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A three-stage optimization model for production and outsourcing under China's export-oriented tax policies



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ABSTRACT

This paper studies an integrated optimization problem on outsourcing and production decisions in the context of the global supply chain and China's export-oriented tax policies. A three-stage decision model is proposed for this integrated optimization problem. A cross-entropy-based solution method is also developed to solve the three-stage decision model. Numerical experiments are performed to investigate the effectiveness of the proposed model and the efficiency of the proposed method. Additionally, some managerial insights are drawn from these experiments.

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1. Introduction

Since China was opened up to the world three decades ago, it has gradually become a vital part of the global supply chain, as the world's largest manufacturer of a range of products, including textiles, clothing, telephones, PCs, household appliances, etc. In the environment of the global supply chain, many multinational manufacturing companies in China are facing various management decision problems, such as the adoption of outsourcing channels (i.e., suppliers) in overseas and domestic markets, and coming up with production plans for customers in the overseas and domestic markets. In this paper, the term 'outsourcing' mainly denotes the activities that manufacturing companies procure components from some third party suppliers, which may be located in overseas and domestic markets.

The Chinese government designed some tax and tariff policies to encourage exports. Under these export-oriented tax policies, an exported product and its imported parts are exempted from tariffs and value-added taxes (VAT), which are normally imposed on every stage of the production process in China. Moreover, when domestically produced parts are used in an exported product, the manufacturer can obtain a partial or full refund of the VAT paid on the domestically produced parts.

China's export-oriented tax and tariff policies have influences on the multinational manufacturing companies' final profits and their operation management decisions, e.g., outsourcing channel adoption, production planning for the domestic and overseas markets, etc. These decisions are also intertwined. However, few of the supply chain management related literature investigates these problems comprehensively. It motivates us to investigate how we might optimize these decisions regarding outsourcing and production under China's export-oriented tax policies. This paper combines the traditional decision problems on supply chain management with the factors of tax refund and tariff policies in realistic business practice.

By considering some details of the export-oriented tax policies in China, a three-stage decision model is proposed for an integrated optimization problem on outsourcing and production decisions. In order to solve the complex model, with three

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stages of decisions and stochastic demands in the domestic and overseas markets, a cross-entropy-based solution method is developed. Then, based on some practical cases, numerical experiments are performed to validate the effectiveness of the proposed model and the efficiency of the proposed method of solution. Some managerial insights are also drawn from these experiments.

The remainder of this paper is organized as follows. Section 2 presents the literature review. The background to the problem is elaborated in Section 3. Then, a mathematical model and some analysis of it are given in Section 4. In order to solve the model, Section 5 addresses a cross-entropy-based solution method. Section 6 lists the results of the numerical experiments. Some managerial implications are discussed in Section 7. Some closing remarks are given in the final section.

2. Related works

There is a rich body of literature on production and supply chain decision in the global environment. Readers are referred to some recent survey papers, such as Meixell and Gargeya (2005), Van der Vaart and Van Donk (2008), Lu and Van Mieghem (2009), Melo et al. (2009). These papers gave summaries of research methodologies used to solve problems on global supply chain decision.

Studies on production, outsourcing, and supply chain decision have usually used quantitative methods, such as mathematical programming, to investigate various decision problems. Pan and Nagi (2013) proposed a mathematical programming model for supply network design in agile manufacturing. A Lagrangian heuristic was developed to solve industrial-sized instances of the problem. Li and Womer (2012) developed a new model based on both mathematical programming and constraint programming, so as to simultaneously optimize sourcing and planning decisions in a make-to-order supply chain. Plenty of related studies in the field of supply chain management incorporate integrated optimization models. For example, Ben-Daya et al. (2013) studied an integrated problem on production and inventory replenishment decisions in a three-layer supply chain. Qi (2011) designed an integrated model on outsourcing and production scheduling for a two-stage supply chain. In addition, some scholars have built multi-objective models of supply chain decisions. Zhang et al. (2012a,b), for example, proposed a supply chain design model for dispersed manufacturing in China. They investigated how the trade-offs between costs and lead time affect facility location decisions. Liu and Papageorgiou (2013) developed a tri-objective model for decisions on production, distribution, and capacity planning in a global supply chain. The ε -constraint method was designed in order to generate a set of Pareto-optimal solutions.

This paper is concerned with decisions over outsourcing and supplier selection, which have been widely studied in the field of supply chain management. Lee and Choi (2011) considered a two-stage production scheduling problem with outsourcing option. The objective was to minimize the weighted sum of the makespan and total outsourcing cost. Zhen (2012a) studied a production planning problem with considering outsourcing decisions; and this work was extended to a multi-product decision problem in a paper by Zhen (2012b). Feng et al. (2011) built a multi-objective model of supplier-selecting decisions. They also developed a multi-objective algorithm based on Tabu search in order to solve it. Unlike these studies, in this paper we propose a three-stage decision model for optimizing outsourcing and production decisions in the global supply chain. We also consider more realistic factors in this study. Supply chains comprise a lot of different factors. Many scholars have considered some of these factors in their models. For example, Balachandran et al. (2013) explored how in-house capability affects contractors' supply chain decisions. Liu and Nagurney (2011) took account of the impacts of foreign exchange risk involved in offshore-outsourcing activities. Nickel et al. (2012) considered stochastic interest rates and demands in a multi-stage stochastic supply network design model. Qiang et al. (2013) included various factors, such as supplier competition, distribution channel investments, and uncertainties, in their model. Su and Geunes (2012) investigated how price promotions affect forward buying and increased consumption from brand switchers. Palsule-Desai (2013) considered revenue sharing for supply chain coordination in the movie industry. The following studies are close to this paper. Zhang and Huang (2012) designed a bi-objective integer programming model for supply chain configuration decisions with considering not only cost issue but also lead time factor. Their study found that coastal China is still attractive for products with short order lead time. Zhang et al. (2012a,b) proposed a mixed integer programming model to investigate the influence of some economic changes on the Chinese Pearl River Delta region's competitive advantages. Huang et al. (2013) reevaluated the location decision of global manufacturing facilities in China. Their study indicated that Chinese currency appreciation brought high risk for retaining production in China, and Hong Kong remained a robust location choice for trade operations because of its favorable tax policies. This paper is similar with the above studies in some perspectives. All of them use mathematical modeling methodology to investigate the influence of some realistic factors on the global operation decisions for multinational manufacturers. However, the difference is that the above studies mainly considered the factors, such as the Chinese currency appreciation, rising labor costs, highly volatile oil prices and new trade policies, while this study mainly considers the China's export-oriented tax policies.

Our study considers component adoption in product configuration. Similarly, some recent studies have analyzed the effects of product configuration factors on the supply chain decision. Nepal et al. (2012) analyzed the impact of product architectural strategy on supply chain designs in the heavy equipment and automobile industries. Marsillac and Roh (2013) studied the direct and indirect impacts of product design on supply chain activities, and investigated how these changes influence global supply chain behaviors and capabilities.

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