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Design of cooperative processes in a customer–supplier relationship: An approach based on simulation and decision theory

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ABSTRACT

Performance improvement in supply chains, taking into account a customer demand in the tactical planning process is essential. It is more and more difficult for customers to ensure a certain level of demand over a medium term horizon as their own customers ask them for personalisation and fast adaptation. It is thus necessary to develop methods and decision support systems to reconcile the order and book processes. In this context, this paper intends firstly to relate decision under uncertainty and the industrial point of view based on the notion of risk management. This serves as a basis for the definition of an approach based on simulation and decision theory that is dedicated to the design of cooperative processes in a customer–supplier relationship. This approach includes the evaluation, in terms of risk, of different cooperative processes using a simulation-dedicated tool. The evaluation process is based on an exploitation of decision theory concepts and methods. The implementation of the approach is illustrated on an academic example typical of the aeronautics supply chain.

1. Introduction

Supply chain management emphasises the necessity to establish cooperative processes that rationalise or integrate the forecasting and management of demand, reconcile the order and book processes, and mitigate risks.

These cooperative processes are often characterised by a set of point-to-point (customer/supplier) relationships with partial information sharing (Galasso et al., 2006). In this context, at each level of the supply chain, a good understanding of the customer demand is a key parameter for the efficiency of the internal processes and the upstream supply chain (Bartezzaghi and Verganti, 1995). However, due to a substantial difference among the supply chain actors in terms of maturity regarding their use of enterprise systems, it is more or less difficult to implement cooperative processes for the different participating companies. Indeed, while large companies have the capability of using and managing efficient cooperative tools, small and medium enterprises (SMEs) suffer from a partial vision of the supply chain and have difficulties to analyse the uncertain information communicated from customers.

This paper aims at providing suppliers (e.g. in aeronautics) with a cooperation support that takes advantage of the information provided by customers in a cooperative perspective, even if this information is uncertain. Thus, we propose a decision and cooperation support approach based on a simulation of planning processes in the point-to-point supply chain relationship.

More precisely, we are concerned with the joint evaluation of the impact of the customer's supply management process and the supplier's demand management and planning processes.

After discussing the state of the art (cf. Section 2) on cooperation in supply chain management and supply chain risk Management, we introduce the context and the related challenges (cf. Section 3). Then, Section 4, describes the approach based on simulation and decision theory proposed to evaluate the risks pertained to the choice strategies for demand management (supplier) and supply management (customer). At last, the proposed methodology is implemented on an illustrative example (cf. Section 5).

2. State of the art

In this section, the state of the art regarding two main points of interest is given. The first issue refers to the decision making under uncertainty in connexion with the supply chain risk management. The second one investigates the problematics of cooperation within the supply chain.

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2.1. Decision under uncertainty and supply chain risk management (SCRM)

In the industrial context, the concept of decision under uncertainty is generally not explicitly addressed, but the concept of risk management is prominent. It is undeniable that the concepts of "*uncertainty*" and "*risk*" are linked even if it is sometimes difficult to perceive this link. Risk management, particularly in the field of supply chain management, turns out to be an important industrial challenge. SCRM is the "management of external risks and supply chain risks through a coordinated approach between the supply chain partners in order to reduce supply chain vulnerability as a whole" (Christopher, 2003). So far, there is still a "lack of industrial experience and academic research for SCRM" as identified by (Ziegenbein and Nienhaus, 2004) even if, since 2004, it has been an increasing number of publications in this field. More specifically, the question of risk management related to the use of advanced planning systems (APS) has to be studied (Ritchie and Brindley, 2004). The academic community paid a lot of attention to the clarification of definition, taxonomies and models linked to the SCRM (Brindley, 2004; Tang, 2006). Holton (2004) defines risk as the combination of two mains elements: the exposure and the uncertainty. Thus, he defines risk as the "exposition to a proposition (i.e. a fact) that one is uncertain".

However, from the viewpoint of decision theory, the distinction between "decision under risk" and "decision under uncertainty" is well established according to the knowledge of the state of the nature: the term decision under risk is used if objective probabilities are associated to the occurrences and if not, the term decision under uncertainty is used (Lang, 2003). The latter corresponds to the situation of imperfect knowledge. The imperfection of the knowledge of a system can be due to the flexibility inherent to the knowledge or due to the acquisition of such knowledge. Among these imperfections, Bouchon-Meunier (1995) synthesizes the distinction (Dubois and Prade, 1988): uncertainty; imprecision and incompleteness. Uncertainty refers to the "doubt about the validity of the knowledge", which refers to the fact of being unsure whether a proposition is true or not (for example: "I believe but I am not sure"…). Imprecision concerns "the difficulty to express knowledge". Indeed, it can be knowledge expressed in natural language in a vague way (for example: "it is important"…) or quantitative knowledge not precisely known because of, for example, imprecise measurement ("this value lies between *x* and *y*" or "this value can be *x*, *y* or *z*"). Incompleteness refers to "the lack of knowledge or partial knowledge about some characteristics of the considered system".

A lot of criteria can be used in order to finely classify the different kinds of uncertainties (Teixidor, 2006). Bräutigam et al. (2003) distinguish between two main kinds of uncertainties: endogenous uncertainty (specific to the studied company or system) and exogenous uncertainties (external to the studied company or system). More precisely in the field of supply chain management, Ritchie and Brindley (2004) propose a contingency framework over four dimensions: the environment characteristics, the supply chain context, the decisional system (decision level, type of decision, information availability,…), the human and its behaviour in presence of risk.

Regarding the production planning models under uncertainty, Mula et al. (2006) have recently proposed a complete state of the art. In this review, the authors distinguish conceptual; analytical; artificial intelligence and simulation models in order to deal with risk management issues. In the last category, the model proposed by Rota et al. (2002) can be pointed out as it is close to our approach embedding an analytical model in a simulation framework. Indeed, it is one of the first attempts made in order to evaluate the interest of taking into account forecasts in the planning process, while software such as APS just began to be implemented. Nowadays, considering the spreading out of the use of such tools, practitioners aim at quantifying the risk inherent to the planning process with an APS in the supply chain context (Ritchie and Brindley, 2004). In that sense, Génin et al. (2007) propose, for example, an approach that provides a robust planning with an APS. Beyond the planning process in itself, it becomes more and more important to assist industrial practitioners in defining demand management in order to deal with uncertainty while maximising the potential use of the planning tools.

2.2. Cooperation in supply chains

The implementation of cooperative processes for supply chain management is a central concern for practitioners and researchers. This awareness is linked, in particular, to the Bullwhip effect whose influence has been clearly shown and studied (Lee et al., 1997; Moyaux, 2004).

Recently, many organizations have emerged to encourage trading partners to establish cooperative interactions (that rationalise or integrate their demand forecasting/management, and reconcile the order-book processes) and to provide standards (that could support cooperative processes): RosettaNet (Rosetta, 2007), Voluntary Inter-industry Commerce Standards Association (Vics, 2007), ODETTE (Odette, 2007), etc. On the other hand, McCarthy and Golicic (2002) consider that the cooperative process brought by the CPFR (collaborative planning, forecasting and replenishment) model is too detailed. They suggest instead that companies should plan regular meetings to discuss the forecast with the other supply chain partners, so as to develop shared forecast.

In the same way, many recent research papers are devoted to cooperation in the context of supply chain management. Under the heading of cooperation, authors list several aspects. One of these aspects on which we focus in this paper, is cooperation through information sharing. Using Huang et al. (2003) literature review, we can distinguish between different classes of information that play a role in the information sharing literature: (i) product information, (ii) process information, (iii) lead time, (iv) cost, (v) quality information, (vi) resource information, (vii) order and inventory information and (viii) planning (forecast) information (Lapide, 2001; Moyaux, 2004). Another aspect of cooperation concerns that extend information sharing to collaborative forecasting and planning systems (Dudek and Stadtler, 2005; Shirodkar and Kempf, 2006). In this paper, we will focus on information sharing and more precisely sharing information concerning planning (forecast).

Nevertheless little attention has been paid to the risk evaluation of new collaborative processes (Småros, 2005; Brindley, 2004; Tang, 2006). This is also true when planning processes under uncertainty are concerned (Mula et al., 2006), even if Rota et al. (2002) introduced the problem of managing tactical planning with an APS and Génin et al. (2007) studied its robustness.

Thus, this paper is focused on risk evaluation of cooperative planning processes within a customer–supplier relationship and thus, a decision and cooperation support tool for dealing with uncertainty is proposed.

3. Context and challenges

It has been stressed in Section 2, how building cooperative processes is of major importance. The main concern regarding