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A strategic-tactical model for the supply chain design in the delocalization context: Mathematical formulation and a case study

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ABSTRACT

In this paper, we propose a mathematical model for the design of supply chains in the delocalization context. Our main objective is to develop a strategic-tactical supply chain design model that integrates all the relevant components that characterize the delocalization problem. We adopt the activity based approach to model the problem and we focus on the logistic decisions of activity location, technology choice, supplier selection, etc., and the financial decisions of transfer pricing, transportation costs allocation, etc. The mathematical formulation is illustrated by a case study from the automotive sector. A comparison between the model solution and the real decisions is used to prove the applicability and the utility of the proposed model.

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1. Introduction

In the current context of globalization, the manufacturing capacities are higher than the demand for several types of products, which implies an increasing level of competition on the international market. Hence, most companies that aim to preserve and develop their positions are considering the option of delocalizing a part or the total of their activities in low-cost countries. Delocalization commonly refers to the transfer of certain production activities from developed to developing countries, essentially to benefit from low labor costs. The increasingly attractive economical, political, technological, and legal/regulatory environments, especially in developing countries, are reflected in the rising number of delocalization undertaken by the multi-national companies (MNCs) such as the case of French companies in North Africa (Tunisia, Morocco). This is accentuated by the continuous decrease in telecommunication and transportation costs all over the world, with the exception of recent tendencies, and the development of powerful and efficient information systems.

In a previous work, we have identified the main characteristics of the delocalization problem and their impacts on the design of supply chains in terms of decisions, cost factors, constraints, and other aspects (Hammami et al., 2008). For example, we showed that such models should take into account the following factors:

- *decisions:* activity location, technology selection, supplier selection, transfer pricing, capacity acquisition, capacity relocation, etc.,
- *costs:* labor cost, technological cost, supplier fixed cost, purchasing cost, operation cost of an activity, transportation cost, fixed cost of closing/opening sites, capacity acquisition and relocation cost, etc.,
- *constraints:* capacity of supplier, technological constraints, etc.,
- *international factors:* exchange rate, profit taxation, etc.

To integrate these aspects and model the problem, we demonstrated that we should adopt an activity based

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modeling approach which consists in considering the firm's global manufacturing process as a set of activities (Hammami et al., 2008). We define an activity as the process that converts a set of input products into a set of output products by the means of a certain technology and using a set of resources. The relationship between activity and technology is bijective; to each activity is associated a unique technology and vice-versa. In other words, if an input group of products can be converted into an output group of products using two different technologies, this necessarily leads to the definition of two different activities. An activity can refer to either a manufacturing or a distribution process. Otherwise, the definition of an activity does not depend on its location; which means that the same activity may be implemented in different facilities.

Then, we adopted this activity based approach and considered some of the previous factors to develop a supply chain design model (Hammami et al., 2007). Although it was shown that this proposed model is well adapted to the delocalization problem compared to existing literature, this model presents some weakness. Indeed, it ignores some pertinent aspects for the delocalization problem such as:

- *the supplier selection issues* (decision, purchasing cost, fixed cost of managing and integrating suppliers, supplier constraints),
- *the technological issues* (fixed cost of implementing technologies in developing countries, technological constraints).

Our main objective in this paper is to develop a strategic-tactical supply chain design model that integrates all the relevant components that characterize the delocalization problem. We organize the remainder of this paper as follows. In Section 2, we highlight the technological and supplier selection issues which are among the most relevant features of supply chain design in the context of delocalization. Section 3 is dedicated to the presentation of a case study which will be used to illustrate our activity based modeling approach and describe the different features of our problem. We give a description of our model in Section 4. The mathematical formulation of the model is given in Section 5. In Section 6, we present a brief review of the literature related to model-based supply chain design in order to show how well the proposed model is adapted to the delocalization context. The computational experiments are given in Section 7. Finally, we give concluding remarks and future work directions.

2. New modeling aspects

In this section, we do not aim to review all the supply chain design features in the delocalization context but we only focus on the important technological and supplier selection issues which are among the novelties of this work.

2.1. Technological issues

Technological issues are among the most important factors that characterize the design of supply chains in the context of delocalization. They concern the decision of selecting appropriate technologies in developing countries as well as the economical criteria (costs) and constraints that guide this choice.

- *Technology selection.* Although it is usually dealt with separately in the supply chain design related literature, the location of facilities and the choice of manufacturing technologies are becoming highly interdependent with the high level of globalization as highlighted by Verter and Dasci (2002). The facility location and technology selection decisions are intertwined, especially within the delocalization context where technology implementation and operation costs are location dependent. This is accentuated by the fact that decisions related to technology selection constitutes a very challenging task faced by delocalized companies. Indeed, on the one hand, companies would like to profit from low labor costs in host countries by setting up less automated and more labor-intensive technologies. In fact, Bruun and Mefford (1996) concluded that a less advanced form of a production process is called for in developing countries given their lower labor costs. On the other hand, they would like to use, in delocalized units, the same manufacturing technologies as in the original plants in order to achieve economies of scale, make a rapid transfer of production activities, maintain a high labor productivity level, guarantee the similar high standards of efficiency and quality, and keep customers' confidence.
- *Technological costs.* To make appropriate technological choices, delocalized companies should take into account the different costs that are incurred by the selection and the use of a given technology. Indeed, the costs of introducing and operating a new technology are generally more significant in developing countries and have various sources. Bruun and Mefford (1996) highlighted that many MNCs have experienced difficulties with the low technology process because some factors were not considered in the factor cost approach. Clearly, technological costs may include training costs. Such costs may be significant in host countries which, in general, do not have the training infrastructure required for basic industrial skills.
- *Technological constraints*. The discussion about technology selection for delocalized companies is always complicated given the necessity of considering various appropriate constraints. Indeed, on the one hand, a plant that is a part of a global supply network has many constraints on its technological choice (Mefford and Bruun, 1998). On the other hand, given the technological gap between origin and host countries, the delocalized plants are technologically dependent of origin units in most cases. For instance, delocalized plants are usually incapable of implementing a high quality production system without foreign assistance

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