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Model-Based Decision Support in Supply Chains – Requirements for Monetary Supply Risk Quantification

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Abstract

Optimization of the total risk level by economically feasible risk mitigation can only be achieved through a well-grounded monetary evaluation of the current risk situation. In the field of material supply and procurement directly affecting production and distribution processes a lack of such quantitative simulation model has been identified. Efficient modeling and simulation of monetary supply risk quantification in manufacturing enterprises requires target oriented simplification of the quantification model. Thereby requirements from three different disciplines need to be considered: (1) procurement in supply chains, (2) supply risks, and (3) monetary risk quantification. In this paper we propose a target oriented approach to deviate and discuss requirements for an applicable monetary supply risk quantification model particularly focusing on supply risks providing meaningful results to derive reasonable risk mitigation measures. Hence, a requirement checklist will be provided to be considered in development of monetary supply risk quantification models.

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1. Introduction

Today's manufacturers encounter challenges of global markets. Limited differentiation potentials of products by functionality, quality or price elevate the importance of logistics performance in their supply chain as a major factor of competitiveness [1]. Logistics in general include all tasks of planning, realizing or controlling the spatial transformation of goods and related transformations of goods in terms of quantity, types, handling characteristics as well as logistic determination. [2] Key performance indicators (KPI) are defined to support and facilitate these task by transforming rather abstract objectives into specific and measurable quantitative information and hence making process performances transparent and comparable [3,4]. Usually KPIs are designed to support enterprise's monetary based decision making process. However, enterprises are continuously challenged in meeting their set cost-based targets. Supply risks corrupt supply chains resulting in deviation of the set targets forcing enterprises into decision problems, such as:

What is the best inventory policy to compensate for supply disruption? What is the optimal supplier base? To solve such economic problems a transformation of the decision situation into a symbolic-mathematical decision model properly describing existing economic relations is required [5]. Decision models comprise a sound cost target function and a decision base consisting of action alternatives (scenarios), environmental conditions, and resulting consequences [6]. Considering the expected monetary impact of risk in the target function for the decision-making process increases the decision-base and hence results in a more comprehensive and realistic estimation of the expected outcome [7]. This allows balancing costs related with possible action alternatives and expected benefits and hence ensures reasonable decision making in accordance with corporate targets. Quantifying supply risk monetarily, however, is a challenging task that requires a suitable model accounting for the complex dependencies in supply chains.

Thus, the objective of this paper is to identify basic requirements models for monetary supply risk quantification

need to meet as decision model to generate adequate and meaningful results supporting the decision making process. Models are applied to represent real systems to gain insight about their behavior and in turn, use this knowledge in reality [8]. Hence a model needs to be limited to the aspects that affect the problem under investigation to be utilizable and manageable, while being sufficiently detailed to permit drawing valid conclusions about reality. Therefore, in this paper we systematically analyze which capabilities of solution procedures, model elements, dependencies, inputs, and outputs need to be considered by discussing:

- Procurement in supply chain structures, its relevant activities, and objectives
- Supply risks
- The basics of risk quantification

The paper is structured into 5 sections. After having introduced the purpose of this paper, section 2 provides an overview about the field of supply chain management (SCM) and identifies procurement as the main activity determining supply risk exposure. Subsequently, in section 3 the understanding of supply risk is discussed to identify relevant risk categories and potential consequences that need to be quantified. The basics of risk quantification and implications on proper risk models are visualized in section 4, before in section 5 the identified requirements are summed up and discussed to conclude the paper.

2. Logistics in Supply Chains and Procurement

2.1. Supply Chain Management

The overall goal of all logistics activities is to increase enterprises' competitive capability by improving delivery capability and reliability while minimizing logistics costs [9]. To achieve high logistics efficiency, material and information flows throughout the entire supply chain need to be optimized. Supply chains ideally incorporate all companies involved in value adding activities required for the production of a final product, from raw materials production to the final product's delivery to the end customer [10,11]. Consequently, supply chains include both, cross-company relationships between separate legal entities, and intra-company relations between different departments or sites. Fig. 1 illustrates the basic structure of a supply chain. Even though in literature on SCM some confusion exists in terms of what SCM really is, some commonalities can be identified [12, 13]:

- Intra- and inter-organizational integration and coordination of bidirectional flows of products (services and material) and information, managerial and operational activities from the initial source to ultimate consumer involving many independent organizations and departments
- Providing high customer value with appropriate use of resources to build chain advantages
- Focus on business processes
- Strategic relevance of SCM activities

Consequently SCM sets the overall framework for all logistics activities along the supply chain.

2.2. Procurement

Procurement includes all material planning and disposition activities [14]. Hence, procurement comprises all strategic sourcing decisions and operative purchasing activities, as well as activities related to goods arrivals. The overall goal is to provide supply of proper goods, of proper quality and quantity, at the exact time and location at minimum costs [15]. It aims to define appropriate and cost-optimal sourcing strategies, inventory and safety stock levels, as well as reordering points, and quality assurance programs. As part of the corporate policy the exact set of procurement goals has to be aligned with superior business objectives, hence general definition of procurement objectives need to be specified further [16,4]. According to ARNOLD procurement objectives can thus be classified into cost-reduction-objectives, quality objectives, security objectives, and flexibility objectives [17]. Basically, procured goods are classified into four article types [18]: raw materials, utilities, trade goods and miscellaneous. As this paper focuses on supply risks directly affecting a company's performance due to faulty supplies of components, modules, systems or other auxiliaries needed for production, the relevant scope of procurement objects is limited to materials being supposed to be assembled to final products. Particularly, relevant procurement objects are production materials in form of raw materials and auxiliaries.

Concluding, procurement is the enabler for subsequent manufacturing and sales processes and ensures a continuous supply of proper raw materials and auxiliaries to the demanded quality in sufficient quantity, at due time, and to the lowest possible costs. Procurement thus is the interface connecting business internal processes with external suppliers and is exposed to the area of conflict between the logistics targets of efficiency and security.

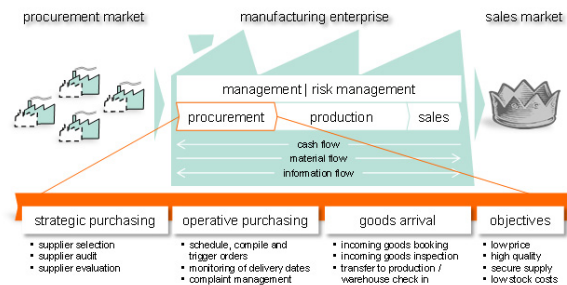


Fig. 1: Procurement in the context of supply chains

2.3. Derivation of Requirements

Based on the insights gained above, some requirements for models for monetary supply risk quantification can already be derived. To be able to accurately represent supply chain processes intra- and inter-organizational relations need to be representable through model elements accounting for sourcing, manufacturing, and sales processes (R1). Sourcing elements should represent the supplier base based on the

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