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Supply chain dynamic configuration as a result of new product development

Mahdi Jafarian, Mahdi Bashiri *

Department of Industrial Engineering, Shahed University, Tehran, Iran

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ABSTRACT

This study considers supply chain network configuration in an innovative environment while the new product development (NPD) will affect the supply chain configuration (SCC). The time of new product introduction has a significant effect on the market performance while it has an effect on the supply chain configuration. Supplier integration into the new product introduction is the key parameter for successfully new product introduction, which may contribute to supply chain reconfiguration. Consequently By considering the new product development concept, we may face with dynamic supply chain configuration during a planning horizontal time. In this study, a new model is presented to consider the dynamic configuration of a supply chain by developing new products. In the proposed model, the dynamic configuration of a supply chain and the new product launching time is optimized simultaneously. The proposed model considers production, sales and transportation planning for the entire supply chain in order to achieve an integrative and efficient supply as well. Then some numerical analyses have been done to show the applicability of the proposed model. The results show that the new product development has a significant effect on the configuration of supply chain.

1. Introduction

In the recent years by raising competition in the market, products life cycle has shortened and new product design and its introduction to the market is a key factor to be alive in the market. In many industries, firms should reduce the cost of new products development and facilitate the smooth launch of new products in such a competitive environment [1]. Lunching a new product in a firm depends on its designing aspect, as an internal effect, and external aspect in the supply chain (SC) outline. The first one is related to firm's expert's abilities to use technologies and considering customer specifications. Second aspect, depends on supply chain elements and their flexibility and integration to the new product introduction. As noted by Forza et al. [2] supplier selection, their engagement and their involvement timing are critical factors of successful NPD process, which should be decided by product development team. As another study in the literature, Petersen et al. [1] discussed that supplier integration in the new product development process has direct impact on the supply chain configuration decisions. Therefore, SC elements integration, supplier selection, supplier involvement time and an optimal configuration of the supply chain are the requirements for achieving beneficial new product diffusion. Consequently, Supply chain should adapt to market changes to gain sustainable competitive advantage [3] which relies so heavily on marketing and supply chain interactive coordination. By expanding the field of vision, it is obvious that the supply chain configuration should be changed

* Corresponding author. Tel.: +98 9123150355.
E-mail address: bashiri.m@gmail.com (M. Bashiri).

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by considering the new products because of dynamic marketing demands, so in this study it is assumed that the supply chain configuration is dynamic during the products life cycles.

Rollover strategy, new product introduction and old product phasing out, is highly influential parameter for the SCC and NPD problem. In the case of product rollover, time of introducing new product and phasing out the old product is key parameter and has an effect on firms' performance and their related supply chain as well. We refer to Lim and Tang [4] study for more details about the tradeoff between the introduction and phasing out for an individual firm. We can find two main rollover strategy studied by Billington et al. [5] in the literature. They proposed two product rollover strategies namely single-product roll and dual-product roll. In the single-product strategy, the old product is phased out first then the new product is introduced, consequently the firm produces only one of the old or new products in a moment. Nevertheless, in the dual-product strategy both products can be produced concurrently so the old product phasing out and the new product introduction are occurred distinctly. These strategies should be considered in the supply chain and examine their properties and preferences. In the presented model of this paper, single-product roll is considered as the rollover strategy. In another hand Petrick and Echols [6] categorized the new product production specifications by required system and components in three sections as follows: new product constructed by new component using existing system, new component constructed by new system and the condition which existing component is operated by the new system. This is also the other essential parameter for the proposed problem. As Amini and Li [7] mentioned, after the NPD and SCC decisions and during the product life cycle, production and sales planning for the firms and transportation for the whole supply chain are the only part of big picture.

In this study, we attempt to model interaction of NPD and SCC problems. In the simulated supply chain (SC), we consider a five echelon SC with multiple firms, which individually decide to introduce new products. In the proposed model, the supply chain configuration and the time of new product lunching are optimized simultaneously because of their effects to each other. It is clear that new product lunching should be done in a firm continuously to have the competitive advantage, so in the proposed model it is assumed that the SCC is dynamic and will be changed in different periods according to the new product development. Moreover, production, sales and transportation planning of the supply chain are considered during the new product development and supply chain configuration decisions. For better illustration, a sensitive analysis of more effective parameters of the problem such as reconfiguration cost and product life cycle are considered and their effects on the supply chain configuration and product rollover during different periods are discussed in the paper.

The rest of this paper is organized as follows. In Section 2, a brief literature review of the problem is documented. In Section 3, the proposed model of the dynamic supply chain configuration is presented. For more illustration, numerical studies and a sensitive analysis have been done in Section 4 and finally, conclusions are demonstrated in Section 5.

2. Literature review

Our research is interaction of the two main area of science, covering supply chain configuration and new product introduction. These two aspects are separately and simultaneously discussed in the literature. In this part, we provide a brief review of related studies.

In the case of supply chain configuration, we can categorize the studies in static and dynamic configuration that are presented in the following. Li and Womer [8] presented a modeling framework based on multi-mode resource-constrained project scheduling for configuring the supply chain subjected to explicit resource constraints. Their model includes quality requirement levels and lead time as SC measures. They use constraint programming as solution approach. Altiparmak et al. [9] studied the supply chain network design problem by considering plants and distribution centers opening decisions. They modeled a single-source, multi-product and multi echelon SC that belongs to production–distribution and facility location problem. They developed a steady-state GA algorithm to solve the problem. Piramuthu [10] incorporated machine-learning techniques to develop a dynamic configurable supply chain framework, and evaluate its effectiveness with respect to comparable static supply chains. Nagurney [11] proposed a framework for supply chain configuration design and redesign including determination of the optimal levels of capacity and operational product flows associated with manufacturing, storage, and distribution activities of supply chain. In mentioned study, after the designing stage and obtaining the initial configuration, redesigning is implemented based on the capacities in order to determine the optimal solution. Ramezani et al. [12] designed a multi objective forward/reverse network in the stochastic environment. Their model considers a systematic SCC that maximizes the profit, customer responsiveness and quality. Constructed network has three echelons in forward direction and two echelons in reverse direction. The set of Pareto optimal solutions is presented in the mentioned study. Castillo-Villar et al. [13] generated a model for supply chain design by considering the cost of quality. Goal of their study is computation of cost of quality as a global performance measure for the entire supply chain. They illustrated that how cost of quality function changes depending on various parameters.

Lim and Tang [4] studied about the product rollover strategies. They introduced the timing of introducing the new product and phasing out the old product and their related pricing as key parameters of their product rollover model. Their proposed model is solved considering the two rollover strategies.

There are some studies which consider the supply chain configuration and the new product development simultaneously such a (Amini and Li [7], Wang and Shu [14], Naraharisetti and Karimi [15]). Amini and Li [7] developed an integrated