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The Fundamentals of Global Outsourcing for Manufacturers

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1. Introduction

Today, international competition is growing rapidly, and enterprises must always remain ahead of the competition to ensure their survival. Therefore, firms must keep pace with dynamic conditions and rapid changes, be innovative, and adapt to new systems, techniques and technologies. In a competitive market environment, customers are becoming more conscious and tend to demand a particular number of customised products at a particular speed. Furthermore, fluctuations in national economies and in the global economy create significant risks. Because of all of these factors in today's competitive environment, firms have begun to make radical changes in their management and production structures. They must also reduce costs to maintain their current position in the market.

Manufacturers must be the forerunners in the competitive race in today's global markets. Today's enterprises are facing fierce competition, which is forcing them to seriously consider new applications that they can use to improve quality and to reduce cost and lead time. Manufacturers must keep pace with the dynamic requirements of the market and be receptive to reform.

Because of the intense global competition among manufacturers, the supply chain must be able to respond quickly to changes, and customer–supplier relationship management is becoming increasingly important. In recent years, very few manufacturers have owned all of the activities along the supply chain. The ability to make rapid and accurate decisions within the supplier network improves the competitive advantage of manufacturers.

Additionally, due to the intense global competition that exists today, firms should be reevaluate and redirect missing resources. Outsourcing plays a key role for enterprises because the cost of raw materials constitutes a significant part of the cost of the final product. Choosing the right supplier reduces purchasing costs and enhances the competitive advantage of firms. As organisations become more dependent on suppliers, the direct and indirect consequences of poor decision-making become more severe. Decisions about purchasing strategies and operations are the primary determinants of profitability. The globalisation of trade and the Internet have enlarged purchaser choice sets. Changing customer preferences require broader, more systematic and faster outsourcing decision making.

An enterprise may produce a specific product itself or may outsource that specific product to achieve a production cost advantage. Global outsourcing can be defined as the

forwarding of specific business to a global supplier. Global outsourcing enhances the competencies of firms while also making firm structures more flexible.

In today's global markets, firms must use new methods to sustain their strength and compete. In recent years, under the influence of this intense competition, global outsourcing has become popular for firms. Firms are widely using global outsourcing to adapt to rapid changes, to reduce the effect of fluctuations, and to take advantage of know-how and current technologies. Global outsourcing allows firms to develop their core competencies and expand their flexibility.

This study reviews the literature on global outsourcing. There has been a great deal of research conducted on global outsourcing within information technology (IT) and service systems. To the best of our knowledge, there have not been many studies on the global outsourcing of manufacturing or production systems. Therefore, this study focused on the global outsourcing of these systems. This paper provides a basic definition of global outsourcing and analyses global outsourcing as either an opportunity or a threat. Furthermore, this study introduces the differences between local and global outsourcing. The methods used to make global outsourcing decisions and the decision criteria used in global outsourcing are also presented in the study.

2. Global outsourcing

Outsourcing is one of the responsibilities of purchasing departments and plays a critical role in an organisation's survival and growth. Materials sourced from outside rather than produced by in-house facilities will influence service quality and profitability (Zeng, 2000). Despite the ongoing debate over the benefits and risks of outsourcing for businesses, outsourcing has become a common approach that purchasing managers cannot ignore. Indeed, outsourcing has exhibited dramatic growth in recent years.

Since the 1980s, the opinions of purchasing managers and management scholars regarding optimal firm sourcing strategies have changed significantly in two respects. First, firms have replaced vertical integration with increased outsourcing based on the conviction that lean, flexible enterprises that focus on their core competencies perform better (Quinn & Hilmer, 1994). Second, in the era of globalisation of the 1990s, enterprises were advised to use the principles of "global outsourcing" to pick the best global suppliers and thereby to improve their competitiveness (Monczka & Trent, 1991; Quinn & Hilmer, 1994). Implementing both or either of these strategies has important consequences for the structure and performance of multinational corporations.

Given the rapidly shifting contours of the global economy, companies need to be able to anticipate changes in the economics and geography of outsourcing. Forward-thinking companies are making their value chains more elastic and their organisations more flexible. Furthermore, with the decline of the vertically integrated business model, outsourcing is evolving into a strategic process used to organize and fine-tune the value chain.

Supplier selection and evaluation play an important role in reducing the cost and time to market while improving product quality. Supplier selection can significantly affect manufacturing costs and production lead time. Although several techniques and models have been used to select and evaluate suppliers, each technique or model has its own strengths and

limitations in different situations. Therefore, it is necessary to further improve the performance and effectiveness of supplier selection and evaluation in manufacturing in different contexts.

According to Boer et al. (2001), the purchasing function and purchasing decisions are becoming increasingly important. As organisations become more dependent on suppliers, the direct and indirect consequences of poor decision making are becoming more severe. In addition, several developments have further complicated purchasing decision making. The globalisation of trade and the Internet have expanded the choice sets of purchasers. Changing customer preferences requires broader and more rapid supplier selection.

Outsourcing can be defined as the provision of services by an outside company when those services were previously provided by the home company. In other words, outsourcing involves focusing on a firm's core competencies while allowing services that require other competencies to be provided by other expert enterprises. Outsourcing is a strategic decision in which the buying firm attempts to establish a long-term business relationship with its suppliers (Zeng, 2000).

It is not always easy to generate precise rules for the supplier selection process, but certain elements of the process remain constant. These elements may be identified based on intuition, experience, common sense, or inexplicable rules. Supplier ratings, for example, are usually generated via subjective criteria, based on personal experience and beliefs, based on the available information, and/or sometimes using techniques and algorithms intended to support the decision-making process (Albino & Garavelli, 1998). The key to enhancing the quality of decision making in the supplier selection process is to employ the powerful computer-related concepts, tools and techniques that have become available in recent years (Wei et al., 1997).

In today's competitive global markets, consumers look for the highest quality products at the lowest prices, regardless of where they are produced. This trend is continuously increasing the significance of global markets and forcing enterprises to enter global markets. Furthermore, increasing pressure from foreign competitors in domestic markets is forcing companies to analyse the available alternatives as they seek to remain competitive.

Monczka & Trent (1991) defined global outsourcing as the integration and coordination of procurement requirements across worldwide business units. As such, outsourcing might involve objects, processes, technologies and suppliers. Kotabe (1998) defined global outsourcing as the purchase of finished products or works-in-process from global suppliers. Under this definition, firms may purchase not only products themselves but also the services required to make these products marketable.

Narasimhan et al. (2006) reported that the strategic objectives of global outsourcing are different from those of traditional purchasing. Whereas traditional purchasing focuses on minimizing procurement costs, strategic global outsourcing considers quality, delivery, responsiveness and innovativeness in addition to costs. Sourcing strategies should be incorporated into the operating strategies of buying firms to support or even improve their competitive advantage (Tam et al., 2007). Internal or global outsourcing plays an important role in firm competitiveness and growth (Zeng, 2000).

Flexibility appears to be an important driver of global outsourcing strategy. Firms need to react more quickly to customer requirements, and global outsourcing is seen as a way to

accomplish this. Global outsourcing may also be perceived as a way to reduce firm risk by sharing it with suppliers and simultaneously acquire the positive attributes of those suppliers (Kremic et al., 2006). The ultimate objective of global outsourcing strategy is for the firm to exploit both its own and suppliers' competitive advantage and to utilise the comparative location advantages of various countries in global competition (Kotabe & Murray, 2004).

The importance of global outsourcing has increased dramatically. Although firms may outsource for cost-related reasons, there are no guarantees that expected savings will be achieved (Kremic et al., 2006).

Global outsourcing strategy requires close coordination between the research and development, manufacturing, and marketing activities of a firm. Conflicts will most likely exist between the differing objectives of these divisions. For instance, excessive product modification and development intended to satisfy a set of ever-changing customer needs will negatively affect manufacturing efficiency and increase costs. Similarly, excessive product standardization intended to lower manufacturing costs will likely yield lower customer satisfaction levels (Kotabe & Murray, 2004). Therefore, effective global outsourcing requires firms to develop a balance between effective manufacturing and flexible marketing.

Global outsourcing is an expected response to competition. However, the choice of where to obtain goods and services is not an obvious decision. Rather, it is subject to continual reevaluation (Carter et al., 2008). Outsourcing strategy is an essential part of the value chain for corporate activities. Outsourcing strategy both affects and is affected by the other aspects of the supply chain (Kotabe et al., 2008).

The degree of internationalization of production and sourcing is negatively related to the size of the focal country. According to Mol et al. (2005) and Buckley & Pearce (1979) when working with a sample of 156 Japanese, French, Swiss, and "Benelux" companies, found the ratios of global outsourcing to final markets to be 2.4%, 8.0%, 91.6%, and 70.7%, respectively.

As Levy (2005) noted, global outsourcing is highly related to efforts to increase the organizational and technological capacity of firms. Mol et al. (2005) described global outsourcing as balancing international production cost advantage and domestic transaction cost advantage rather than characterising it as a performance-enhancing tool. The major operational problems in global outsourcing, as described by Kotabe et al. (2008), are logistics, inventory management, distance, nationalism, and a lack of working knowledge about foreign business practices.

Global outsourcing has become a popular subject of study in both managerial practice and the academic literature. Conflicting results have been presented in the relevant studies. The global outsourcing strategy literature offers arguments both for and against global outsourcing strategy (Kotabe et al., 2008).

According to Gottfredson et al. (2005), a recent survey of large and medium-sized companies indicates that 82% of large firms in Europe, Asia, and North America have outsourcing arrangements of some kind and that 51% use global outsourcers. However, nearly 50% say that the results achieved by their outsourcing programs have fallen short of expectations. What is more, only 10% are highly satisfied with the decreases in costs that they have achieved, and a mere 6% are highly satisfied with the results of their global

outsourcing efforts overall. Mol et al. (2005) stated that global outsourcing can help a firm to enhance its competitive advantage in other markets or to improve its legitimacy. However, multinational supply chains are facing significant managerial problems related to international relations.

According to Kremic et al. (2006), the expected benefits of outsourcing may include providing the same or a better service at a lower overall cost, increased flexibility and/or quality, access to the latest technology and the best talent, and the ability to refocus scarce resources on core functions.

A lack of common methodology is believed to cause some outsourcing failures. Lonsdale (1999) also supported this thinking, suggesting that global outsourcing failures are not due to inherent problems with outsourcing but rather stem from a lack of guiding methodology for managers. Kremic et al. (2006) indicated that global outsourcing has potential pitfalls for strategic reasons. Gillett (1994) noted that enterprises may lose their core competences if they are not careful. If firms outsource the wrong functions, they may develop gaps in their learning or knowledge base that may hinder their ability to capitalise on future opportunities (Kremic et al., 2006). Literature also indicated that in industries with complex technologies and systems, internal synergy may decrease when some functions are outsourced. This could result in lower productivity or efficiency levels for the remaining functions (Quinn & Hilmer, 1994).

Kremic et al. (2006) discussed factors that may impact global outsourcing decisions. These factors are shown below:

- *Core competences*: "Core competences" can be described as a strategic factor that firms use to sustain competitive advantage. Quinn (1999) suggested that there are "core activities" that one firm will perform better than any other firm. In general, a function that is more core to an organization is less likely to be globally outsourced.
- *Critical knowledge:* Some data or knowledge must be under the control of the firm. In general, if a function provides critical knowledge, it is less likely to be globally outsourced.
- *Impact on quality:* The quality of the firm's services establishes its reputation and can create demand. If a firm is currently recognised in the industry for providing a high level of quality in a particular area, then global outsourcing in that area can harm quality. Quality is a relevant factor and can have either a positive or a negative influence on global outsourcing decisions. (Anderson, 1997).
- *Flexibility:* Flexibility includes demand flexibility, process flexibility and resource flexibility. Antonucci et al. (1998) noted that long contracts outsourced into a limited market have sometimes decreased flexibility. However, large enterprises may improve their flexibility via global outsourcing. In the literature, global outsourcing is used as a strategic driver to increase flexibility.
- *Cost:* In the literature, cost is the main reason for global outsourcing decisions. If the firm prefers to outsource a function for cost reasons, then it can be assumed that the current expenditures associated with that function are higher than the expected cost of purchasing the service. However, whether savings will actually accrue from global outsourcing is extremely uncertain. Sometimes, the reported cost savings may not be as high as was expected.

- *Characteristics of the functions outsourced or kept in-house:* In general, the more complex a function the less of a candidate it is for global outsourcing.
- *Integration*: Integration refers to the degree to which function is linked to other functions and systems within the enterprise. The more integrated the function, the more interactions and communication channels there are to maintain and monitor. Therefore, a function that is highly integrated is less of a candidate for global outsourcing.

Firms establish and execute global outsourcing plans in an effort to match competitors' attempts at outsourcing; improve non-competitive cost structures; focus on core competencies; reduce capital investment and overall fixed costs; achieve cost-competitive growth within their supply base for goods, services and technologies in the value chain; and establish future sales footprints in low-cost countries by outsourcing basic goods or business processes (Carter et al., 2008). An effective global sourcing strategy requires continual efforts to streamline manufacturing without sacrificing marketing flexibility (Kotabe & Murray, 2004).

According to the literature, firms prefer global outsourcing for the following reasons:

- *Strategic focus / reduction of assets:* Through global outsourcing activities, an enterprise can reduce its level of asset investment in manufacturing and related areas. Furthermore, global outsourcing can help management teams to redirect their attention to core competencies rather than focusing on maintaining a wide range of competencies (Kotabe et al., 2008).
- *Supplementary power / lower production costs:* Global suppliers are highly specialized in their own business, which lowers both their production costs for those of the firms that are outsourcing their business to them. Therefore, global outsourcing can decrease overall costs if firms globally outsource non-core activities (Quinn, 1999)
- *Strategic flexibility:* Global outsourcing can enhance a firm's strategic flexibility (Harris et al., 1998). If a firm is faced with a crisis in an external environment, it can simply change the volume of globally outsourced products it purchases. If the same product is outsourced to another firm within the home country, the firm will need to pay high reconstructing costs and may not respond quickly to the external environment.
- *Relationship:* Certain relationships with global suppliers can deliver competitive advantage for firms (Kotabe et al., 2008). Misunderstandings between buyer and suppliers may decrease a firm's level of performance (Carter et al., 2008).

Kotabe et al. (2008) suggested that an inverted-U shaped relationship exists between profitability and the degree of outsourcing. On the inverted-U shaped curve, there is an optimal degree of outsourcing for a firm. If the firm moves' away from this optimal point, profitability decreases dramatically.

In global outsourcing strategy, there are also some disadvantages of increasing total product cost. Unfortunately, through global outsourcing, the cost of transportation, communication and information-sharing may increase. Domestic purchasing strategies require only short lead times because they reduce communication and transportation time requirements. The literature suggests that this may be the key reason why some enterprises do not prefer global outsourcing (Dana et al., 2007).

The literature suggests some disadvantages of global outsourcing. These disadvantages can be seen below:

- *The scope of the functions:* If there are important interfaces between activities, decoupling them into separate activities performed by separate suppliers will generate less than optimal results and potential integration problems (Kotabe et al., 2008).
- *Competition loss:* Firms that engage in excessive outsourcing are essentially hollowing out their competitive base (Kotabe, 1998). Furthermore, an enterprise may lose negotiating power with its suppliers because the capabilities of the latter will increase relative to those of the former (Kotabe et al., 2008).
- *Opportunistic behaviour:* Global suppliers may behave opportunistically. Opportunistic behaviour allows a supplier to extract more rents from the relationship than it would normally do, for example, by supplying products of a lower quality than was previously agreed upon or by withholding information regarding changes in production costs (Kotabe et al., 2008).
- *Limited learning and innovation:* Suppliers may capture the critical knowledge by performing the activity. This situation is always a problem between buyer and supplier because both try to obtain all the individual benefits. Appropriation of innovations and rents is always a problem in such a complex buyer–supplier relationships (Nooteboom, 1999)
- *Negative impact of exchange rates:* Higher procurement costs can be seen by the negative impact of fluctuating exchange rates. During the Asian financial crisis, many foreign firms operating in Asian countries learned an invaluable lesson on the negative impact of fluctuating currency exchange rates on their procurement costs and profitability (Kotabe et al., 2008).

According to Kremic et al. (2006), the global outsourcing literature has referenced the following risks of global outsourcing: the potential for both unrealized savings and increased costs, employee morale problems, over-dependence on suppliers, lost corporate knowledge and future opportunities, and under-satisfied customers. Additionally, global outsourcing may fail because the requirements of the relationship are inadequately defined because of a poor contract, a lack of guidance regarding planning or managing outsourcing initiatives, or poor supplier relations. Dana et al. (2007) cited lower production costs as the key advantage of a global outsourcing strategy, with poor control of quality being the main disadvantage.

Lowe et al. (2002) addressed two risks of global outsourcing: fluctuations in exchange rates and relative rates of inflation in different countries. The impact of fluctuations in exchange rates can be analyzed in different ways, and these disparate analyses can yield different results. Brush et al. (1999) stated that many enterprises do not discuss exchange rates as a key factor in global outsourcing. Kouvelis (1999) stated that because of the high cost of switching global suppliers, purchasing managers do not switch suppliers until the effect of exchange rate fluctuation is extremely high. Vidal & Goetschalckx (2000) indicated that the impact of exchange rate fluctuation on overall cost is high.

Under competitive pressure, many U.S. multinational companies globally outsource components and finished products to countries such as China, South Korea, Taiwan, Singapore, Hong Kong, and Mexico. Those countries are also known as low-cost countries (Kotabe & Murray, 2004). Firms in the US and the EU make different choices when selecting global outsourcing locations. In the US, 23% of enterprises prefer China, 14% prefer India, 10% prefer Mexico, 9% prefer Argentina and 8% prefer Brazil. In the EU, 19%

prefer China, 14% prefer the Czech Republic, 12% prefer Poland and 10% prefer Hungary (Timmermans, 2005). The preferences of US and EU firms indicate what is known as "low-cost country sourcing" in the literature. Low-cost country sourcing entails the sourcing of services or functions from low-cost countries with lower labour and material costs. In recent years, low-cost country sourcing has created opportunities for purchasing managers (Carter et al., 2008).

Sourcing from global suppliers can be risky, especially when the projected quality of the outsourced products is unknown. Motwani et al. (1999) noted that as the low-cost countries develop, the quality of the products produced in those countries will likely increase. As a result, firms that choose to forge relationships in these low-cost countries now through sourcing and purchasing may have an edge in these markets in the future. Although they may encounter challenges at first, the advantages that they enjoy in the future could outweigh these problems. This may be especially true for firms that aim to be truly global. Although the main factor driving global outsourcing is lower costs, experienced purchasing managers consider many factors simultaneously in making the decision to outsource internationally. According to the relevant literature, lower labour cost is not the key factor for many US enterprises that engage in global/domestic outsourcing (Sarkis & Talluri, 2002).

3. Outsourcing methods in literature

Outsourcing has been widely discussed in the literature. There are several papers on supplier selection and global outsourcing in information technology (IT) and for service systems. To the best of our knowledge, few studies have been conducted on global outsourcing in manufacturing or production systems. This section is divided into two subsections: one that addresses general supplier selection methods in the literature and another that addresses global outsourcing methods in the literature.

3.1 General supplier selection methods in the literature

There are several methods of general supplier selection presented in the literature. Categorical methods are qualitative models. Based on the buyer's experience and historical data, suppliers are evaluated using a particular set of criteria. The evaluations involve categorizing the supplier's performance as 'positive', 'neutral' or 'negative' with reference to a series of criteria (Boer et al., 2001). After a supplier has been rated for all the criteria, the buyer provides an overall rating, allowing the suppliers to be sorted into three categories.

Data Envelopment Analysis (DEA) is concerned with the efficiency of decision making. The DEA method helps buyers to classify suppliers into two categories: efficient suppliers and inefficient suppliers. Liu et al. (2000) used DEA in the supplier selection process. They evaluated the overall performance of suppliers using DEA. Saen (2007) used IDEA (Imprecise Data Envelopment Analysis) to select the best suppliers based on both cardinal and ordinal data. Wu et al. (2009) proposed an augmented DEA approach to supplier selection. Songhori et al. (2011) presented a structured framework for helping decision makers to select the best suppliers for their firm using DEA.

Cluster Analysis (CA) is a class of statistical techniques that can be used with data that exhibit "natural" groupings (Boer et al., 2001).

Case-Based Reasoning systems (CBR) combine a cognitive model describing how people use and reason from past experience with a technology for finding and presenting experience (Choy et al., 2003-a). Choy et al. (2002-b) enhanced a CBR-based supplier selection tool by combining the Supplier Management Network (SMN) and the Supplier Selection Workflow (SSW). Choy et al. (2005) used CBR to select suppliers in a new product development process.

In linear weighting, the criteria are weighted, and the criterion with the largest weight has the greatest importance. The score for a particular supplier is based on the criteria and their different levels of importance, and some criteria have a high degree of precision. Ghodsypour & O'Brien (1998) integrated the Analytic Hierarchy Process (AHP) and linear programming to consider both tangible and intangible factors in choosing the best suppliers and the optimum order quantities. Lee et al. (2001) used only the AHP for supplier selection. They determined the supplier selection criteria based on purchasing strategy and criterion weights using the AHP. Liu & Hai (2005) used DEA to determine the supplier selection criteria. They then interviewed 60 administrators to determine the priority level of the criteria and used the AHP to select suppliers. Ting & Cho (2008) presented a two-step decision-making procedure. They used the AHP to select a set of candidate suppliers for a firm and then used a Multi-Objective Linear Programming (MOLP) model to determine the optimal allocation of order quantities to those suppliers. Boer et al. (1998) used the ELECTRE 1 technique to evaluate the five supplier candidates. Xia & Wu (2007) used an integrated approach to the AHP, which was improved using rough set theory and multi-objective mixed integer programming to simultaneously determine the number of suppliers to employ and the order quantities to be allocated to these suppliers in the case of multiple sourcing and multiple products. Multiple criteria and supplier capacity constraints were both taken into account. Wang et al. (2004) used an integrated AHP and preemptive goal programming (PGP)-based multi-criteria decision-making process to analyze both the qualitative and quantitative factors guiding supplier selection. Liu and Hai (2005) compared the use of the Voting Analytic Hierarchy Process (VAHP) and the use of the AHP for supplier selection. Chan & Kumar (2007) identified some of the important decision criteria, including risk factors in developing an efficient system of global supplier selection. They used the Fuzzy Extended Analytic Hierarchy Process (FEAHP) to select suppliers. Chan & Chan (2010) used an AHP-based model to solve the supplier evaluation and selection problem for the fashion industry. Kumar & Roy (2011) proposed the use of a rule-based model with the AHP to aid decision makers in supplier evaluation and selection.

Total Cost of Ownership models (TCO) include all costs related to the supplier selection process that are incurred during a purchased item's life cycle. Degraeve & Roodhooft (1999) evaluated suppliers based on quality, price and delivery performance using TCO. They emphasised that uncertainty related to demand, delivery, quality and price must be reflected in the decision problem. Ramanathan (2007) proposed the integrated DEA-TCO-AHP model for supplier selection.

According to Boer et al. (2001), Mathematical Programming models (MP) allows the decision maker to formulate the decision problem in terms of a mathematical objective function that must subsequently be maximized and minimized by varying the values of the variables in the objective function. MP models are more objective than rating models

because they force the decision maker to explicitly state the objective function, but MP models often only consider more quantitative criteria. Karpak et al. (1999) developed a supplier selection tool that minimizing costs and maximizing quality reliability. Ghodsypour & O'Brien (1998) integrated the AHP and Linear Programming (LP) models. Their model presented a systematic approach that took into account both qualitative and quantitative criteria. They also developed sensitivity algorithms for different scenarios. Ghodsypour & O'Brien (2001) used mixed integer programming, taking into account the total cost of logistics. Degraeve & Roodhooft (2000) computed the purchasing cost associated with different purchasing strategies using MP. Barla (2003) reduced the number of suppliers from 58 to 10 using the multi-criteria selection method. Hong et al. (2005) decomposed the supplier selection process into two steps. They used cluster analysis to pre-select suppliers and then used MP to select the most appropriate supplier. Yang et al. (2007) studied a supplier selection problem in which a buyer facing random demand must decide the quantity of products it will order from a set of suppliers with different yields and prices. They provided the mathematical formulation for the buyer's profit maximization problem and proposed a solution method based on combining the active set method and the Newton search procedure. Kheljani et al. (2007) considered the issue of coordination between one buyer and multiple potential suppliers in the supplier selection process. In contrast, in the objective function in the model, the total cost of the supply chain is minimized in addition to the buyer's cost. The total cost of the supply chain includes both types of costs. The model was solved using mixed-integer nonlinear programming. Liao & Rittscher (2007) developed a multi-objective programming model, integrating supplier selection to procure lot sizing and carrier selection decisions for a single purchasing item over multiple planning periods during which the demand quantities are known but inconstant. Rajan et al. (2010) proposed a supplier selection model for use in a multiproduct, multi-vendor environment based on an integer linear programming model.

Artificial intelligence (AI)-based systems are computer-aided systems that can be trained using data on purchasing experience or historical data. The available types of AI-based supplier selection applications include Neural Networks (NN) and Expert Systems (ES). One of the important advantages of the NN method is that the method does not require the formulation of the decision-making process. As a result, NNs can cope better with complexity and uncertainty than traditional methods can; these systems are designed to be more similar to human judgment in their functioning. The system user must provide the NN with the properties of the current case. The NN provides information to the user based on what it has learned from the historical data. Albino & Garavelli (1998) further developed the neural network-based decision support system for subcontractor ratings in construction firms. The system includes a back-propagation algorithm. The constructed network is trained using examples so that the system does not require decision-making rules. Vokurka et al. (1996) and Wei et al. (1997) developed an expert system for supporting the supplier selection process. Chen et al. (2006) used linguistic values to assess the ratings and weights of various supplier selection factors. These linguistic ratings were expressed using trapezoidal or triangular fuzzy numbers. Then, they proposed the use of a hierarchy Multiple Criteria Decision-Making (MCDM) model based on fuzzy-sets theory to address supplier selection problems in the supply chain system.

Wang & Che (2007) presented an integrated assessment model for manufacturers to use to solve complex product configuration change problems efficiently and effectively. The model

made it possible to determine what fundamental supplier combination would best minimize the cost–quality score if and when proposed by the customer and/or engineer. The researchers combined fuzzy theory, T transformation technology, and genetic algorithms. Liao & Rittscher (2007) studied the supplier selection problem under stochastic demand conditions. Stochastic supplier selection is determined by simultaneously considering the total cost, the quality rejection rate, the late delivery rate and the flexibility rate while also taking into account constraints on demand satisfaction and capacity. The researchers used GA to solve the problem. Wang (2008) developed a decision-making procedure that could be used for supplier selection when product part modifications were necessary. The aim of the research was to determine acceptable near-optimal solutions within a short period of time using a solution-finding model based on Genetic Algorithms (GA). Aksoy & Öztürk (2011) presented a neural network-based supplier selection and supplier performance evaluation system for use in a *just-in-time* (JIT) production environment. Chang et al. (2011) proposed the use of a fuzzy decision-making method to identify evaluation factors that could be used for supplier selection. Jiang & Chan (2011) proposed a method of using a fuzzy set theory with twenty criteria to evaluate and select suppliers.

3.2 Global outsourcing methods in the literature

Canel & Khumawala (1996) proposed a 0-1 mixed integer programming formulation model for international facilities location problems. They determined the location of the international facility and the capacity of that facility. The objective of the model is to maximize the after-tax profit. The proposed model includes different costs, including investment cost, fixed costs, transportation costs, shortage costs and holding costs. The researchers developed two different mathematical models: one for a capacitated case and the other for an uncapacitated case. They used demand and price as the deterministic parameters. Their research could be extended by relaxing the assumptions of deterministic demand, prices, costs, etc. within the problem and treating those factors as stochastic parameters. Huchzermeier & Cohen (1996) developed a stochastic dynamic programming formulation for evaluating global manufacturing strategy options while taking switching costs into account in a stochastic exchange-rate environment. The objective of the model is to maximize after-tax profits. The model includes taxes, fixed and variable costs, capacity and exchange rates. The decision variable in the model is production quantities. The researchers developed different scenarios for different exchange rates. Each model has its own solution. However, the model does not include qualitative parameters. Canel & Khumawala (1997) presented an efficient branch-and-bound procedure for solving uncapacitated, multi-period international facilities location problems. The branch-and-bound problems can be solved using LINDO. The parameters of the model are assumed to be deterministic. Dasu & Torre (1997) presented a model for planning a global supply network for a multinational yarn manufacturer. The objective of the model is to maximize the overall profits of the global supply chain network. The model includes tariffs, exchange rates and transportation costs. The proposed model is non-linear, but the authors make some assumptions in the model to give it a linear structure.

Kouvelis & Gutierrez (1997) solved the newsvendor problem in the textile industry for "style goods". The proposed model determines the production quantities while minimizing shortages and holding costs for a multiple-location manufacturer in a multiple-location market. Shortage costs in this context include the costs associated with

lost sales, and holding costs includes the cost associated with excess inventory left over after the selling season. The model includes transportation costs, exchange rate uncertainty and stochastic demand uncertainty, but the model does not include global cost factors such as taxes and tariffs. The study evaluates alternative plans for supply chain design and centralized and decentralized production decision-making mechanisms. The researchers also stated that centralized production decision-making is superior to decentralized production decision-making but that application and control problems are associated with centralized coordination. The proposed model can be easily implemented by purchasing managers. The researchers noted that the production decision-making process can be affected by the uncertainty of global markets and that models with stochastic parameters (such as models for analysing political risk and exchange rate fluctuations) can be used in future research. Munson & Rosenblatt (1997) described local content rules and developed models for selecting global suppliers while satisfying local content provisions. The parameters of the model are deterministic, and the penalty for breaking local content rules is very high. The researchers used the mixed integer programming method to solve the model. The decision variables for the model are the selection of the global supplier and the allocation of orders among the selected suppliers. The objective of the model is to minimize purchasing, production, transportation and fixed costs. The model considers only costs and local content rules. The model does not take into account quantitative parameters or exchange rates.

Coman & Ronen (2000), formulated the global outsourcing problem as a linear programming (LP) problem, identified an analytical solution, and compared that solution with the solutions obtained using the standard cost accounting model and the theory of constraints. The decision variable for the model is the production quantity in terms of preference to manufacture versus preference to outsource. The solution attained indicated that linear programming yielded better results than the two other methods (standard cost accounting and the theory of constraints).

Canel & Khumawala (2001) solved an international facilities location problem using the heuristic method. They developed 12 heuristic methods, but their models do not include quantitative parameters or exchange rates. Vidal & Goetschalckx (2001) presented a model for optimizing global supply that maximizes after-tax profits for a multinational corporation. The model includes transfer prices and the allocation of transportation costs as explicit decision variables. Transfer prices and flows between multinational facilities are calculated in the model. The model does not address the supplier selection problem. The model entails a non-convex optimization problem with a linear objective function, a set of linear constraints, and a set of bilinear constraints. Because the resulting problem is NP hard, the researchers developed a heuristic successive linear programming solution procedure.

Canel & Das (2002) proposed the use of a 0-1 mixed integer programming model to determine for particular time periods which countries a firm should choose as the locations of its global manufacturing facilities. The model was also used to determine the quantity to be produced at each global manufacturing facility and the quantities to be shipped from the global facilities to customers. The study had two goals: to determine the location of the global manufacturing facility and to develop a mathematical model that included global marketing and manufacturing factors. The proposed model does not include quantitative parameters or take exchange rates into account. Hadjinicola & Kumar

(2002) presented a model that includes manufacturing factors together with factory location, inventory, economies of scale, product design, and postponement. In the study, different manufacturing and marketing strategies were evaluated for two different countries. The proposed model is a descriptive model; therefore, the decision variables are not entirely clear. The model can be used to evaluate different manufacturing and marketing strategies in terms of cost and profit functions. The model also includes the effect of exchange rates. Lowe et al. (2002), proposed a model that included exchange rates, using it to choose the location and capacity of global manufacturing facilities in the chemical industry. They analysed data from the year 1982, setting the production capacity, purchasing volume, capacity, fixed and variable costs, transportation costs and taxes for each production facility. To take into account the effect of exchange rates, they reviewed historical data from 22 years and constructed nine different scenarios, calculating the costs for each scenario. They developed a two-stage method of solving the problem. The first stage is a short planning period (as an example 1 year), and the second stage is an optional stage that can be used for long-term planning. However, for longer periods, the first stage can also be repeatedly used.

Teng & Jaramillo (2005) presented a model for global supplier selection in the textile industry. They weighted their criteria and sub-criteria based on expert opinions. The overall scores for the global supplier are calculated by multiplying the score and the weight of the criteria. Goh et al. (2007) presented a stochastic model of the multi-stage global supply chain network problem, incorporating a set of related risks: supply, demand, exchange, and disruption. The objective of the model is to maximize after-tax profits. The model includes demand uncertainty, exchange rates, taxes and tariffs. The researchers composed different scenarios for demand uncertainty and exchange rates and presented different clusters of stochastic parameters. Because the proposed model is a convex linear model, the authors relaxed certain parameters to make the problem linear, but theirs is a descriptive model that is not applied to a real-world scenario.

Lin et al. (2007) proposed the use of a decision model to support global decision making. The model uses two multiple-criteria decision aid techniques (the AHP and PROMETHEE II) and incorporates multiple dimensions (infrastructure, country risk, government policy, value of human capital and cost) into a sensitivity analysis. The authors used the AHP to determine the weight of the criteria and used PROMETHEE to select global suppliers based on weighted criteria. Kumar & Arbi (2008) used a simulation model to forecast lead time and total cost in a global supply environment. Based on their results, it seems that important cost savings can be attained through global outsourcing. However, lead time is an essential factor in real life. The authors stated that global outsourcing is not a viable way to meet short-term market demands but that for large seasonal orders, global outsourcing can be a significant cost-saver. Ray et al. (2008) described the cause of the outsourcing problem, formulated it as a linear programming problem, developed a corresponding function, and offered a simplified criterion for ordering products in terms of preference for manufacturing versus preference for global outsourcing. The authors used a hybrid approach, incorporating the Hurwicz criterion, the theory of constraints (TOC) and linear programming. Some weaknesses of the proposed method are that it is difficult to change the traditional cost accounting system, that it would take time to implement the approach, and that people may be reluctant to use the approach because it requires them to justify their preferences rather than simply saying yes or no. It also requires a new decision-making process.

Wang et al. (2008a) divided firm activities into core activities, core-close activities, core-distinct activities and disposable activities. They used the ELECTRE 1 method to determine which of those four activities can be globally outsourced. Wang et al. (2008b) presented a model for the global outsourcing of logistics activities. They determined the evaluation criteria, ranked the criteria using the AHP and constructed a method using PROMETHEE for global supplier selection. Feng & Wu (2009) presented several tax-saving approaches and developed a tax savings model for maximizing after-tax profit from logistics activities by global manufacturers. Using this model, logistics activities are evaluated in terms of tax savings. It has been observed that the tax saving model has dramatically increased manufacturer profits. The suppliers are selected based on tax savings, whereas any other criteria are disregarded.

Ren et al. (2009) treated global supply chains as agile supply chains and explained agility as the ability to change and adapt quickly to changing circumstances. The model facilitates supplier selection for agile supply chains. The authors determined 10 criteria and 32 sub-criteria for supplier selection. The weights of the criteria were determined based on expert opinions and used to rank the suppliers. Perron et al. (2010) presented a mathematical model for multinational enterprises to use to determine transfer prices and the flow of goods between global facilities. The model includes bilinear constraints; therefore, the authors relaxed the constraints to simplify the model. They developed a branch-and-cut algorithm and two different heuristics to solve the model. The heuristic methods can be summarised as follows:

1. *Variable Neighbour Search Method (VNS):* This method is based on the concept of systematic changes in neighbourhoods during the search. VNS explores nearby and then increasingly far neighbourhoods for the best-known solution in a probabilistic fashion. Therefore, often favourable characteristics of the best-known solution will be kept and used to obtain promising neighbouring solutions. VNS was repeatedly used with a local search routine to transition from these neighbouring solutions to local optima.
2. *Alternate Heuristic (ALT):* Given two subsets of variables, the ALT heuristic solves the problem by alternately fixing the variables of one of the subsets. The subsets of variables must be such that the model becomes linear when fixing the variables of one of the subsets. When one of these linear programs is solved, its solution becomes a set of parameters in the other one. ALT can be converging to local optima.

The objective of the model is to maximize after-tax profit given taxes, capacity, transfer prices and demand. Satisfactory results were reported when small problems were solved using heuristic methods.

4. Outsourcing decision criteria

To be competitive in the global market, firms must attain the knowledge necessary to systematically evaluate all potential suppliers and select the most suitable ones. The factors most often used in current supplier evaluation are quality, supplier certification, facilities, continuous improvement, physical distribution and channel relationships (Weber, 1991).

In the supplier selection process, it is not always easy to recognize precise rules, but there is, in general, a coherent way to solve the problem. This coherence can be rooted in intuition, experience, common sense, or inexplicable rules. Supplier rating is then a problem usually solved by subjective criteria, based on personal experiences and beliefs, on the available information and, sometimes, on techniques and algorithms supporting the decision process (Albino & Garavelli, 1998). The key to enhancing the quality of decision making in supplier selection include the powerful computer-related concepts, tools and techniques that have become available in recent years (Wei et al., 1997).

Chao et al. (1993) concluded that quality and on-time delivery are the most important attributes of purchasing performance. Ghodsypour & O'Brien (1998) agreed that cost, quality and service are the three main factors that should influence supplier selection. Brigs (1994) stated that joint development, culture, forward engineering, trust, supply chain management, quality and communication are the key requirements of supplier partnerships apart from optimum cost. Petroni & Braglia (2000) evaluated the relative performance of suppliers with multiple outputs and inputs, considering management, production facilities, technology, price, quality, and delivery compliance. Wei et al. (1997) examined factors such as supply history, product price, technological ability and transport cost.

Making sourcing decisions based on delivery speed and cost is the best way to improve performance (Tan 2001). Global outsourcing reduces the fixed investment costs of a firm in its own economic region. Today, in making global outsourcing decisions, many enterprises also consider quality, reliability, and technology when evaluating the components and products to be procured (Kotabe & Murray, 2004) rather than only considering price. In developing global outsourcing strategies, firms must consider not only manufacturing costs, the costs of various resources, and exchange rate fluctuations but also the availability of infrastructure (including transportation, communications, and energy), industrial and cultural environments, and ease of working with foreign host governments, among others (Kotabe et al., 2008).

Several factors influence global outsourcing decisions. Canel & Das (2002) outlined the factors that most commonly influence global manufacturing facility locations. Those factors are labour and other production inputs, political stability, the attitude of the host government towards foreign investment, host government tax and trade policies, proximity to major markets, access to transportation and the existence of other competitors. Choy et al. (2005) stated that good customer–supplier relationships are necessary for an organization to respond to dynamic and unpredictable changes. They considered price, delivery, quality, innovation, technology level, culture, commercial awareness, production flexibility, ease of communication and current reputation when selecting and evaluating suppliers. Teng & Jaramillo (2005) used five main criteria and 20 sub-criteria for global supplier selection in the textile-apparel industry. Those criteria are delivery (geographic location, freight terms, trade restrictions and total order lead time), flexibility (capacity, inventory availability, information sharing, negotiability and customization), cost (supplier selling price, internal costs, ordering and invoicing), quality (continuous improvement programs, certification, customer service and the percentage of on-time shipments), reliability (feelings of trust, the national political situation, the status of the currency exchange and warranty policies).

Narasimhan et al. (2006) composed a model, for global supplier selection and order allocation and considered criteria such as direct product cost, the indirect cost of coordination, quality, delivery reliability and complexity of the supply base. Lin et al. (2007) used infrastructure, country risk, government policy, human capital and cost when evaluating global suppliers. Carter et al. (2008) analysed the low-cost countries and their capabilities. They evaluated the factors such as labour cost, work ethic, intellectual property, market attraction, delivery reliability, reliable transportation, transportation costs, government support for business, political stability, flexibility, predictable border crossing and corruption in 12 different low-cost countries using perceptual mapping. They stated that experienced purchasing managers not only consider cost but also conduct a multi-criteria evaluation of global outsourcing decisions.

Au & Wong (2008) identified four main categories of factors from the literature: cost (labour costs, material costs and transportation costs), product quality (technological capabilities, reliability and trust), time to market (geographical proximity and transportation time) and country factors, including both internal country factors (such as infrastructure and ethical issues) and external country factors (such as the political and economical situation and social, linguistic and cultural differences).

Chan et al. (2008) examined the decision variables influencing global supplier selection and identified five main criteria and 19 sub-criteria: total cost of ownership (product cost, total logistics management cost, tariffs and taxes), product quality (conformance with specifications, product reliability, quality assessment techniques and process capabilities), service performance (delivery reliability, information sharing, flexibility, responsiveness and customer responses), supplier background (technological capabilities, financial status, facilities, infrastructure and market reputation), and risk factors (geographical location, political stability and foreign policies, exchange rates and economic position, terrorism and the crime rate).

Ku et al. (2010) identified the following criteria as important to global supplier selection: cost (product price, freight costs and custom duties), quality (rejection rate, process capabilities and quality assessments), service (on-time delivery, technological support, responses to changes and ease of communication), risk (geographical location, political stability and the status of the economy). Ku et al. (2010) suggested that qualitative criteria (e.g., the characteristics of the purchased items) be considered in future research.

5. Conclusion

Manufacturers must be the forerunners to be competitive in today's global markets. That is why manufacturers must keep in touch with the dynamic requirements of the market and be receptive to reforms. An increasing proportion of raw materials and work-in-process (WIP) for manufactured products is sourced globally by multinational manufacturers in today's industries.

To become a world-class manufacturer, a firm must not only compete globally in the marketplace but also be competitive and consistent in terms of costs, technological leadership, and quality. High-quality inputs are becoming the focus of many purchasing departments.

The design of global supply chains has been a challenging optimization problem for many years. In a continuing effort to remain competitive, many firms are considering new sources for their raw materials and components, new locations for their production and distribution facilities, and new markets in which to sell their products without regard for national boundaries. The design of global supply chains has been a challenging optimization problem for many years. The current globalization of the economy is forcing firms to design and manage their supply chains efficiently on a worldwide basis.

It is well known that large enterprises no longer operate in a single market. In seeking to penetrate global markets and obtain their benefits, firms are under excess pressure to reduce the price of their products and thus their production and material costs.

According to the literature, global outsourcing is mainly analyzed in terms of cost. During the evaluation of global outsourcing, neither multi-criteria evaluations nor qualitative assessments are always made, but many decision criteria must be considered when configuring a global supply chain system. Historically, labour cost has been one of the most decisive factors in global outsourcing decision making. Recently, the rapidly changing business environment has increased pressure on decision makers to properly analyze the relevant decision criteria. Strategic decision making requires the use of tangible, intangible, strategic and operational decision criteria. There are many factors that need to be considered simultaneously, and purchasing managers need a structured method of using these criteria in their decision making.

The AHP is the widely used a multi-criteria, decision-making method used by academicians and practitioners for supplier selection and global outsourcing decision making. The AHP is based on dual comparisons of decision criteria. As the number of decision criteria increases, the complexity of the system also increases. Mathematical models are not sufficient for evaluating qualitative criteria.

One of the major factors complicating the modelling of global outsourcing decision making is "uncertainty". Exchange rate fluctuations, variable transportation times, demand uncertainty, the variability of market prices, and political instability are among the most important sources of uncertainty. An effective decision-making methodology for global outsourcing must address those uncertainties. In recent years, artificial intelligence tools such as neural networks, fuzzy logic and genetic algorithms have been increasingly used for outsourcing decision making. Those methods are more appropriate under uncertainty and can better address qualitative criteria.

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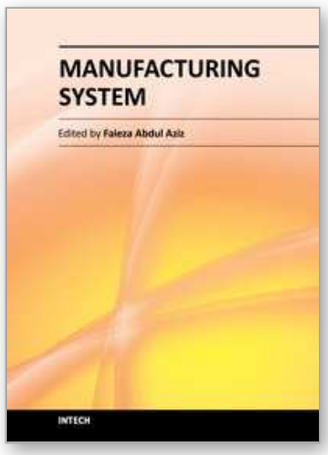

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This book attempts to bring together selected recent advances, tools, application and new ideas in manufacturing systems. Manufacturing system comprise of equipment, products, people, information, control and support functions for the competitive development to satisfy market needs. It provides a comprehensive collection of papers on the latest fundamental and applied industrial research. The book will be of great interest to those involved in manufacturing engineering, systems and management and those involved in manufacturing research.

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