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Measuring and evaluating of the network type impact on time uncertainty in the supply networks with three nodes

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ABSTRACT

Nowadays, business competition turns from inter-company competition into competition between supply networks (Rice and Hoppe, 2001) [1]. Winning customer satisfaction is one of the primary elements of survival in the market. Organizations are no longer committed to long-term cooperation with suppliers. Furthermore, choosing suppliers is only based on their qualifications with regard to providing service and their compatibility with the type of customers' demands. Thus, each supply network needs to be designed according to a specific market opportunity with regard to structure and members. As a result, the structure of supply networks must be more flexible and move toward dynamics (Humphries and Mena, 2012) [2]. Delivery time is one of the main criteria for evaluating the performance of a supply network. Delivery speed and accuracy in dynamic supply networks are the main challenges ahead of network managers due to the short-time nature of such networks (da Silveira and Arkader, 2007) [3]. Therefore, from a different viewpoint, uncertainty and its sources, which directly affect delivery time, could not be ignored easily. Therefore, this study essentially focuses on the impact of uncertainty on delivery time in three nodes supply networks. The aim of this paper is to identify the impact of the accumulation of the individual delivery time uncertainties on overall delivery time uncertainty. The idea is the type of network and their structures have a crucial impact on the delivery time uncertainty. To prove this idea a probabilistic method is created to measure and evaluate this influence by implementing the Markov theorem. This research is an important step toward the better understanding of more complex networks and the impact of network type in the delivery time uncertainty of these networks.

1. Introduction

Today's business has rapidly changed and has become more competitive. Organizations realize the effective role of supply networks to compete in the global market and networked economy more and more. In Peter Drucker's (1998) new management paradigms, this concept of business relationships extends beyond traditional enterprise boundaries and seeks to organize entire business processes throughout a value chain of multiple companies [4]. Introducing the term "network" into the supply chain management (SCM) field has extended the SCM concept into more strategic areas. During the past decades, globalization, outsourcing and information technology has enabled many organizations, such as Dell and Hewlett Packard, to successfully operate collaborative supply networks in which each specialized business partner focuses on only a few key strategic activities. This

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inter-organizational supply network can be recognized as a new form of organization. Firms can now decide which parts of the supply network they will manage directly and which they will outsource the activities. These learnings, in turn, have enabled firms to achieve highly competitive performance levels through narrowing their focus and deepening their expertise. Some of the first studies of supply networks took place in the automotive industry [5,6]. Harland (1996) provided the four-level framework for SCM presented in Fig. 1, The framework mirrors the development of academic work in this area over time from level 1 in the 1960s to level 4, in the early 1990s [7].

According to the studies mentioned above, value creation within the manufacturing industry is realized in supply networks. Since a supply network is considered as the collaboration between suppliers and an OEM[1] with the objective to release a product; the management of quality, cost and time is not the issue of one single organization any more but of the collaboration.

A supply network is not a static system. Quantities, delivery times, due dates, start times etc., in the network may change at any time. Hence, the supply network is a dynamic system where values are changing continually. Consequently, supply network systems must be updated accordingly so that decisions are based on dynamic information, not static information [9]. The trend of companies to outsource activities to outside parties has certainly created a new source of uncertainty. The chance of having a delay in raw material delivery is increasing if a company relies on outside parties to do most of the inbound logistics activities. Increasing uncertainty requires manufacturers to spend more resources to anticipate and control demand, supply, and delivery time for better sustainability of their supply network. Interestingly, the increasing uncertainty is not solely induced by the external business environments, but also due to the increasing complexity of the supply network structure [10].

The importance of delivery time and response time as a strategic weapon has been recognized in the arena of global competition [3,11,12]. Time-based competition apparently has emerged as the competitive paradigm of the 1990s [13]. This time-based paradigm was first highlighted explicitly in literature in the late 1980s by Stalk [13].

Delivery time reliability -which means the real delivery time of a supply network-, should not exceed the guaranteed delivery time with a probability at least a specified percentage of confidence [14], and it is a key component of order fulfillment. Reliability in delivery time has become critical due to increased competitive pressure in the context of the recent and growing emphasis on supply network effectiveness and efficiency. Delivery time uncertainty is understood as a lack of confidence to guarantee the certain percentage of deliveries in the defined time frame. The strategic importance of delivery time reliability and delivery time uncertainty has been recognized by many researchers and practitioners, and it has emerged as a key competitive factor in a supply network. Thus, many manufacturers are adopting the use of delivery-time

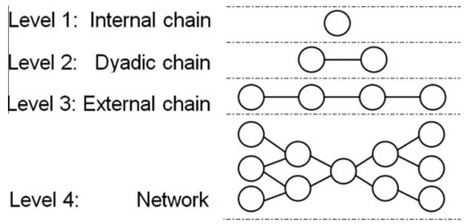

Fig. 1. Harland framework for SCM [7,8].

guarantees as part of their market positioning strategy [15,16].

Srai and Gregory in 2008 described the impact of network type on supply network performance. The common basic network types are star, bus, ring, and tree. More complex networks can be built as hybrids of two or more of the above basic types, which can be called "generalized networks" [17]. The type of supply network has an essential impact on the accumulation of the individual uncertainties and therefore on the overall uncertainty which the network can guarantee for the final customer. Whereas delivery time uncertainty has an impact on supply network performance, study on the impact of the network type on delivery time uncertainty in supply network is a gap in this area. Our aim in this research is to provide a better understanding of the impact of the network type on delivery time uncertainty in the supply network. Individual uncertainties need to be accumulated to the total uncertainty of the network.

This study is part of the ongoing academic research. Methodology of this paper is based on literature review on supply network, network typology, probability theory, graph theory and Markov properties. The differential effect of delivery time uncertainty of a supplier of the final delivery time according to the network type has been studied. With consideration of probability theory, graph theory and Markov properties, two mathematical formulas with generated data regarding the possible types of network with three nodes are given. The results of the example are presented by the schematic diagrams in Excel software.

In this paper, the problem is the identification of the network type impact on the accumulation of the individual delivery time uncertainties. Different network types which can be generated by three nodes are considered. The paper is organized as follows. Section 2 introduces potential types of networks. Section 3 describes the uncertainty and the delivery time uncertainty and then in the next section explains the mathematical ways of uncertainty explanation. Section 5 discusses the impact of the network type on delivery time uncertainty in supply networks. Different network types, which can be generated by three nodes, are being discussed.

2. Network types

The supply network concept appears to be more complex than the supply chain concept. Supply networks encompasses the mess and complexity of networks involving lateral links, reverse loops, and two-way exchanges, and include a broad, strategic view of resource acquisition, development, management, and transformation [8].

[1] Original Equipment Manufacturer