volatilities of identified market risks are to be determined and, as far as historical data is available, estimators are to be obtained.

$$X_t = X_0 e^{\upsilon t + \sigma \epsilon_t \sqrt{t}} \quad (7)$$

$$\upsilon = \mu - \frac{\sigma^2}{2} \quad (8)$$

With the help of the drift rate μ and the volatility σ market developments may be modelled as stochastic processes. In doing so, μ represents the expected growth rate per time unit and σ the volatility of the development. Possible

developments may be calculated by the repeated extraction of a random number ϵ_t from N(0;1) and the subsequent adding as illustrated in equation (7) [18].

Specific supplier risks, as part of the endogenous risks, are determined by the supplier candidate's capability to perform. The determinants illustrated in Fig. 6 are rectified directly when they occur. The mapping of the endogenous specific supplier risk is performed by taking the deterministic probability of success p_k into consideration. The variable p_k represents a parameter estimated by the purchasing company for the purpose of forecasting periods k. This variable contains information the company was collecting during past business relationships with the supplier candidate (e.g. price negotiations, audits, and development plans). Modelling of supplier risk is indispensable since the ability and motivation to perform and therefore the success in developing a supplier may not be assumed as certain, especially not in low-wage countries. In addition, the willingness to perform may not be ensured by institutions in these countries due to a lack of legal protection.

3.6. Estimation of risks

Subsequently, approximate estimates have to be calculated for identified exogenous risks and for specific supplier risks. On the one hand, the needed estimators may be obtained from historical observation data, on the other hand relevant data may be generated on the basis of subjective expert knowledge. For an estimation of market uncertainties based on the analysis of historical time series, standard deviation of changes in the observed parameter need to be determined. An estimation of macroeconomic risks may, for instance, be performed by means of considering various country ratings or the yield of government securities and will be integrated into the discount rate.

The discount rate is greater than the risk-free interest rate and is also greater than the company-specific capital costs since it takes the risk aversion of the investor into account. The estimation of the specific supplier risk has to be performed by the planning team. It is recommended to use the fault tree analysis which is exemplary illustrated in Fig. 7. The method of estimating probabilities of success by experts is often used in practice, for instance in assessing research and development projects [30] [31] [32]. Furthermore, historical data about failed supplier developments have turned out to be useful since empirical values may be available to the purchasing company or industry associations as it is the case for financial institutions which are using historical data records of loan defaults for estimating a company's credit standing [32].

4. Summary

The presented paper is dealing with the issue of global procurement in low-wage countries whereby the focus is placed on the configuration of the supplier relation by taking business environment into account. The aim of the purchasing company involved in the supplier development process is to

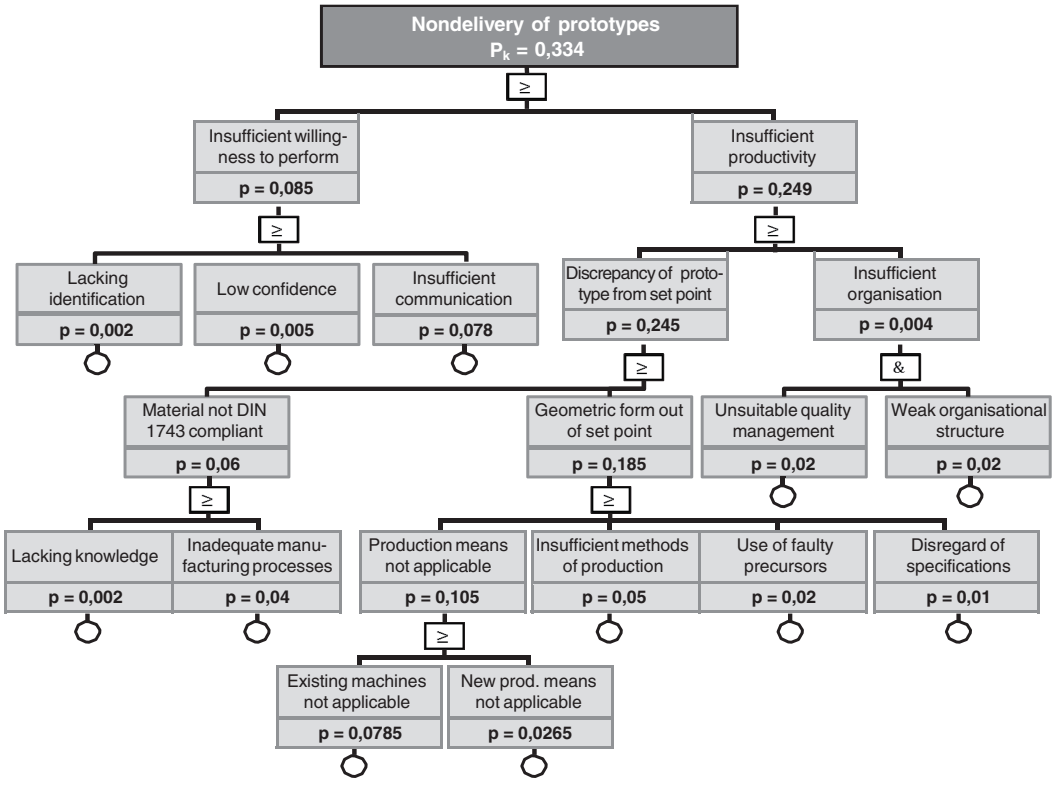

Fig. 7. Fault tree for the risk of non-delivery of prototypes during a supplier development [15].

increase its profitability. Therefore an approach is presented on how potential suppliers can be selected with the help of a requirement profile and a cost structure analysis. In addition, an approach for modelling and estimating dynamics and risks has been developed. Dynamics can be determined by using the drift rate whereat the risks are estimated using fault tree analysis. With the help of these approaches a purchasing company is capable of analysing a supplier-customer relationship by using an active-stochastic assessment.

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