

INTERNATIONAL SUPPLIER SELECTION AND ORDER ALLOCATION DECISION:
A COMPARISON OF A TURKISH AND AN AUSTRALIAN COMPANY

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2010

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Thesis submitted to the
Institute for Graduate Studies in the Social Sciences
in partial fulfillment of the requirements for the degree of

Master of Arts
in
International Trade Management

by
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2010

Thesis Abstract

Aycan Aytekin, “International Supplier Selection and Order Allocation Decision: A Comparison of a Turkish and an Australian Company”

International supplier development is a multi-criterion decision problem which includes qualitative and quantitative factors. In the literature, it is seen that although there are abundant studies on various domestic supplier selection, the impacts of globalization on the level of sourcing and international supplier selection are not adequately discussed.

This study seeks to provide a better understanding about international sourcing through an integrated approach to supplier selection and order allocation. By extending the literature and incorporating country-specific as well as supplier-specific factors into the selection decision, it is aimed to contribute to the supply chain development of internationally sourcing companies. Through the analytical hierarchy process (AHP), in consideration of both tangible and intangible criteria, a set of candidate suppliers are identified. A linear programming (LP) model with an objective of maximizing the total value of purchasing and a set of constraints, is then formulated and solved to allocate the optimal order quantities among the candidate suppliers.

This study also aims to benchmark the importance given to the selection criteria by the companies in different countries. The hybrid model is applied to both a Turkish chemical company and an Australian chemical company and the differences in selection methods are indicated. Although the results may not be generalized, they can be a reflection of the differences between two cultures and the challenging trends in international trade. This might also form a basis for similar studies in the future.

Tez Özeti

Aycan Aytekin, “Uluslararası Tedarikçi Seçimi ve Sipariş Dağıtım Kararı: Türk ve Avustralyalı Şirket Karşılaştırması”

Uluslararası tedarikçi seçimi nicel ve nitel faktörleri içeren çok kriterli bir karar verme problemidir. Yapılan çalışmalar incelendiğinde, yerli tedarikçi seçimi üzerine oldukça çalışma yapılmış olmasına rağmen, küreselleşmenin kaynak bulma ve tedarikçi seçimi üzerine etkisinin yeterli şekilde tartışılmadığı gözlenmektedir.

Bu çalışmada, tedarikçi seçimi ve sipariş dağıtımına uygulanan birleşik bir yaklaşımla, uluslararası kaynak bulma konusunun daha iyi anlaşılması amaçlanmaktadır. Yapılan çalışmalara, tedarikçinin bulunduğu ülkedeki kararı etkileyebilecek faktörler ve tedarikçiye özgü faktörler de katılarak, uluslararası kaynak bulan firmaların tedarik zinciri gelişimine katkı sağlamak hedeflenmektedir. Analitik Hiyerarşi Prosesi (AHP) yöntemi ile, somut ve soyut kriterler ele alınarak, tedarikçi adayları belirlenmiş, Doğrusal Programlama (LP) yöntemi ile de satınalmanın toplam değerini arttıracak bir model oluşturulmuş, firmanın talebine uygun bir sipariş dağıtımını en iyi tedarikçiler arasında gerçekleştirilmiştir.

Bu çalışma, aynı zamanda farklı ülkelerde ancak aynı sektörde yer alan firmaların tedarikçi seçiminde kriterlere verdikleri önemi kıyaslamayı da amaçlamaktadır. Bu bağlamda, model kimya sektöründe yer alan bir Türk şirketine ve Avustralyalı şirkete uygulanmış, seçimlerinde kriter önceliklerindeki farklar vurgulanmıştır. Sonuçlar genelleme yapabilmek için yeterli olmamasına rağmen, iki kültürün ve ülkelerin uluslararası ticaret eğilimlerinin arasındaki farklılıkları yansıtması açısından önemlidir. Ayrıca bu çalışma, gelecekte yapılacak benzer çalışmalar için de temel oluşturmaktadır.

ACKNOWLEDGEMENTS

I am extremely grateful and indebted to Arzu Tektař for guiding me through my thesis. Her patience, understanding and valuable advice have been the reason this thesis is seeing the light of the day. It was privilege for me to work with her.

I am also grateful to Zeynep Ata and Dilek Ünalán for their kind interest and for the time they have devoted to reading and commenting on my thesis.

I would like to express my warm and sincere thanks to my parents, Nilgün and Zeynel Aytekin, my sister Pınar Aytekin for their endless support. It has always been comforting to know they exist, not only during my studies but also in a life time.

Very special thanks goes to my friend Peter Murphy for his kind help in gathering data and making me feel at home in Australia.

Heartfelt thanks to my beloved friends, Şükrü Nenem, Tülay Karakaş and Selçuk Savaşal for their everlasting friendship and motivation in the toughest times of my research, for making life beautiful and easier for me.

Finally, I gratefully acknowledge the financial support of TÜBİTAK (BİDEB-2210 Fellowship) during my master studies.

To my grandfather who could not see the final

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CHAPTER I

INTRODUCTION

In today's global competitive environment, effective supply chain management (SCM) has become a valuable way of improving organizational performance and sustaining competitiveness. Hence, this concept has received a great deal of attention from the organizations as well as academics.

Increase in competition in the 1990s and the globalization of markets have led to challenges associated with getting a product and service to the right place at the right time at the lowest cost. Tracey and Tan (2001) state that increases and varieties of customer demands, advances of recent technologies in communication and information systems, competition in global environment, decreases in governmental regulations and increases in environmental consciousness have forced companies to focus on the supply chain. Organizations have realized that it is not sufficient to improve efficiencies at the organizational level; their whole supply chain has to be made competitive.

Christopher (1998, p.15) describes the supply chain as a "network of organizations that are involved, through upstream and downstream linkages in the different processes and activities that produce value in the form of products and services in the hand of the ultimate consumer". This definition stresses that all the activities along a supply chain should be designed according to the high customer expectations for high quality products at a reasonable price as well as short lead times.

As Hokey Min stated at the Euro Conference (2009), “A supply chain is as strong as its weakest link.” Any disruption in the supply chain might result in a failure for the overall system since all organizational units are interdependent. Hence, all the units must be coordinated in a way that one common goal is sought to be satisfied.

SCM is the task of integrating organizational units along a supply chain and coordinating materials, information and financial flows in order to fulfill customer demands with the aim of improving competitiveness of the supply chain as a whole (Stadtler, 2005). SCM integrates the suppliers, manufacturers, warehouses and stores efficiently so that merchandise is produced and distributed at the right quantities, to the right locations and at the right time (Simchi-Levi et al., 2000).

Supply chain drivers, namely the facilities, inventory, transportation, sourcing, pricing and information play a significant role in supply chain coordination and effective supply chain management parallel to the competitive as well as supply chain strategies of the company.

The role of sourcing is crucial when the main process in the upstream chain that affects all parts of an organization is considered. Chopra and Meindl (2007, p. 417) emphasize that the most critical decision for any supply chain function is whether to outsource the function and focus on core competencies or perform it in-house. The company makes the same crucial decision for the raw materials or any indirect materials as well, let alone functions.

As the market becomes globalized, an increasing number of firms that once concentrated on domestic sourcing are now seeking their suppliers around the world (Min, 1994). Birou and Fawcett (1993) point out that the opportunity to reduce production costs, the availability of unique products, possessing a worldwide

operation and competitive strategy are the most referred reasons for venturing into international sourcing.

The internationalization of sourcing occurs as firms evolve or transform from purely domestic purchasing to the global coordination and integration of common items, processes, designs, technologies and suppliers across worldwide locations (Trent and Monczka, 2003). Birou and Fawcett (1993) emphasize that only after establishing the scope of the international sourcing strategy and planning for its implementation, the firm should move to the second step – supplier selection and development.

The selection of suppliers plays a key role in an organization because the supplier link in the supply chain appears to have significant cost-cutting opportunities. By selecting the right suppliers, the purchasing costs can be reduced and corporate competitiveness could be improved significantly. Hence, the high potential suppliers should be identified carefully by the decision maker and the supplier's ability should be analyzed in order to ensure that the expectations can be satisfied.

Organizations have two major approaches to supplier selection. The first approach is to select the best single supplier who can meet all the requirements alone. The second approach is to select an appropriate combination of suppliers when no single supplier can satisfy all the requirements. Accordingly, management should allocate order quantities among the available suppliers for a variety of reasons including creating a constant environment of competitiveness (Sanayei et al., 2008).

Multi-criteria considerations must be incorporated into the international supplier selection decision due to the fact that it is much more complex than domestic supplier selection and needs more critical analysis. International sourcing

involves many disciplines including logistics, marketing, product evaluation, international distribution, negotiation, linguistic skills, cultural awareness of the international environment and so forth (Branch, 2001, p.6). Hence, apart from the common criteria such as cost and quality, a wide range of factors that cover supplier's attributes and the overall environment in the supplier's country must be taken into account.

Effective international supplier selection must deal with a myriad of quantitative and qualitative factors. Therefore, a technique that can support the decision making process in the presence of tangible and intangible factors and a set of alternatives is required. Analytic Hierarchy Process (AHP) is a method that can integrate both of these criteria under a hierarchy and calculate relative priority weights based on the decision maker's preferences about the criteria. It identifies choice criteria in a hierarchy and then prioritizes them by assigning weights. It is easy to use, has great flexibility and wide applicability. It provides an estimate of additive utility weight that best matches the initial information provided by the decision maker (Barbarosoğlu and Yazgaç, 1997; Ghodyspour and O'Brien, 1998; Saaty, 1977).

By employing this technique, not only are the rankings of criteria defined by a decision maker compared relatively, but also the importance given to those weights by two different companies in different countries can be examined. Hence, by creating a common AHP hierarchy that can be applied by decision makers in different countries, international sourcing strategies of organizations can be compared easily and systematically.

AHP is also used with other techniques such as mathematical programming to consider not only tangible and intangible factors but also some real-world resource

limitations. Such hybrid models can offer a systematic, easy-to-use approach to the supplier selection decision problem. They may also enable allocating the order quantity among the best suppliers subject to the constraints.

This study incorporates AHP and Linear Programming (LP) for modelling the international supplier selection process. The AHP model identifies and systematically prioritizes the multidimensional supplier selection criteria relevant to the current global business environment. Hence, by emphasizing the multidisciplinary nature of the supplier selection problem, the developed model will aid any manufacturing or trading company in selecting and benchmarking best international suppliers.

In this study, AHP model is used to compare the criteria importance weights of two chemical companies – one in Australia and one in Turkey. Thus AHP model systematically weighs and evaluates the priorities of each company in supplier selection decision. By combining the weight of each criterion and supplier's rating, the overall weight of each supplier is determined. Subsequently, these ratings are used as coefficients of an objective function in LP to allocate order quantities to the suppliers such that the total value of purchasing (TVP) becomes maximum. Taking into consideration supplier as well as buyer related constraints, LP model selects the best suppliers and allocates the orders among them optimally. Hence, not only does the hybrid model give indications about how the two countries approach the international sourcing problem but also aids the decision maker in selecting the external suppliers that best match his expectations.

This thesis initially focuses on the supply chain management and the related concepts in Chapter II. The role of sourcing in the supply chain and the internationalization of the sourcing process are investigated further in Chapter III.

Chapter IV reviews decision models in supplier selection and the related past researches. The methodology of this thesis is presented in Chapter V. In Chapter VI, the importance given to the supplier selection criteria by decision makers is evaluated by implementing the AHP model on companies in different countries. The implementation of the hybrid model and optimal order allocation is presented in Chapter VII. The thesis ends with the conclusions, recommendations and directions for future research.

CHAPTER II

SUPPLY CHAIN MANAGEMENT

Today's global environment has shifted competition from firm level to supply chain level (Hult et al., 2004) and has led business managers as well as academicians to focus on "supply chain management" concept. There are many reasons that lay behind of the changes in both the overall environment as well as the company's understanding. Due to the liberalization of trade, the governmental regulations regarding trade restrictions have decreased and free trade movements have been created which made a significant contribution to international trade. Improvements in technology as well as in global logistics have also facilitated international trade. As a result of these developments, the companies are encouraged to source not only domestically but also internationally. They could search for any product that they need to purchase, can get offers from different sellers in the world and find the external suppliers who will provide it at the lowest cost, at the highest quality and at the shortest time interval. Additionally, before making the decision, the buyer can have access to the documents related with the reputation of the seller company, can investigate if the company is well known in that market or if the company shows adequate respect to the environment during the manufacturing process. This implies that the supplier has to satisfy all of the criteria of the buyer in order to remain competitive. However, the competencies of the suppliers are not the only factors that the buyer considers in the decision making process. The buyer also takes into consideration the global environment which is a country related criteria rather than supplier related. The country's macroeconomic indicators, international trade

regulations are deeply observed. Additionally, geographical as well as cultural proximity between the two countries and political stability that may lead to disruption of the supply chain are evaluated. Hence, the buyer takes into account many factors in order to reduce the vulnerability of the supply chain that could be caused by the supplier or the global environment.

This chapter reviews the related supply chain concepts starting with the basics of supply chains and continues with analyzing the supply chain drivers that contribute to achieving strategic fit.

The Supply Chain

Chopra and Meindl (2007, p.10) define supply chain as series of processes and flows that shape the different stages of a product in the process of fulfilling customer needs. These stages include supplier, manufacturer, customer and depending on the length of the chain, the retailer and wholesaler/distributor as well. From an organizational view, the supply chain comprises all functions involved in fulfilling customer requirements and needs. These functions include purchasing, product development, marketing, operations, finance, distribution and customer service (Chopra and Meindl, 2007, p.3). Within a supply chain, continuous flow of information, product and funds are present dynamically. Figure 1 shows a pictorial representation of these backward and forward flows.

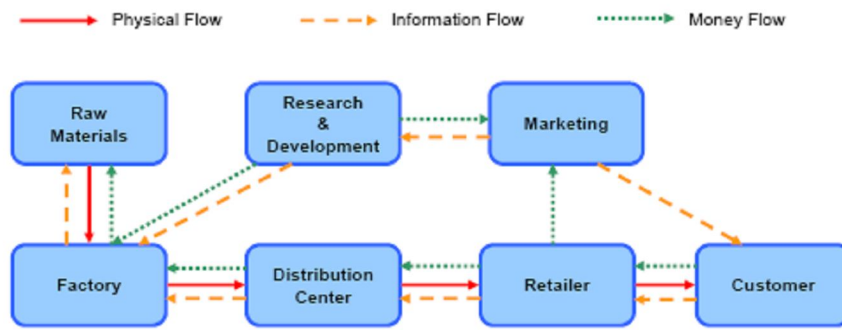


Figure 1. A representation of supply chain flows (Mendoza, 2007)

In order to observe the processes performed in a supply chain and to emphasize the relationship between the supplier and other actors, it is decided that the cycle view, which would also be helpful in analyzing the competitive priorities, should be reviewed. The cycle view of the supply chain precisely defines the content of the processes and the actors owning each process. The processes are sequenced with a series of cycles that is performed between two successive phases of the supply chain (Chopra and Meindl, 2007, p.10).

Considering that the stages of a supply chain are structured with five actors including supplier, manufacturer, distributor, retailer and customer, the phases of the supply chain can be grouped with the following four cycles (Chopra and Meindl, 2007, p.9):

- Customer order cycle
- Replenishment cycle
- Manufacturing cycle
- Procurement cycle

Each of the above mentioned cycles occurs at the interface between two consecutive phases of the supply chain. Consequently, five stages in the supply chain

result in four distinct supply chain cycles. It is worth noting that not every supply chain has necessarily all these four cycles explicitly separated. As demonstrated in Figure 2, each cycle consists of six sub-processes. Each cycle begins with the supplier phase where the product is marketed to customers. The following phase includes a buyer's order that is received by the supplier. After the supply of the order by the supplier, the product is received by the buyer. At the subsequent stage, the buyer may return the whole or components of the product to the supplier or a third party. These cycle of activities and processes are repeated continuously in a loop (Chopra and Meindl, 2007, p.10).

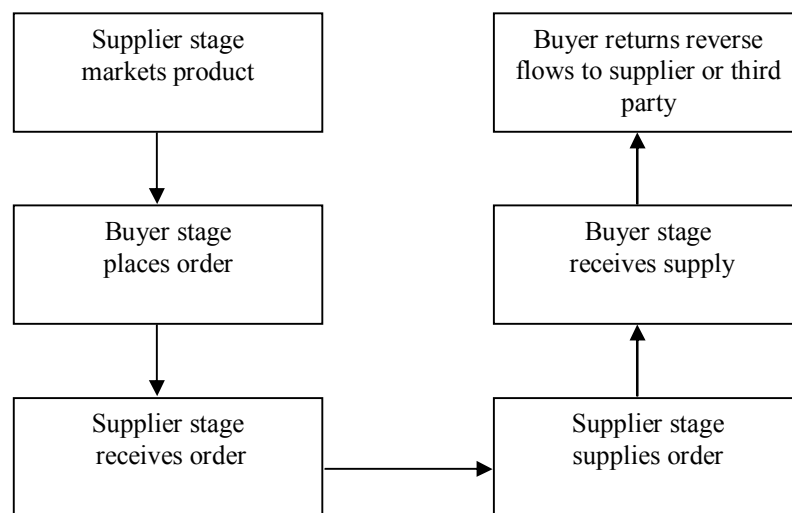


Figure 2. Sub-processes in supply chain (Chopra and Meindl, 2007, p.10)

At each cycle, the objective of the buyer is to guarantee the availability of the product and to attain order efficiency by achieving economies of scale. From the perspective of the suppliers, the goal is to undertake accurate customer demand forecast and reduce the cost of order receipt. The supplier works to meet customer's demands and requirements on time and attempts to improve the efficiency and

accuracy of the order fulfillment process. The buyer, on the other hand, aims to minimize the cost of the order receiving process. Reverse flows are managed to reduce costs and meet environmental objectives (Chopra and Meindl, 2007, p.11).

Although there exists certain similarities in the sub processes of each cycle, they also differentiate in a few aspects. In the customer order cycle, the demand is uncertain since it is external to the supply chain. Within the context of all other cycles, although order placement is an uncertain issue, it can be projected with the assistance of certain policies followed by the particular supply chain stage. The second deviance among cycles is about the scale of an order. While the order moves from customer to supplier, the amount of orders declines while their size ascends. Thus, moving further from the end customer, information sharing and the content of the operational policies become more critical (Chopra and Meindl, 2007, p.12).

The primary objective of the supply chain systems is to satisfy customer needs and to maximize the overall added value generation. The value that a supply chain forms could be assessed by evaluating the difference between what the final product is worth to the customer and the costs that is incurred by the supply chain while meeting the customer requests. The value of the supply chain is strongly correlated with its profitability which simply is the difference between the revenue generated through the customer and the overall cost across the chain (Chopra and Meindl, 2007, p.5).

After identifying all the cycles, mentioning the objectives of the supplier, buyer and the overall supply chain, the next step must be to investigate how to achieve these goals. The first stage must be to observe the meaning of the firm's competitive strategy, supply chain strategy and the strategic fit.

A company's competitive strategy is determined based on the set of customer needs that it aims to satisfy through its products and services. Thus, it will be defined based on its customers' priorities. Competitive strategy targets one or more customer segments and aims to provide products and services that satisfy these customers' needs. A supply chain strategy, on the other hand, determines the nature of procurement of raw materials, transportation of materials to and from the company, manufacture of the product or operation to provide the service and delivery of the product to the customer, along with any follow-up service and specification of whether these processes will be performed in-house or outsourced. Competitive strategy of the company and the supply chain strategy that covers each function must fit together in order to constitute a coordinated overall strategy and to achieve strategic fit between the elements and function of the supply chain. Therefore, the company, as a first step, must define its competitive strategy and design its supply chain accordingly (Chopra and Meindl, 2007, p.24).

Depending on the company's competitive strategy, the supply chain of a company can range from being totally responsive to totally efficient which will be discussed further. The primary goal of the responsive supply chain is to respond quickly to demand (Chopra and Meindl, 2007, p.30). Therefore, inventory holding cost will be high, there will be many facilities in different parts of a particular region, the products will be customized and a wide variety of products will be handled. On the other hand, efficient supply chains focuses on supplying demand at the lowest cost. The trucks will be fully loaded, the inventory will be minimized. The lead times are reduced but not at the expense of costs and unlike responsive supply chains, lower margins are gained because price is a prime customer driver. These two terms are also important as far as supplier selection is concerned since as a supplier

strategy, efficient supply chains select its suppliers based on cost and quality whereas responsive supply chains select based on speed, flexibility, reliability and quality.

In order to discuss these two terms as well as the strategies in a more detailed way, it is best to analyze the drivers in supply chain separately. There are six main drivers in a supply chain, which are inventory, transportation, facilities, sourcing, pricing and information (Chopra and Meindl, 2007, p.44). Facilities, such as production sites and storage sites, are the physical locations in the supply chain network. Inventory, which arises because of the mismatch between supply and demand, covers all raw materials, semi-finished goods and end products within a supply chain. These two drivers play significant roles in supporting a company's competitive strategy. The number and location of facilities, the amount of inventory that the company holds depend on the responsiveness level of its supply chain. If the company aims to respond quickly to its customers' demand, it can decentralize and have warehouses or distribution centers close to its customers and can stock high level of inventory. However, if the company's competitive priority is cost, then it will concern the holding and any other operational costs and keep the number of facilities as well as inventory low, at the expense of being responsive.

Transportation enables to move inventory from one point to another in the supply chain. Like the other supply chain drivers, transportation has a large impact on both responsiveness and efficiency. A company can choose a plane as a type of transportation for its upper-end customers with high responsiveness requirements. This situation, however, would reduce its efficiency. Therefore, like all other drivers, companies reach a point when they must make the trade-off between efficiency and responsiveness.

Information that involves all data and analysis within the supply chain, provides coordination between different stages of a supply chain and enables accuracy as well as on-time data availability. Due to the huge growth of the importance of information technology, it is an important driver that companies have used to become more efficient and more responsive. Many technologies exist to share and analyze information in the supply chain. Electronic Data Interchange (EDI), for instance, allows companies to place instantaneous purchase orders with suppliers. By EDI, the transactions become faster as well as accurate since it is not paper based and reduces the lead time. The internet also is a useful tool with respect to information sharing since it conveys a wide variety of information.

Pricing is the determinant of profitability of the firm, as a result the performance of the supply chain. It affects the customer segments purchasing the product. Through their pricing, the companies are targeting a range of customers, some of whom can afford high prices resulting from customization and require responsiveness while others place strong emphasis on cost and can stand longer lead times which result in a more efficient supply chain.

Sourcing is the choice of who will perform a particular supply chain activity, in other words whether to perform in-house or to outsource. Sourcing decisions are crucial because they affect the level of efficiency and responsiveness the supply chain can achieve. The decision of the business managers must be based on the growth in supply chain profitability. Therefore, if the growth in total supply chain profit is significant, then it is best to outsource. After the outsourcing decision is made, then the managers must decide whether to outsource efficient or responsive component or both of them. This issue will be elaborated in Chapter III since it is directly related to the subject of the study.

In order for a company to be successful, as previously mentioned, its supply chain strategy and competitive strategy must fit together, which is called strategic fit. In other words, there must be a match between the customer priorities that the competitive strategy seeks to satisfy and the supply chain capabilities that the supply chain strategy aims to build. There are three basic steps to achieving this strategic fit. First, a company must realize the customer needs for each targeted segment and the uncertainty the supply chain faces in satisfying these needs that help the company define the desired cost and service requirements. The supply chain uncertainty helps the company identify the extent of the unpredictability of demand, disruption and delay that the supply chain must be prepared for. Second, a company must understand what its supply chain is designed to do well, in other words, the supply chain's capabilities in terms of efficiency as well as responsiveness. Lastly, if a mismatch exists between what the supply chain does particularly well and the desired customer needs, the company will either need to restructure the supply chain to support the competitive strategy or redefine its competitive strategy (Chopra and Meindl, 2007, p.26).

Therefore, a company may fail either because of a lack of strategic fit or because its overall supply chain design, processes and resources do not provide the capabilities to support the desired strategic fit (Chopra and Meindl, 2007, p.25). On the contrary, the company will guarantee success if all functions within the firm and stages in the supply chain target the same goal which is consistent with customer needs.

Supply Chain Management

Supply chain management (SCM) terminology was introduced and attracted an intensifying interest both in the literature and business environment by 1982 (Oliver and Webber, 1992). Before describing the SCM concept and emphasizing its importance, it would be beneficial to observe the historical developments in supply chain systems that necessitated to build this notion.

The supply chain systems of the post-World War II were composed of linear and individualized processes that linked manufacturers, warehouses, wholesalers, retailers and consumers in the form of human/paper chain. The coordination and synching of the processes regarding procurement, demand estimation and planning, inventory management as well as tracking were not satisfactorily scientific enough. With the flourishing of manufacturing and the advancement of the growth in the economy during the 1950s, the interest for proper supply chain management systems have risen (Mayer, 2001) (as cited in Öztuzcu, 2005).

By the 1960s, initial versions of the inventory management computer programs were observed. Those softwares were typically customized and were assisting inventory control in manufacturing. During the 1970s, innovations and developments in SCM brought the necessity for Material Requirements Planning (MRP). In the 1980s, a phase that enabled to plan all manufacturing resources including the items related to operational, financial, business, capacity requirements planning as well as main production scheduling called Manufacturing Resources Planning (MRP-II) was developed. The extensions of the MRP-II have led to a new area in the information technology sector: Enterprise Resource Planning (ERP) (Mills and Blaine, 2001) (as cited in Öztuzcu, 2005) which has enabled the

companies to manage cash flow, human resources, manufacturing, purchasing and other major functions within a unified framework. Hence, thanks to these developments, the company has taken all the necessary measures within their own organization.

As the competition between firms got harsher and markets started taking their roles within the context of globalization, the challenge of offering a product and service to the right place at the right time with minimum cost became the priority of the company managements. Organizations began to realize that, in order to develop and improve efficiency, measures needed to be taken not only within their own organization but within their whole supply chain. Accurate and consistent understanding and practicing of supply chain management has become an essential priority and prerequisite for being competitive in the global race and for enhancing profitably (Li et al., 2006). Considering all these facts, the SCM concept is further discussed in order to gain the most thorough understanding.

SCM that aims to develop the competitiveness of the SC as a whole, is the complex task integrating and linking organizational units along a SC and coordinating the flow of materials, information and financials in order to meet customer demands (Stadler, 2004). The value of SCM is reflected in how firms use their supply chain as a strategic matter to increase their competitiveness.

In this context, organizations such as Wal-Mart, Toyota and Dell have made use of their supply chains as strategic weapons to gain comparative advantages over their peers (Chopra and Meindl, 2007, p.23). Meanwhile, being unable to effectively manage supply chains could lead to serious negative consequences. For instance, Cisco wrote off \$2.25 billion of inventory in 2001 due to the problems it encountered with contract manufacturers (Lee, 2004). The failures show that in terms of stock

price, in case a major problem is announced within the supply chain, a firm's market value could erode by an average of 10 percent (Hendricks and Singhal, 2003).

According to Lee (2004), agility, adaptability and alignment dictate the effectiveness of a strategic supply chain management. Agility refers to the ability and flexibility of a supply chain system to respond to unexpected or rapid shifts in supply and demand. Adaptability covers to reshape the structure of supply chains when necessary, without being bonded to legacy issues or the way the chain has been operated previously. Adaptable supply chains make use of information systems to follow the trends and identify shifts in the market which would help in taking appropriate responsive actions. Such responsive actions would include for instance moving facilities, changing suppliers and outsourcing. Alignment on the other hand refers to the consistency of the interests of all participants within a supply chain.

According to Hult and Ketchen (2007), the best value supply chain aims to excel along multiple priorities that are labeled as "competitive priorities" – involving speed, quality, cost and flexibility. Since the supply chains of the organizations are competing, the contents of these terms gain additional importance. Speed reflects the time it takes from the beginning until the ending of a supply chain process. By ensuring speed, on-time delivery is intended, which is set to a schedule. While, quality-focused supply chains concentrate on developing their supply chain processes to ascend the reliability of their product and hence enhance customer satisfaction, cost-driven supply chains aim to develop customer value by either decreasing costs or increasing benefits within the supply chain equation where value is defined as the ratio of benefits to costs. Flexibility that includes both the flexibility in the supply chain process itself and the flexibility of the product or service offered, covers supply chain's responsiveness to altering needs of its users.

In today's competitive business climate, in order for a company to have the best value supply chain, instead of focusing only one of these priorities, it must focus on all of them at the same time and design its supply chain in a way that is both responsive and efficient.

CHAPTER III

INTERNATIONAL SOURCING

Role of Sourcing in Supply Chain Management

Affecting the level of a supply chain system's efficiency and responsiveness, sourcing decisions are critically crucial. In some instance, in case it is costly for companies to develop and undertake a function on their own, the organization may outsource to responsive third parties and focus on their core competences. In other cases, firms keep the responsiveness through their in-house processes which they could thereby control.

Sourcing stands for the set of business processes that are required to purchase goods and services (Chopra and Meindl, 2007, p.58). Ellram and Carr (1994) indicate that through proper selection of suppliers, sourcing plays a key role in maintaining corporate strategic success, supporting the organization's long term vision and competitive positioning. For most of the industries, significant savings can be realized especially through the production unit by implementing correct and efficient sourcing strategies especially in the production unit because of the fact that the raw material's cost and component parts compose the largest percentage of the entire product's cost. Although the raw materials and components are related to the production unit and the scope of sourcing could include all the functions in the supply chain, by applying right sourcing strategies, similar savings can be achieved also in other units.

Within the framework of sourcing, executives must initially decide which tasks will be outsourced and which will be performed in-house. For each of the tasks that would be outsourced, the decision maker must clarify whether to source from a single supplier or from a portfolio of suppliers. If it is decided to source from a multiple combination of suppliers, then the role of each supplier must be identified and assigned. Clarifying the set of criteria for selecting suppliers along with their key performance indicators is the next step to be taken. After completing the above mentioned phases, managers then choose suppliers and negotiate contracts. In contracts, the role of each supply source must be defined and structured to further advance the performance of the supply chain and to minimize information distortion from one stage to the other. Once suppliers and appropriate contracts governing the relations between the two sides are in place, procurement processes which facilitate the transfer, placement and delivery of orders play a crucial role (Chopra and Meindl, 2007, p.58).

Components of Sourcing Decisions

In order to understand the sourcing decisions better, the components of these decisions, in-house or outsource, supplier selection and procurement will be discussed respectively.

Undertaking a task in-house or delegating the duty to a third party through outsourcing is among the most significant sourcing decisions for a firm (Chopra and Meindl, 2007, p.59). If the company believes that the supplier can do it better since it has better management, staff or knowledge, the outsourcing decision for that specific function is given. Bragg (1998, p. 42) states that outsourcing is the most unusual item

if achieving lower cost is aimed since suppliers can only offer lower costs in limited situations such as lower prices on larger purchase volumes. Nevertheless, while absorbing all associated fixed as well as capital costs, the supplier can do the work better and allows the company to work on their most strategically important functions. This results in a tradeoff between being responsive and efficient. If the company believes that outsourcing a function brings a surplus to the supply chain which means that the value of a product to the customer will be greater than the total cost of all supply chain activities involved in bringing the product to the customer (Chopra and Meindl, 2007, p. 418), then it will find the supplier which is expert in that field.

In order to make a decision, the advantages and disadvantages of outsourcing must be analyzed. As far as the advantages are concerned, it is certain that outsourcing creates extra space for the company and reduces the level of administration (Bragg, 1998, p. 342). For instance, the best reason for outsourcing the accounting function especially the collections is that the supplier may pursue those customers who refuse to pay with greater energy than would the in-house collection staff. It is probable that the in-house staff may not overcome this issue although they deal with this a long time which means that they lose time and there is no output yet. Persuading companies to pay for old voices requires a particular skill which the collection suppliers have since they deal with many people of this kind. Therefore, the supplier's better knowledge in addition to having better staff constitute the other major advantages of outsourcing. This would be also beneficial in manufacturing function since suppliers have special skills and can manufacture products more cheaply with better quality.

On the other hand, there are some disadvantages of outsourcing which require attention. Lack of company knowledge, loss of confidential information, possible low quality result, high variable cost in addition to distance to supplier are the main drawbacks (Bragg, 1998, p. 343). For instance, if a company manager seeks to outsource computer services function, he should also consider that it would be risky to put the developed customized programs in the hands of a supplier. Additionally, there will be a particular problem especially in the production side if the company's orders are only small fraction of the supplier's total backlog. In such conditions, the supplier normally gives the best service to the company giving it the most business and other companies have a lower priority on the supplier's production schedule.

The negative and positive sides of outsourcing show that this decision must be made after analyzing the need and the core competences very carefully and the risks that could grow upon outsourcing. If it is still believed that the third party will increase the supply chain surplus relative to performing the activity in-house, then the next step is finding the right suppliers. Cooperating with right suppliers is not only important when an outsourcing function decision is made, but also purchasing any component that could be used by the company as a raw material in manufacturing.

Heavily contributing to the overall performance of the supply chain, supplier selection is another fundamental issue. For companies whose material costs form a significant aspect of their overall costs and who spend a high portion of their sales revenue on parts and material supplies, the context of supplier selection challenge is of particular importance. Carefully selecting the suppliers significantly decreases the cost of purchasing and develops corporate competitiveness which is the reason why many experts claim that supplier selection is the most vital function of a purchasing

department (Sanayei et al., 2008). Since sourcing does not only cover the parts and material supplies in production unit but also the other departments, by selecting the right suppliers, similar savings could be achieved in other units as well.

Organizations have two approaches to the supplier selection problem. Single sourcing approach involves picking a single supplier, which can best meet all the requirements (Sanayei et al., 2008). There are many reasons for a firm to source from one supplier. First, prior commitments, an ongoing long-term contract with a preferred supplier might prevent the possibility of splitting the order. Second, the supplier may be the only owner of patents or processes and therefore is the only possible source. Under such conditions, the buyer has no other options. Additionally, the existing supplier might welcome the opportunity to have all the buyer's business and has adequate capacity to fulfill buyer's demand and deliver high quality products to the right place on time with a possible discount. Alternatively, the order may be so small so that it will not be worthwhile dividing it.

Multiple sourcing approach is about selecting a combination of multiple appropriate suppliers in case no single unique supplier can meet all the requirements (Sanayei et al., 2008). In all companies, there is a risk of accident, fire, strike, bankruptcy which could directly affect the output. By splitting the quantities of the order, therefore, dependence on a single supplier is avoided, assurance of supply is increased and the risk is alleviated. It also somehow contributes to the competition between the suppliers which has to be alert to the need of buyers. Another reason might be the inadequacy of the single supplier's capacity.

Soon after the decision regarding the number of suppliers to be employed, managers must define and identify the criteria for which the potential supplier candidates will be evaluated and selected. Dickson (1966) identifies 23 distinct

criteria that are evaluated in the process of vendor selection and many related studies are conducted further. In that article, quality is interpreted as the utmost critical indicator while delivery, performance history, warranties and claim policies, production facilities and capacity, price, technical capability and financial position are regarded as considerably important factors during the vendor selection process. Other related studies are in Chapter V and mentioned in detail.

Within the process of selecting the vendor, managers must decide if they will employ the direct negotiations technique or resort to an auction. If an auction is used, its structure must be designed to ensure the desired outcome (Chopra and Meindl, 2007, p. 58).

The third constituent of sourcing decision is procurement. Chopra and Meindl (2007, p. 417) define the procurement term, also called purchasing, as “the process by which companies acquire raw materials, components, products, services or other resources from suppliers to execute their operations”. The standard statement of the general purposes of the purchasing division is that the right materials that meet quality requirements should be obtained in the correct quantity and to be delivered to the right place at the requested time, from the right source, with the right service and at a reasonable price (Leenders and Fearon, 1997, p. 34).

Once suppliers are selected and contracts are designed, the buyer and suppliers engage in procurement transactions which begin with the order placement by the buyer and end with the receipt and payment for the order. In designing the procurement process, the most important step is to consider the goods that the process will be used to purchase and categorize them. The purchased goods are classified into direct and indirect. Direct materials are components that are used to make finished goods whereas the indirect materials can be described as goods

supporting the operations of a firm. Direct materials can be further categorized into bulk purchase, critical and strategic items, based on the value of the item and how critical it is for the buyer (Chopra and Meindl, 2007, p. 448).

The procurement processes of these two groups significantly differ. Since direct materials directly affect the production, the procurement process for these materials must be in a way that ensures the availability of the components in the right place, in the right quantity as well as at the right time. For bulk purchase items such as packaging materials, procurement should focus on the value-added service provided and performance along other dimensions that affect total cost. For critical items, procurement should focus on improving coordination of forecasting and fulfillment with the supplier. For strategic items, procurement should focus on improving design and manufacturing collaboration. On the other hand, given the focus on numerous low-value transactions, the procurement process for indirect materials should focus on reducing the transaction cost of each order (Chopra and Meindl, 2007, p. 450).

This information shows that the companies should be more careful when purchasing a direct material. The procurement process for these materials should be designed in a way that the supplier is aware of the stock level as well as the production plan of the manufacturer in order to ensure on-time delivery. On the other hand, the manufacturer must be sure that the supplier has the adequate capacity to respond to its changing demands.

Procurement becomes more critical as international sourcing is concerned. The documentations required for order and delivery of the product must be prepared in a clear and accurate way in order not to lead to any disruptions which may affect

the lead time. They also must guarantee that the product to be received matches with the customer's expectations.

Internationalization of Sourcing

World business environment has experienced radical changes in recent decades. Min (1994) states that three events especially, which are the official foundation of the European Community (EC) 1992 under the auspices of the Single European Act, the demise of Communism in the Eastern bloc countries and the pending ratification of the North American Free Trade Agreement contributed heavily to the globalization of the world economy. The progressive lowering of trade barriers, the advancement of information as well as communication technologies, the development of transport systems and infrastructures have eased the international trade and have increased the level of competition worldwide (Nassimbeni, 2003). Intensifying degrees of global competition today greatly accelerated the growth in international sourcing which allowed firms to utilize worldwide resources more effectively by enabling them to decouple regional economies from their countries of origin (Fawcett and Scully, 1998).

Fawcett and Scully (1998) define international sourcing as “materials and component purchases from suppliers located outside the national borders”. It is quite different from domestic sourcing due to the fact that it is influenced by a greater variety of uncertain and uncontrollable aspects than the case in domestic sourcing. These factors include complicated documentation requirements, trade regulations, quotas, customs duties, currency exchange rates, cultural differences, unique ethical standards in addition to complex distribution channels (Min and Galle, 1991).

Eventually, many buyers unfamiliar with these factors often hesitate to internationalize their sourcing processes.

The output of Monczka and Trent's study (1998) show that the primary motivation for firms to start sourcing internationally is the availability of lower cost. Increasingly, many firms are turning to suppliers located in low-cost countries (LCC) owing to the fact that the lower labor costs in LCCs offer an attractive alternative to the higher cost suppliers from more developed economies. For instance, the labor cost in China which is regarded as a LCC, is only 5 percent of that in Japan, a neighboring developed country (Jiang and Peter, 2002). The existence of unique products is determined as the next most common motivation. The third most referred reason for venturing into international sourcing is sourced from the firm's passion to possess a worldwide operation within the framework of its competitive strategy. Additionally, the study summarizes the commonly identified benefits of the internationalization of sourcing as reducing unit prices, gaining better access to product and process technology, higher quality and introducing competition to the suppliers at home.

Fagan (1991) states that the keys for accomplishing successful international sourcing are top management support, development of clearly defined goals, comparison of total cost, establishment of trust and respect, use of information technologies that enhance control and risk management, respectively. Thus, as a first step, companies must determine the appropriate level of internationalization of its businesses' sourcing processes (Monczka and Trent, 1992) and reorganize their activities on an international base (Nassimbeni and Sartor, 2005). By taking into account the differences in contractual modalities, normative systems, language, culture, contractual style, logistical complexities, governmental regulations and so on

(Fawcett and Scully, 1998), the company reduces the risk of experiencing difficulties such as cultural and communication barriers, longer lead times, political instability of foreign countries, higher transportation costs and risks associated with transactions.

Hence, in order to reach the benefits, the company needs to have adequate information and organizational infrastructures, effective coordination mechanisms and logistic capabilities. Apart from manufacturing costs, the firms must consider the cost of various resources, exchange rate fluctuations, the availability of infrastructure including transportation, communications, energy, industrial as well as cultural environments, the ease of working with foreign host governments and so forth (Caddick and Dale, 1987; Hefler, 1988). This situation necessitates a general view on both the supplier related and country related factors.

Monczka and Trent's study (2003) is very beneficial for a company to clearly understand the levels through global sourcing and to set its sourcing level. They state that sourcing ranges from purely domestic purchasing to the global coordination and integration of common items, processes, designs, technologies and suppliers across worldwide locations and note that a sophisticated level of worldwide sourcing activities could be reached only after going through some preceding lower levels.

They distinguish five levels of worldwide sourcing. Level I represents the base case of engaging in domestic purchasing exclusively. Reacting to changes in the business environment such as new competitive pressure, companies progress to Level II, which can be characterized as international purchasing performed on a reactive basis. Along with Level II, Level III corresponds to what has been identified as international purchasing. In Level III worldwide sourcing is treated more strategically but still rather isolated and thus lacks global coordination. Level IV has to be considered as an advanced level of sourcing strategy development. Single

global sourcing strategies are coordinated and integrated across worldwide locations. The highest level of worldwide sourcing, Level V, adds the aspect of coordinating and integrating “common items, processes, designs, technologies and suppliers across worldwide purchasing centers and with other functional groups, particularly engineering”. Global sourcing encompasses the production, purchase and assembly of parts and finished products worldwide. It involves decisions relating to how components are supplied for production and which production units serve particular markets (Davidson 1982, Kotabe, 1992) (as cited in Monczka and Trent, 2003). The strategies that progressively require more capital and longer-term commitments could be finding qualified materials and services; entering into joint-venture relationships; and making a 100 percent equity investment in a foreign country (Hefler, 1988). Figure 3 summarizes the possible levels of worldwide sourcing and shows the current positioning of 162 mainly large companies who participated in the research conducted by Monczka and Trent (2003).

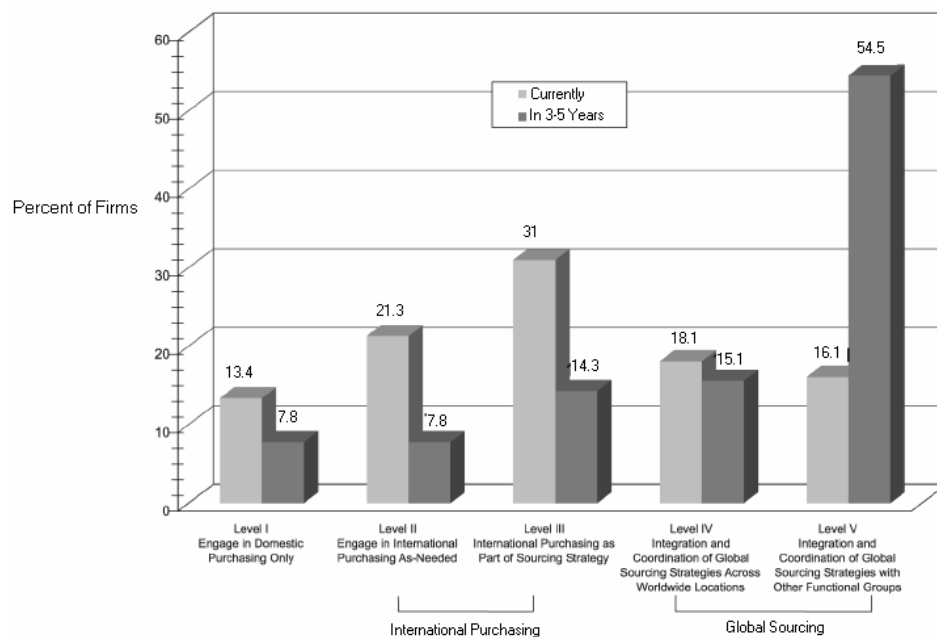


Figure 3. Worldwide sourcing levels (Monczka and Trent, 2003)

The levels of worldwide sourcing show that a company must first decide on its sourcing process in accordance with its business objectives and needs, then find the best suppliers that could assist the firm in staying competitive. It must be noted that supplier selection is one of the most fundamental issue in company's success and becomes more complicated as the sourcing is internationalized. Hence, it is important for the company to define its expectations clearly and the capabilities that it seeks in suppliers. However, although the company might think that it reached the best suppliers in the world who can stand on the firm's specific decision criteria, it can still experience difficulties which have lead the company to consider the supplier's country related factors as well. It is obvious that while the determinants for selecting suppliers were limited to two or three variables in the past, such as quality, delivery and price, today, it is seen that recent developments in technology and global competitive environment have significantly increased the determinants of supplier selection process.

This study aims to assist any manufacturing or trading company in sourcing a direct material internationally by considering all the factors that could be effective in decision making process. The study could be further extended to apply to a company that seeks to outsource a function such as production or transportation, let alone a component. Additionally, a similar study could be achieved for the companies that look for services instead of product. The related studies in the literature and the factors that are included in the model of this study will be observed in Chapter V in a detailed way.

CHAPTER IV

DECISION MODELS IN SUPPLIER SELECTION

Supplier selection is a strategic decision-making process which is generally dealt as an optimization problem (Aissaoui et al., 2007). Many useful approaches have been proposed in the literature for solving this problem. When these models are observed, it is clearly seen that the approaches utilized could differ based on many criteria such as the company's sourcing policy, supplier's performance uncertainty, the number of materials to be purchased, the possibility of discount and many other factors.

Recent operations research literature offers a range of methods and techniques that may enhance the efficiency as well as the effectiveness of the purchasing decision making process by enabling computerized calculation, efficient storage of this process and assisting the buyer in taking into account several criteria when making sourcing decisions (De Boer et al., 2001).

Supplier selection problems can be classified into two groups based on the existence of constraints. If there are no binding supplier-specific constraints such as capacity, delivery, this implies that all suppliers can meet all the buyer's requirements. Hence, the buyer only needs to find the best supplier among them. However, if there are some limitations in supplier's attributes, this means that none of these suppliers can fulfill the buyer's requirements alone and the buyer has to allocate the required quantity to be ordered between these suppliers (Ghodsypour and O'Brien, 1998).

In single sourcing models, although it is relatively easier to control only one supplier, the risk is higher since any problem occurring between supplier and buyer

might significantly affect the relationship between the buyer and its own customers. However, in multiple sourcing models, allocation problem has been considered along with the selection problem so that the risk has been alleviated (Sharafali and Henry, 2000).

Generally, in single sourcing models ranking techniques have been applied and the one with the highest score is chosen, but in multiple-sourcing models mathematical programming models have been implemented.

In his study, Kağnıcıoğlu (2001, p.120) categorizes the proposed models in the literature into four groups; namely, linear weighting models, total cost models, mathematical programming models and statistical models. However, since the models are represented for the supplier selection concept, it is better to discuss these models according to De Boer et al.'s framework. In their study (2001), the existing supplier selection literature is updated and the process is classified into four steps which are problem definition, formulation of selection criteria, pre-qualification and final selection. Mendoza (2007) shows these steps and summarizes the related literature review framework as given in Figure 4. Based on this, the major approaches are discussed further in detail.

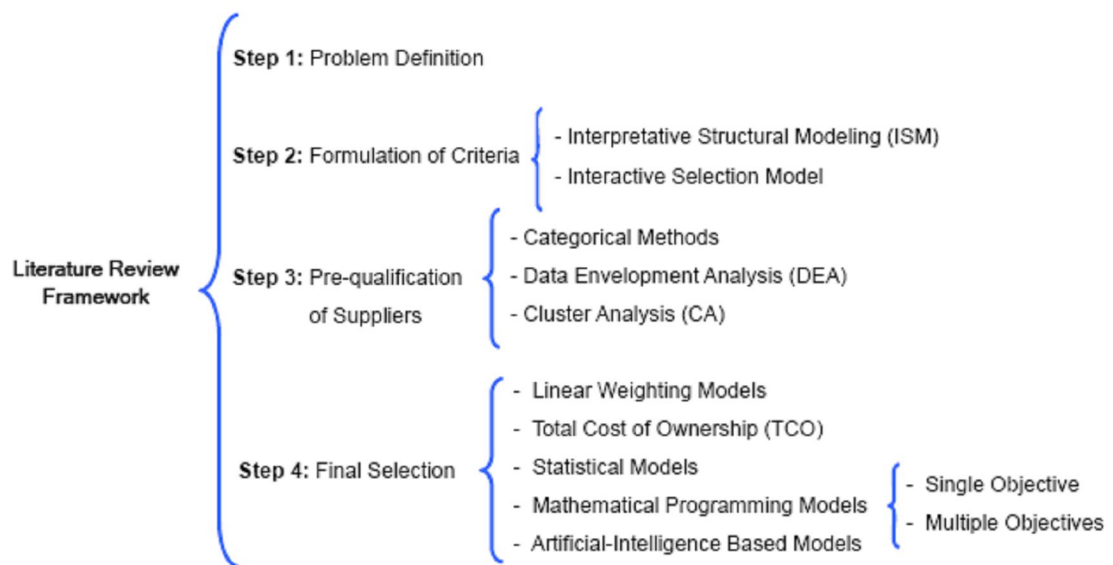


Figure 4. Decision models used in supplier selection (Mendoza, 2007)

Problem Definition and Formulation of Criteria

If a company needs any kind of goods or services, as a first step, it has to decide on whether to buy or not to buy the product (De Boer et al., 2001) and manufacture it by itself. If it decides to buy the product, it has to consider the performance of existing suppliers as well as the total number of suppliers to purchase. In order for the companies to make the right decision, they have to define their needs and search for the right suppliers that fulfill all their expectations.

The studies conducted in the late twentieth century shows the change in sourcing trend and in importance of selection criteria very clearly. Dickson (1966) examines the importance of supplier evaluation criteria, forms a questionnaire which is sent to purchasing agents and managers and presents 23 supplier attributes that are taken into consideration during the decision making process. Quality, cost and performance history are identified as the three most important criteria in supplier

selection. In their survey, Weber et al. (1991) classify all published papers according to the studied criteria and they identify quality, cost and on-time delivery as the most important supplier selection criteria in the evaluation of supplier performance.

Production facilities and capacity, technical capability and geographical location are also identified as important factors.

The comparison of these two studies is quite useful since the differences in ranking may reflect the changes due to the effects of globalization. Based on the two mentioned studies, Table 1 shows the change in importance of each criterion in supplier selection process.

Table 1. Supplier Selection Criteria

Rank		Criteria
Dickson [40]	Weber et al. [1]	
1	3	Quality
2	2	Delivery
3	10	Performance History
4	23	Warranties and Claim Policies
5	4	Production Facilities and Capabilities
6	1	Net Price
7	6	Technical Capability
8	9	Financial Position
9	16	Bidding Procedural Compliance
10	18	Communication System
11	8	Reputation and Position in Industry
12	21	Desire for Business
13	7	Management and Organization
14	14	Operational Controls
15	11	Repair Service
16	12	Attitude
17	20	Impression
18	13	Packaging Ability
19	17	Labor Relations Records
20	5	Geographical Location
21	22	Amount of Past Business
22	15	Training Aids
23	19	Reciprocal Arrangements

As Mendoza (2007) states in his study, the change in the rank of geographical location is the most important one. Recently, the globalization of the economy has

enabled the companies to choose suppliers from different countries in which the labor costs and other expenses are lower and the quality is the highest. In other words, internationalization of sourcing has become widely common. Another significant change is in the definition as well as in the meaning of price. Price is no longer considered the supplier's offer which includes freight charges and discounts. Today, it is replaced by total cost which may additionally include the inventory holding cost (Tempelmeier, 2002 as cited in Mendoza, 2007) and ordering cost (Ghodyspour and O'Brien, 1998).

In twenty first century, it is obvious that there is a myriad of factors that could be taken into account in supplier selection process. The replacement of domestic sourcing by an international one necessitates considering the criteria already defined in domestic sourcing and additional issues and recent global developments that might affect the competitiveness of both the supplier and the buyer. First, since globalization has led the companies to source internationally, the political, social, as well as economic environment in the countries have become important. The fluctuations in exchange rates, the international trade relations of countries, political intervention into international trade, cultural differences are some of the country-specific factors that has to be considered in addition to supplier-specific criteria. Second, due to global warming, the natural environment continues to be a challenging supply chain management issue and the environmental concerns of suppliers have been widely investigated by the regular audits performed by the buyers.

It is important to integrate the criteria that are firstly defined by Dickson (1966) and the studies conducted after the globalization period. The related international sourcing criteria are discussed in Chapter 5 in a detailed way.

Using the related literature and the opinions of a senior purchasing manager, Vokurka, Choobineh and Vadi (1996) develop an expert system that covers multiple phases in the supplier selection process and formulate supplier selection criteria. Additionally, Mandal and Deshmukh (1994) propose interpretative structural modeling (ISM) which could assist buyers in formulating and identifying criteria in a systematic approach. By separating dependent criteria from the independent ones, ISM identifies the step in the supplier selection process where the criteria must be considered.

Pre-qualification of Potential Suppliers

De Boer et al. (2001) define the pre-qualification as “the sorting rather than a ranking process of reducing the set of all suppliers to a smaller set of acceptable suppliers”. By eliminating the suppliers that do not meet buyer’s demand at all, this step enables the buyer to focus on the remaining ones in a more detailed manner. The techniques that are used for the pre-qualification step are categorical methods, data envelopment analysis and cluster analysis which are discussed further.

Categorical method is the most simple linear weighting model that assigns either good (+), neutral (0) or unsatisfactory (-) to each defined criteria for all suppliers based on historical data and the buyer’s experience, so that a total rate for each supplier is calculated. Although this technique is very straight-forward and intuitive, it depends heavily on human judgment and also weighs the criteria equally, which rarely happens in practice (De Boer et al., 2001). Nevertheless, the method can be useful if weights are assigned to the attributes and the -, 0, and + are coded as -1, 0 and 1 respectively (Ghodyspour and O’Brien, 1998).

Data Envelopment Analysis (DEA) is a mathematical programming technique that has been employed successfully for assessing the relative performance of a set of firms, usually called decision-making units (Bhutta and Huq, 2002). It is designed with the idea of the efficiency of a decision alternative. The alternatives are assessed based on benefit factors (output) in addition to cost factors (input). The efficiency of an alternative is defined as the ratio of the weighted sum of its outputs to the weighted sum of its inputs. For each supplier, the DEA method finds the most favorable set of weights that maximizes the supplier's efficiency rating. In this way DEA methods assist the buyer in classifying suppliers into two categories: the efficient suppliers and the inefficient suppliers (De Boer et al., 2001) and help decision makers to eliminate the inefficient ones.

Weber and Desai (1996) propose DEA for evaluation of suppliers that are already selected. Weber et al. (2000) integrate multi-objective programming (MOP) and DEA methods to develop supplier-order quantity solutions using MOP and then evaluating efficiency of these suppliers on multiple criteria using DEA. Additionally, by using DEA, Forker and Mendez (2001) benchmark the suppliers to identify the most efficient and those who are not on the efficient frontier. It is worth mentioning that although this method is used in the pre-qualification step, it is also effective in the final selection stage.

Cluster analysis is a basic statistical method which uses a classification algorithm to group a number of items which are described by a set of numerical attribute scores into a number of clusters such that the differences between items within a cluster are minimal and the differences between items from different clusters are maximal. The result is a classification of suppliers in clusters of comparable suppliers (De Boer et al., 2001). Teng and Jaramillo (2005) develop a

straight-forward and flexible model that considers five main clusters, namely delivery, quality, reliability, cost and flexibility, to reflect the performance of a global supplier in a textile and apparel supply chain.

Final Selection

Literature emphasizes the final stage of supplier selection more than other three steps. As a result of this step, the answers of the two questions, “Which suppliers are best and how much should be purchased from each selected supplier?” are reached.

Linear weighting models enable the decision makers to weigh each criterion and obtain a single figure for each supplier. By multiplying criteria ratings by their weights and summing them all, a single score for each supplier is reached. As a result, the supplier with the highest score is selected (De Boer et al., 2001). Monczka and Trecha (1988) propose a linear weighting technique for assessing supplier performance. In their study, they consider many supplier performance attributes simultaneously and weigh those attributes based on the opinions of sourcing managers.

The weighted point model is the most frequently used approach for single sourcing. This method allows the decision makers to weigh a wide range of factors such as quality, price, delivery according to their relative importance (Teng and Jaramillo, 2005). However, the performance measures for these factors must be expressed in standard units to give an unbiased score which constitutes the major drawback (Willis et al., 1993).

The Analytic Hierarchy Process (AHP), introduced by Saaty (1977) is another linear weighting model that gives the ability to incorporate both qualitative and

quantitative factors in decision making process. It facilitates decision making by organizing perceptions, feelings, judgments and memories into a multi-level hierarchic structure that exhibits the forces that influence a decision (Bayazit, 2005).

The AHP procedure begins with the development of a hierarchical structure of a supplier selection problem. Once the hierarchy has been constructed, the decision makers evaluate the elements by making pair-wise comparisons. In AHP, pair-wise comparison matrices, based on comparing the relative importance or preferences of two elements with respect to element in the level above, are generated by verbal judgments (Saaty, 1990).

Nydick and Hill (1992) employ the AHP as a framework to formalize the assessment of tradeoffs between the conflicting selection factors related with different suppliers' offers. Barbarosoğlu and Yazgaç (1997) design an AHP model to solve the supplier selection problem in the Turkish industry and apply this model to the leading electromotor manufacturer in Turkey. They develop a five-level hierarchy in which the top level stands for the main mission of the supplier selection and the alternative suppliers constitute the last level. The objectives are defined as performance assessment, business structure/manufacturing capability assessment and quality system assessment. Suresh and Kamana (2005) develop a vendor evaluation model for a research institute in India by using the principle of AHP for prioritizing the factors involved in evaluation. They claim that the new system would generate an index for the supplier so that the competing suppliers can be judged based on their individual score. Additionally, the suggested system would put forward the idea of a centralized database wherein all the data about the supplier and his performance could be stored.

Multiple Attribute Utility Analysis (MAUT) is also considered a linear weighting technique. It is targeted in solving a complex problem of a simple hierarchy and subjectively evaluating a wide range of tangible as well as intangible criteria in an uncertain environment. It is used to assess the decision-maker's preference structure and model it mathematically with a multiple attribute utility function. This multiple utility function is then applied to help the decision maker in reaching an optimal decision. Min (1994) states that the main advantage of MAUT is its ability to deal with both deterministic and stochastic decision environments and proposes multiple attribute utility theory (MAUT) as a useful tool for supplier selection that can effectively deal with both quantitative and qualitative factors in multiple criteria.

Total Cost of Ownership (TCO)-based models consider all quantifiable expenses in the supplier selection which are incurred throughout the purchased item's life cycle. They consist of summarization and quantification of all or several expenses related to the choice of suppliers and consequently adjusting or penalizing the unit price quoted by the supplier with this figure. The cost-ratio method is a complicated method in which the cost of each criterion is calculated as a percentage of the total purchased value and a net adjusted cost for each supplier is obtained. As can be seen, this method requires a great deal of financial information (De Boer et al., 2001). The cost-ratio method is not widely used because of its complexity and requirement for standard cost-analysis system (Teng and Jaramillo, 2005). Although its complexity and lack of readily available accounting and costing data in many organizations may limit its usage, it provides many benefits. It enhances the buyer's understanding of supplier performance issues and cost structure. Additionally, it

enables a long-term purchasing orientation by putting emphasis on TCO rather than just price (Ellram, 1994).

Statistical models deal with the stochastic uncertainty related to the vendor choice. Although stochastic uncertainty exists in most types of purchasing conditions, only few supplier selection models can handle this problem. The published statistical models only accommodate for uncertainty based on one criterion at a time (De Boer et al., 2001). Ronen and Trietsch (1988) develop a decision support system for supplier choice and ordering policy in the context of a large on/off project where the order lead time is uncertain.

Artificial Intelligence (AI)-based models are computer-based systems trained by the decision maker using historical data and experience. In this way, the system is able to replicate certain human decisions. Using these types of systems, the complexity as well as uncertainty involved in the supplier selection process are handled easily (Mendoza, 2007). Albino and Garavelli (1998) present a decision support system for rating subcontractors in a construction environment. Khoo et al. (1998) discuss the concept of internet-based technology, intelligent software agents, to automate procurement decisions. Vokurka et al. (1996) develop a system that incorporates the strategic partnership considerations of supplier selection. There are only few examples of AI methods applied to the supplier evaluation problem in the literature. Examples of methods based on AI technology that have been applied to supplier selection include neural networks and case-based reasoning systems.

An Artificial Neural Network (ANN) is an information processing paradigm in which the key issue is the novel structure of the information processing system. It is composed of a large number of highly interconnected processing elements working in unison to solve specific problems (De Boer et al., 2001). Using the ANN for

supplier selection consists of two functions: one is the function measuring and evaluating performance of purchasing and storing the evaluation in a database to provide data sources to neural network (Wei et al., 1997). The other is the function using neural network to select suppliers. Although ANNs require software and qualified personnel, it can cope better with complexity and uncertainty than other methods since it is designed to be more like human judgement functioning (Mendoza, 2007).

Case-based-reasoning (CBR) system is a software-driven database that solves problems by making use of previous similar situations and reusing information and knowledge related with such situations. It is still new however since it is capable of using information from previous negotiations and the system is very easily trained. It receives attention in supplier selection field (De Boer, 2001). Ng et al. (1995) develop a CBR system for the qualification of suppliers.

Mathematical programming (MP) models can be grouped as single objective and multiple objective models. In many studies, single objective techniques such as linear, nonlinear or mixed integer programming, in which one criterion is considered as the objective function and other criteria are taken into account as constraints, are used (Pan, 1989 and Gaballa, 1974) (as cited in Ghodyspour and Brien, 1998). Linear programming (LP) that seeks to maximize or minimize an objective, has been applied to military, industrial, financial, marketing, accounting and agricultural problems in the past 50 years. There are some constraints that limit the degree to which the objective can be obtained and there exists some alternatives to choose from (Heizer and Render, 2006, p. 242).

In LP models regarding the supplier selection and order allocation problem, the objective is generally maximizing profit or minimizing cost of the company.

Moore and Fearon (1973) (as cited in Mendoza, 2007) state that price, quality and delivery are important criteria for supplier selection. They discuss the use of linear programming in the decision making process. Anthony and Buffa (1977) (as cited in Mendoza, 2007) develop a single objective LP model to support strategic purchasing scheduling. This model minimizes the total cost while considering purchasing budget and supplier's capacities as constraints. Turner (1988) employs a single objective LP model for evaluating alternative suppliers and allocating order quantities among them. This model minimizes the total discounted price by considering constraints, supplier's capacities, maximum and minimum order quantities, demand and regional allocated bounds. Pan (1989) proposes multiple sourcing to improve the reliability of supply for critical materials. He formulates a single objective LP model to select suppliers based on price, quality and service.

Linear, integer and goal programming all assume that a problem's objective function and constraints are linear. On the other hand, nonlinear programming is the case in which objectives or constraints are nonlinear (Heizer and Render, 2006, p.479). Analyzing the problem of determining order quantities for multiple items by considering all-units quantity discounts on the purchasing price, Pirkul and Aras (1985) propose a nonlinear mathematical model with the objective of minimizing purchasing, holding and ordering costs. Additionally, they develop a Lagrangian relaxation procedure to solve the model. Aguezzoul and Ladet (2007) develop a nonlinear multi-objective programming approach of selecting suppliers and allocating the order quantity among them, integrating transportation policies. The model seeks to minimize the total product cost and the lead time simultaneously.

An integer programming is very similar to LP in that both of these models have constraints and an objective function. The only difference is that one or more of

the decision variables has to take an integer value in the final solution. There are three kinds of integer programming problems: pure integer programming problems in which all variables are required to have integer values; mixed-integer programming problems in which some of the decision variables are required to have integer values; and 0-1 integer programming problems in which all the decision variables must have integer solution values of 0 or 1 (Heizer and Render, 2006, p. 452). Bender et al. (1985) apply single objective programming to develop a commercial computerized model for supplier selection at IBM. They employ mixed integer programming to minimize purchasing, transportation and inventory costs. Narasimhan and Stoyhoff (1986) apply a single objective mixed integer programming model to a large manufacturing firm to optimize the allocation procurement for a group of suppliers. Chaudry et al. (1993) use mixed integer linear programming to minimize the total cost of supplier selection by considering price breaks. Dahel (2003) employs a multi-objective mixed integer programming approach to simultaneously determine the number of vendors to source from and the order quantities to allocate to these vendors in a multi-item, multiple sourcing environment. This process is driven by the price, delivery and quality objectives of the buyer and subject to the capacity constraints of the vendors.

Dynamic programming is a quantitative analysis technique that breaks a difficult problem into sub-problems, which are then evaluated by stages. Unlike LP, there is no algorithm that can be programmed to solve all problems. Additionally, it differs from LP in that LP gives one time period solutions. On the other hand, dynamic programming uses a multistage approach. The optimal solution over a one-year time horizon can be achieved by breaking the problem into 12 smaller one-month horizon problems and to solve each of these optimally (Heizer and Render, 2006, CD-ROM).

Alidaee and Kochenberger (2005) develop a dynamic programming algorithm that efficiently solves Rosenblatt et al.'s (1998) formulation.

In today's business environment, profit maximization or cost minimization are not the only objectives of the company. The shortcoming of MP techniques such as linear and integer programming is that their objective function is measured in one dimension only. Therefore, it is not possible for LP to have multiple goals if they are not measured in the same units. Multiple objective models deal with optimization problems involving two or more conflicting criteria (Mendoza, 2007).

Goal programming is a useful technique that has been developed to supplement LP. Instead of maximizing or minimizing the objective function directly, goal programming minimizes the deviations between the set goals and what can be actually achieved within the given constraints (Heizer and Render, 2006, p.468). Buffa and Jackson (1983) present a multi-criteria linear goal programming model that considers two set of factors. In the first set, supplier attributes include quality, price, service experience and deliveries. In the second set, the buyer's specifications include material requirements and safety stock. Chaudry et al. (1991) suggest the use of goal programming to select suppliers and allocate specific order quantities to these suppliers. The criteria considered in their model are lead time, service and quality performance. Karpak et al. (1999) use visual interacting goal programming as a tool to approach the supplier selection problem.

Weber and Current (1993) use multi-objective mixed integer programming to minimize the total purchasing price, late deliveries and rejected units. An actual case is used to illustrate the model. Weber and Ellram (1992) employ multi-objective programming in a just-in-time environment considering the simultaneous trade-offs of price, delivery and quality. Narasimhan et al. (1983) propose a multi-objective

programming model to select suppliers and allocate order quantities to them. They assume that the relative importance of supplier selection criteria varies according to the product's life cycle. The resulting order quantities are determined after a bidding process.

Multi-objective analysis has several advantages over single objective analysis. For example, it allows the various criteria to be evaluated in their natural units of measurement and therefore, eliminate the necessity of transforming them to a common unit of measurement such as dollars. Another major advantage of multi-objective techniques is that they provide a methodology to analyze the impacts of strategic policy decisions. Such decisions frequently entail a reordering of the priorities on a firm's objectives (Weber and Current, 1993).

Given an appropriate decision setting, MP allows the decision-maker to formulate the decision problem in terms of a mathematical objective function that subsequently needs to be maximized or minimized by varying the values of the variables in the objective function. On the one hand, it may be argued that MP models are more objective than rating models because they force the decision-maker to explicitly state the objective function. On the other hand, MP models often consider only the quantitative criteria. Many of the MP models assume predetermined levels on quality, service and delivery constraints. Weber and Current (1993) overcome this problem by using more complex weighting and constraint methods and presenting tradeoff curves among the multiple objectives as decision support to purchasing managers.

Although MP models can assign different weights to various criteria, they also have problems in involving qualitative factors. Therefore, both single and multiple objective MP models applied to supplier selection have problems in

including qualitative criteria which are very important in this decision making process (Ghodyspour and O'Brien, 1998).

Hybrid models have been applied to deal with the supplier selection problem in order to cope with this situation. Ghodyspour and O'Brien (1998) develop an integrated AHP and LP model to help managers consider both tangible and intangible factors in the purchasing activity in a systematic approach and to optimize order allocation among suppliers. Cebi and Bayraktar (2003) propose the AHP to evaluate the relative importance weightings of the suppliers with respect to the evaluation criteria such as lead time, problem solving skill and reputation. The weightings of the suppliers are used as coefficients of the objective function of an integrated lexicographic goal programming model. Percin (2006) integrates AHP and multi-objective pre-emptive goal programming (PGP) to consider both quantitative and qualitative factors such as defect rate and rate of late-order delivery. Kokangül and Susuz (2009) integrate AHP and non-linear integer and multi-objective programming to determine the best supplier and to allocate the optimum order quantity among selected suppliers under the constraints such as quantity discount, demand, capacity and budget. The objectives of the mathematical models developed in this study are (1) maximizing the total value of purchase (TVP), (2) minimizing the total cost of purchase (TCP) or (3) maximizing TVP and minimizing TCP at the same time. Sanayei et al. (2008) propose an integrated MAUT approach and an LP model for rating and choosing the best suppliers and identifying the optimum order quantities among the selected suppliers in order to maximize total additive utility. They consider not only tangible as well as intangible criteria but also the probabilistic nature of supplier performance. Ramanathan (2007) highlights how DEA could be beneficially used to incorporate the powers of broadly employed

objective (namely TCO) and subjective (namely AHP) techniques for supplier evaluation. They use TCO to consider the quantitative factor of cost and the AHP to take into account a mix of qualitative criteria. Additionally, the use of three different kinds of DEA models are illustrated, namely the traditional DEA model, super efficiency model and the assurance region model to combine the results of TCO and AHP. Yu and Tsai (2008) propose a framework that integrates AHP and integer programming to rate suppliers' performance via cost, delivery, service and environment and then to allocate periodical purchases. They state that the rating weights of criteria should be flexibly considered in peak and off seasons to meet actual requirements and develop a flexible and objective method accordingly.

In this work, international supplier selection problem is analyzed via a hybrid model utilizing AHP and LP techniques. AHP systematically prioritizes the set of supplier-specific as well as country-specific criteria and derives the relative weights for each criterion and the alternatives. Weights of the criteria are derived based on the decision maker's pair-wise comparison of the criteria. The decision maker uses his own preferences, judgment, experience and expertise in making the comparisons. For this purpose, AHP is regarded as one of the ideal methods for the supplier selection problem (Bello, 2003) (as cited in Kağnıcıoğlu, 2007). LP selects the "best" suppliers and allocates the optimum order quantity among them so that the buyer's total value of purchasing will be maximized. By using these two models together, the subjectivity is included in the optimization problem which is the most criticized part of LP. Consequently, the two-stage model is implemented in an Australian manufacturing company.

CHAPTER V

METHODOLOGY

The thesis focuses on international trade and international supplier selection with the objective of making more effective decisions through the use of optimization techniques. In an effort to maximize buyer's total value of purchasing (TVP), as a first step, the comprehensive as well as unique selection criteria are determined. Second, the weights of the criteria are calculated by using the Analytic Hierarchy Process (AHP) which allows to make inter-cultural evaluations of prioritizing supplier selection criteria due to the differences in companies' sourcing strategies. Third, the suppliers are rated based on the decision maker's pair-wise comparison in addition to real quantitative data. The overall weights of each supplier are reached by incorporating the weight of each criterion with the supplier's rating. Finally, in order to maximize TVP, the orders are split among the best suppliers by employing the Linear Programming (LP) technique. These five steps are summarized in Figure 5 and elaborated further.

In the methodology of this thesis, a modified version of Ghodsypour and O'Brien's (1998) design method is followed. However, it must be mentioned that the focus of the studies are different. In the thesis, the application of the algorithm focuses on international trade and international supplier selection rather than using optimization techniques. Hence, supplier-specific as well as country-specific factors are taken into consideration. Owing to that fact, the criteria selected are also significantly different.

The designed model will be used by manufacturers as well as traders who aim to source a direct material from multiple external suppliers. Although it deals with a single item, depending on the availability of data, it can easily be converted to handle multi-items.

Before discussing the five steps in detail, the techniques used in the study, namely AHP and LP, and the objective of developing a hybrid model will be discussed.

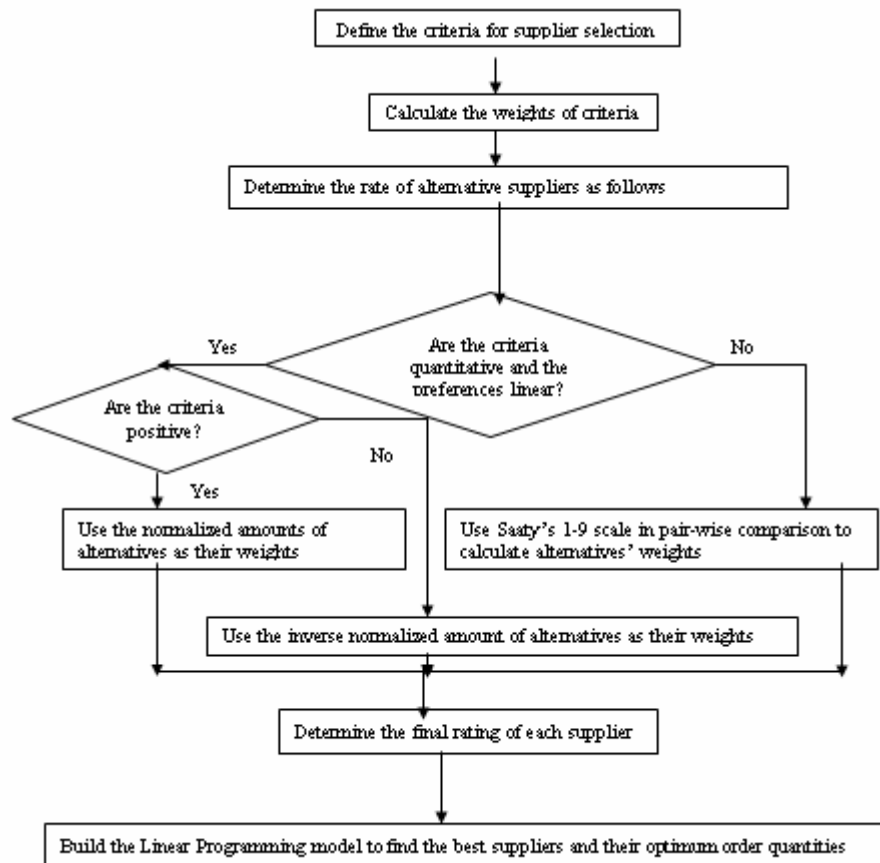


Figure 5. Supplier selection algorithm in multiple sourcing (adapted from Ghodyspour and Brien, 1998)

The Analytic Hierarchy Process (AHP)

AHP is a multi-criteria subjective decision making tool developed by Saaty (1977) that evaluates and weighs a number of factors and sub-factors which affect the final decision (Figure 6). It decomposes an unstructured problem into a set of qualitative as well as quantitative criteria and sub criteria and transposes it into a multilevel hierarchic form. It is a structured as well as subjective decision making process. Its being structured enables one to see the whole picture clearly and to minimize the possibility of overlaps (Bayazit, 2005).

AHP serves the purpose of calculating relative priority weights of a sufficient number of factors based on decision maker's preferences. Unlike the subjective and priori weight assignments in a number of multi-attribute decision models, AHP calculates factor weights systematically throughout the process itself which reduces bias and subjectivity significantly. Using the same hierarchy and the criteria, one might end up with different factor weights depending on the strategies or preferences of the decision makers (Saaty, 1990).

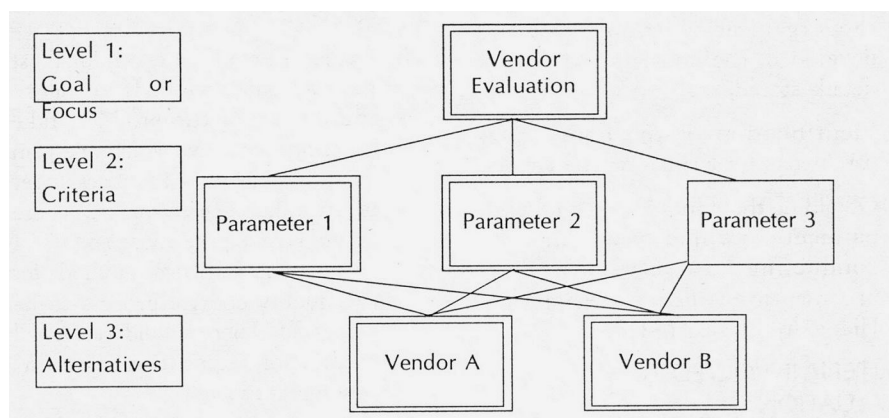


Figure 6. Hierarchy in AHP (Suresh Babu and Kamana, 2005)

In an AHP model, a hierarchy is developed where the highest level is the overall goal followed by factors and sub-factors respectively, down the hierarchy. The factors are compared and evaluated by the decision maker by constructing pair-wise comparison matrices for each hierarchy level. Pair-wise comparisons focus only on two factors which make the quantification of criteria easier and more precise. Instead of estimating the weight of a certain factor among a number of factors, the decision maker answers the question of 'How important is factor A compared to factor B in reaching the final goal?' The responses are evaluated using a scale of 1 (equally important) to 9 (extremely important) as suggested by Miller (1956) (Table 2). The comparisons are reciprocal. If factor A compared to factor B is rated 9 then B compared to A is rated 1/9 (extremely less important). After comparing all possible pairs, mathematical operations are applied to the comparison matrix to obtain the relative priorities (weights) for each factor. Various matrices are prepared to evaluate the criteria at each level of the hierarchy. Matrices that show the pair-wise comparisons of the decision maker will be checked for inconsistency to validate the responses of the decision maker (Saaty, 1990).

Priority weights that will be derived based on the pair-wise comparisons of the decision maker (the buyer) will be used as input parameters of the LP objective function.

Linear Programming (LP)

Decision making situations such as global supplier selection and order allocation involve multiple factors as well as constraints that interact. Therefore, an optimization tool that would consider the simultaneous interactions such as LP would

be appropriate for supplier selection. Linear programming is a commonly employed mathematical modeling technique designed to aid managers in planning and decision making relative to resource allocation. There are four basic properties of LP problems. Firstly, they require an objective function which seeks to maximize or minimize a specific quantity like cost or profit. Secondly, there must be one or more constraints that limit the resources of the problem so that a quantity could be maximized or minimized subject to limited resources. Thirdly, alternative courses of action are required to choose from. Lastly, the objective as well as restrictions in LP problems must be stated in terms of linear equations or inequalities (Heizer and Render, 2006, p. 242).

Technically, an LP problem relies on five basic principles which are certainty, proportionality, additivity, divisibility and nonnegativity. Firstly, it is assumed that numbers in the objective function and constraints are known with certainty and do not change during the period being studied. Secondly, proportionality is assumed to exist in the objective function and constraints. The third principle requires the total of all activities equal the sum of the individual activities. The divisibility assumption allows solution values to be divisible and take any fractional value. Finally, the solution values are assumed to be nonnegative (Heizer and Render, 2006, p. 242). In the proposed model, after the trade-off between qualitative and quantitative factors is made and overall weights of suppliers are calculated by using AHP, these weights are applied as coefficients of an objective function in LP that allocates order quantities between suppliers such that the objective function, TVP, becomes maximum.

The integrated AHP-LP model offers a systematic, straight-forward approach to the international supplier selection problem. It enables the decision makers to

include their own subjective ideas when they deal with the multiple sourcing issue. In this respect, the role of AHP is crucial in operationalizing and evaluating both tangible as well as intangible factors.

Supplier Selection Criteria

In developing the criteria and the related hierarchy, primary and secondary sources are utilized. Literature is compiled and extended by global and contemporary aspects such as international trade, supplier's environmental concern and country's globalization. Additionally, interviews are conducted with the Turkish and Australian company decision makers in order to define common criteria that could be valid for the sourcing process in different countries.

There are many studies in the literature with different purposes regarding supplier selection. Many of those studies focus on domestic sourcing and define supplier selection criteria accordingly. As already mentioned in Chapter 3, Dickson (1966) presents 23 supplier attributes which are highly important in especially local sourcing. In Barbarosoğlu and Yazgaç's (1997) study, the factors affecting supplier selection are grouped under three main categories: performance assessment, business structure and quality system assessment. Çebi and Bayraktar (2003) develop logistics, technology, business and relationship as the criteria of the supplier selection problem. Suresh Babu and Kamana (2005) define quality, delivery, price, technology, financial stability, people, service, strategic business partnership in addition to safety and environmental concern as the affecting factors for the research institute supplier selection. On the other hand, some of those related studies consider international sourcing. Therefore, they involve the international trade-related factors

as well. In addition to the common criteria such as cost and quality, Chan et al. (2008) discuss some of the important decision variables which can play a critical role in case of the international sourcing. The importance of the political-economic environment, geographical location in global supplier selection has also been pointed out and fuzzy based Analytic Hierarchy Process is employed to deal with the tangible as well as intangible factors. In Min et al's study (1998), using MAUT and LP techniques, the effect of perceived risks in international trade is also taken into account. Clearly, international supplier selection is still an issue that requires more attention due to the fast changing global environment and its effects on both supplier's and customer's competitiveness. Hence, the criteria that are determined in the past researches needs to be updated.

Relying on the studies discussed above and by extending the literature further, this thesis defines the decision criteria as financial terms, the supplier's quality management and profile, supplier's safety and environmental concerns, delivery and the global factors (see Figure 7) in order to reach the goal of selecting the best external suppliers in a multiple sourcing environment.

Financial terms is a vital criterion in evaluating the international supplier since the maximization of profit and minimization of cost is a supply chain strategy (Min, 1994). Before the decision makers decide on which suppliers to make the purchase order from, they particularly evaluate the suppliers according to the overall cost of receiving the product and the length of time interval that they can make the payment. Hence, total logistics cost and payment terms are determined as sub-criteria under financial terms and will be reviewed further.

It is not sufficient to consider only the purchase price when evaluating suppliers based on the cost to the company. There are also many other additional

costs that will lead to a significant change in the decision maker's estimation and therefore needs to be considered as well. Total logistics cost involves purchase price, import duties, freight cost and ordering cost as defined in Ghodyspour and Brien's study (2001). In the current global market, the firm must find a low cost supply base so that it can minimize its purchase price, import duties, documentation cost and freight cost (Min 1994, Chan et al., 2008).

Each country has set its international trade regulations and seeks to attract buyers from other countries to develop its economy. However, in order to protect its domestic industry, importing country imposes high tariffs on the goods and services purchased from foreign countries (Min, 1994). Although the tariff rate in many countries has significantly declined due to the effects of globalization, the decision maker should carefully estimate the additional charges before selecting its international supplier since tariff can lead to a substantial increase in purchase price. Additionally, the free trade agreements between countries must be investigated since these agreements enable the importers not to pay for the import duties.

The firm should also cautiously search for the freight terms and condition among different countries. The transport expenses, inventory cost, handling and packaging cost, insurance costs would be high as far as international sourcing is concerned.

The most critical issue in international trade process between a supplier and a buyer is the risk of payment of the delivered goods. The payment term is determined by both sides based on the foreign trade regulations of two countries, trust and the type as well as cost of product. Down payment is the ideal payment term for the exporter (supplier) since the payment is done before shipping the goods. However, it is quite risky for the importer (buyer) because after receiving the payment, the

supplier may not ship the goods or may not send products that match with the buyer's quality requirements. In cash against good type, the buyer makes the payment after the products are delivered and sold by the buyer. Although it seems quite advantageous for the buyer, there is a risk of increase in currency rates during the payment period. Additionally, there is no assurance for the supplier since the buyer may not make the payment. On the other hand, in order to prefer cash against documents, there must be a mutual trust relationship between the supplier and buyer since the banks are not involved in controlling if both sides strictly follow the agreement's requirements. Although it ties up the capital of the buyer, a letter of credit is highly preferred since it protects both the supplier and the buyer. The buyer ensures that the payment will certainly be made if the goods are shipped in accordance with the agreement. On the other hand, the supplier guarantees the delivered product matches perfectly with the requirements.

Taking all the criteria into consideration, as far as the buyer side is concerned in this thesis, it must be mentioned that the buyer should choose the supplier that offers him the longest time interval to make the payment.

The supplier's profile assists in finding the best international suppliers of a particular product. Companies should keep suppliers' information on files and gather information about its performance (Chan, 2008). At the same time, they should investigate potential suppliers and record their related information as well. The supplier's financial strength, its market reputation and position in industry, its capability to respond to changing customer demands, its ability to follow the recent developments in the industry, the ease of communication as well as the duration of close relationships are determined as the important issues affecting decision maker's thoughts and will be discussed respectively.

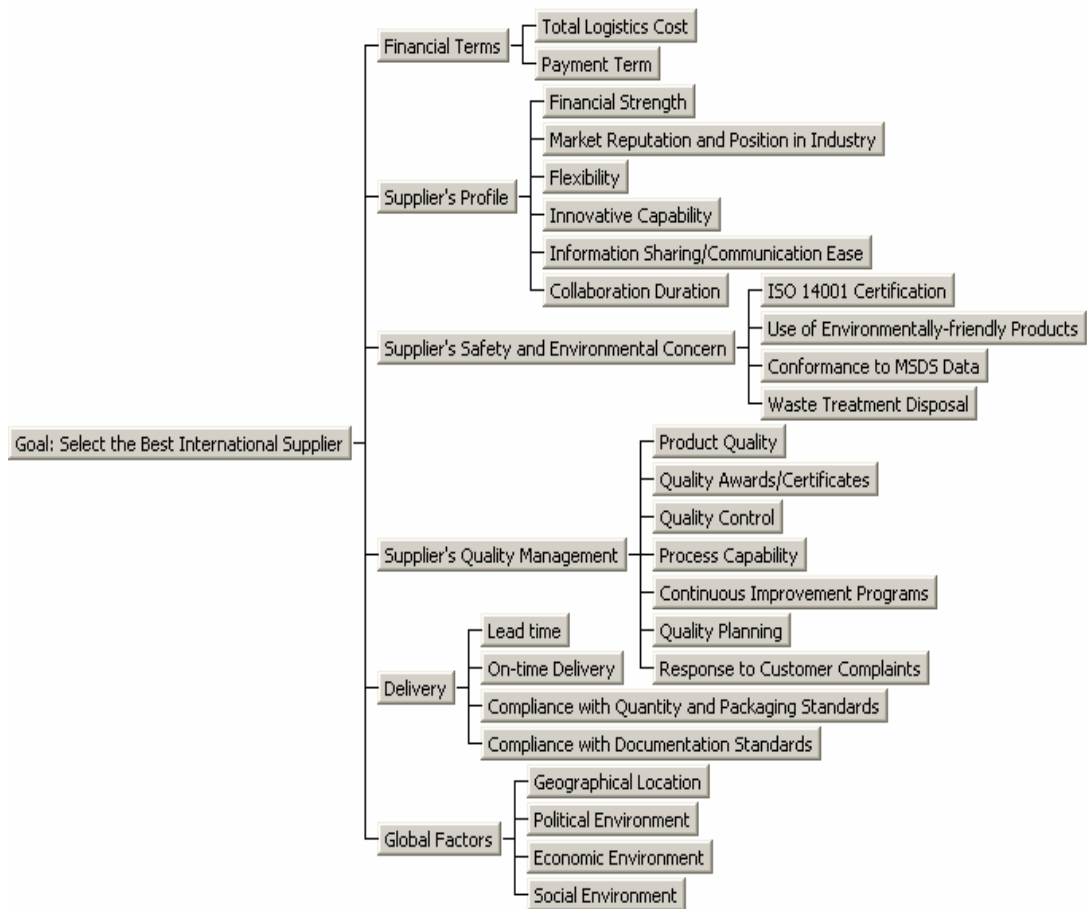


Figure 7. The hierarchy of international supplier selection criteria

The supplier's financial strength is one of the major indicators of its long term stability since it ensures that products will continue to be available (Kahraman et al., 2003). In their study, Suresh Babu and Kamana (2005) state that the supplier should have adequate funds to complete the project given and should be stable in terms of its finance for at least 3-5 years. In order to evaluate the suppliers according to their financial strength, the financial ratios of the firm, namely, the liquidity ratio, debt-equity ratio, interest coverage ratio, profitability ratio and coverage ratio are determined to be analyzed in a careful manner.

A good reputation in the market could be built by the discipline and honesty (Chan et al., 2008). Hence, the past relations of the supplier with other companies as well as its ability to make commercial relations and business references should be analyzed effectively. The position in the industry is also a significant factor that is directly related to the honesty of the supplier and might also give clues about the capacity of the supplier as well as the number of customers.

Perçin (2006) defines flexibility as “the firm’s response to customer expectations in a timely manner to support customer change-over/launches”. The supplier must be ready for the changes in customer demand, order frequency, price structure so that especially the urgent and uncertain demand of the buyer could be met. This requires flexible facilities in the firm, enough to adapt any future changes in design that may take place (Suresh Babu and Kamana, 2005).

The supplier’s innovative capability, in other words, ability to provide advanced technological and R&D support to produce a high quality product, is of primary concern in international supplier selection (Chan et al., 2008). Especially in some dynamic industries where the functions and properties of the products change very fast, the supplier should follow the sectoral trend very closely and update technology in the organization through research and development.

The long-term relation between supplier and buyer depends heavily on the ease of communication which is possible by efficient information sharing. Even if the supplier manufactures high quality products, it will be desired by the buyers if the supplier is good at communication and can keep up with the shortened lead time. This shows that the information flow is as important as the material flow and the use of information technology can set the supplier apart from its competitors. In order to exchange data such as purchase orders, invoices and provide real-time information

regarding product availability, inventory level, material requirements forecast, production and delivery schedules (Paulraj and Chen, 2007) and hence ensure seamless material flow, the role of inter-organizational information systems including direct computer-to-computer links with suppliers, simple Electronic Data Interchange (EDI) systems or shared technical databases are crucial (Min and Galle, 1999). These systems also decrease the affect of differences in languages, business customs and ethics on international sourcing and facilitate the transactions.

Lastly, collaboration duration that stands for the time period that the company and supplier work together needs to be considered as far as supplier's profile is concerned. Selecting among company's previous, existing suppliers and the potential ones for multiple sourcing, the company is expected to create bias for the previous ones considering the past relations.

Supplier's safety and environmental concern is another factor that has to be emphasized due particularly to the recent environmental changes in the world. The natural environment continues to be a challenging supply chain management issue. Additionally, legal as well as public pressure on protection of environment and pollution reduction is increasing which results in many companies beginning to link the particular supply chain management strategy adopted with the environmental management and their supplier's environmental performance. In this respect, as stated by Carter and Narasimhan (1996), the role of purchasing function is important since it can manage its suppliers' environmental policy effectively by auditing for conformance to environmental procedures. Additionally, especially in single sourcing cases, buyers reduce the number of suppliers and establish closer relationships with the remaining companies. Therefore, suppliers must look for ways of differentiating themselves from competitors. Humphreys et al.'s study (2003) that

develops an environmental framework in order to incorporate environmental factors into the supplier selection process is useful for both buyers and suppliers. Humphreys et al.'s study (2003) that develops an environmental framework (see Figure 8) in order to incorporate environmental factors into the supplier selection process is useful for both buyers and suppliers.

The environmental criteria placed in the literature are discussed with sourcing as well as production managers. As a result, supplier's certificates, waste treatment/disposal, use of environmentally-friendly products and conformance to Materials Safety and Documentation Sheet (MSDS) are involved in the developed model.

The recent international formalization of ISO 14001 has begun to force some consensus about the management aspects that must be considered. If management anticipates new environmental issues, moves ahead of public pressure, integrates environmental concerns throughout the manufacturing process and supply chain and generally exhibits characteristics of environmental leadership, a more proactive orientation has been adopted. Extending these ideas to inter-organizational linkages along the supply chain, environmental regulation of both the firm and its suppliers remains an important factor that focuses management attention on environmental supply chain management (New and Westbrook, 2004, pg. 231). Hence, in recent years, waste treatment/disposal processes of the supplier; use of environmentally-friendly products; conformance to MSDS which also involves the safety policy of the supplier and requires controls for handling and storing of especially dangerous and poisonous materials are receiving increasing attention from decision makers of sourcing process.

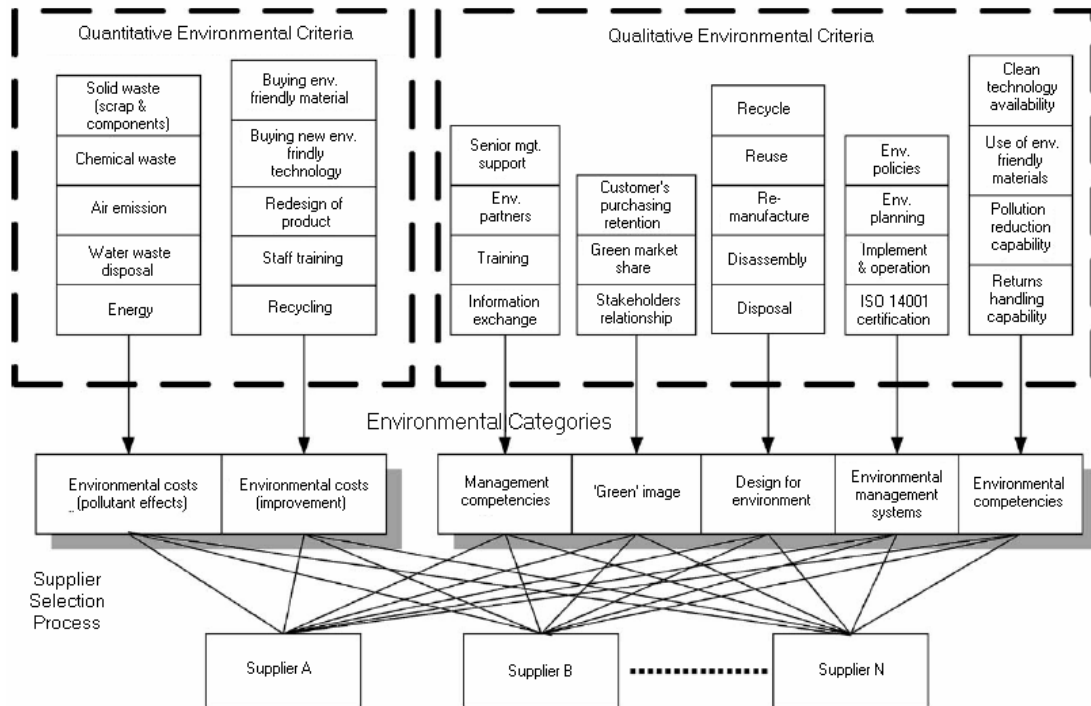


Figure 8. Environmental framework for incorporating environmental criteria into the supplier selection process (Humphreys et al., 2003)

Supplier's quality management is the core issue to be considered since the functions and the properties of the final product affect not only the relation between the supplier and the buyer but the whole supply chain. If the product does not match the requirements of the customer, the entire supply chain will be influenced in a negative way. This factor also constitutes one of the most important reasons for international sourcing.

Product quality is the most important proof of the supplier's performance. In order to stay competitive, suppliers must be able to consistently provide the required quality and avoid from product quality uncertainty resulting from variations in labor, materials, production process conditions. Suresh Babu and Kamana (2005) state that demerit rating and reliability score can be used to judge the product quality.

Additionally, there are different indices such as Cpk index to evaluate the quality of

supplier's product and ensure that the product created is within specified limits. The customers would also like to learn the number of units rejected by quality inspection which constitutes the key performance indicator (KPI) of supplier's manufacturing department.

The certificates/awards received by the supplier at the national or international level by virtue of the quality standards give validity and reliability to the processes followed by the supplier Suresh Babu and Kamana (2005). ISO 9001 (ISO 9001:2000) is now considered as the most commonly accepted standard for providing assurance about the quality of products a supplier provides to its customers. Certification to ISO 9001 enables suppliers to meet their quality management needs as well as customer requirements more efficiently and effectively which results in increased customer satisfaction (<http://www.isocert.co.uk/>). Depending on which industry the product belongs to, there are also additional certificates such as Halal, Kosher and HACCP certificates that the customer would want the supplier to receive.

Quality control is another significant issue due to the fact that the methods that the supplier uses to investigate the quality of the product, take corrective action and plan for improvements to reach better quality are crucial. There should be adequate cause and effect analysis and statistical methods in order to design products that satisfies or exceeds customer requirements and there should be an effective method of separating the non-confirming products (Suresh Babu and Kamana, 2005). Regular quality control evaluations must be done in different steps of the production process, let alone in the final step.

The role of supplier's quality planning is important since the firm could prevent any kind of quality problem by the quality policies as well as procedures it

sets. This requires records and documentation as well (Suresh Babu and Kamana, 2005). Barbarosoğlu and Yazgaç (1997) define compliance with company specifications and instructions, prototype pre-production controls, traceability of shipped products, the performance of quality improvement activities, the follow-up of the quality costs as well as the availability of a quality control database as the main indicators of the supplier's success in quality planning.

Process capability is another significant attribute that assists in investigating the supplier's capability to produce the quality products (Chan et al., 2008) by comparing the output of an in-control process to the specification limits using capability indices (<http://www.itl.nist.gov/>). By process capability indices such as Cp, Cpk (which could also be expressed in parts per million or ppm), Pp and Ppk (<http://www.isixsigma.com/>), the process's ability to create a product within specification limits is measured effectively. Hence, thanks to availability and consistent application of these indices, the regular factory visits which are quite expensive due to the large distance between countries could be decreased since the buyer could observe the performance as well as consistency of the process easily by analyzing these rates.

Considering today's fast changing customer requirements, continuous improvement programs like Kaizen and Six Sigma should also be emphasized since they seek to improve working conditions as well as any kind of activities in the organization. By improving standardized activities of efficiency and processes, Kaizen aims to eliminate waste and incorporate efficiency (Europe Japan Center, 2000). Similarly, Six Sigma identifies and prevents defects in manufacturing and other processes by utilizing information as well as statistical analysis (<http://www.isixsigma.com/>). These programs assist suppliers in focusing on

customer requirements and ensuring high quality product, providing relevant information for timely action, building relationships based on mutual benefit and continually improving processes and products.

It is obvious that the supplier's quality management is not only related to the product quality but with the whole work it provides. Hence, another important factor regarding quality management is the supplier's response to customer complaints. The supplier has to make an effort to deal with customer complaints as much as it does to sell that product and must guarantee that the relationship between the buyer and its own customer is not damaged due to the product it supplied.

Delivery is another critical factor that becomes more and more important in international supplier selection. Because of especially the recent growth in on-line information systems that ease international operations in custom brokers and freight forwarders, the lead time required for purchasing process is shortening. Therefore, suppliers who are not responsive and cannot adapt to the information technologies will certainly lose their customers.

Lead time and on-time delivery are two main issues in successful implementation of Just-in-time (JIT) principles. The time interval to receive an order may be quite shorter when it is supplied from a supplier located in a very far country rather than very close ones. However, the lead time is not adequate to evaluate the supplier due to the probability that the product may not be delivered at the expected time. Min (1994) states that the buyer should assess the reliability of the supplier's commitment for on-time delivery. Additionally, the firm's compliance with packaging standards and predetermined order quantity must be considered.

Lastly, it is worth pointing out that there are many documents that are required to export a product and for the customs approval. If there is any missing

paper or any missing official signature when the product arrives at the customs of the receiving country, the product is kept at customs and the negotiations between the supplier and buyer continue until the problem is solved. This situation results in additional costs since the customs charge holding costs and if the imported product is a raw material, the production has to be delayed which impacts the delivery schedule of the buyer. In some cases, the consequence is much more severe. For instance, Australia pays significant attention to protecting its borders from any causes of threat and Fumigation Certificate is one of the indispensable import documents that shows the methyl bromide fumigation is done correctly. Fumigation is a method of pest control that completely fills an area with fumigants to suffocate or poison the pests within (Australian Quarantine and Inspection Service, 2009). Fumigation certificate provides evidence that the fumigation treatments of shipped goods have been performed in overseas countries prior to export. If this certificate is unavailable or not as required, the product is not taken inside the boundaries and quarantined by the Australian Quarantine and Inspection Service. This will result in both delays in receipt of the good and excessive additional holding cost. The possibility of incineration of the good also exists.

International supplier selection is much riskier than the domestic one due to additional factors affecting international sourcing. The condition that the supplier's attributes match the buyer's expectations does not mean that there will not be any problems occurring during the sourcing process. There is still a possibility of supply chain disruption due to the danger of interruption in transportation, economic and political developments, social environment which as a result indicate that the supplier's country-oriented factors must also be taken into account.

Global factors are considered as a combination of geographical location, economic and political environment as well as social environment in the supplier's country. These sub-criteria will be discussed further in a detailed manner.

The geographical location of the supplier's country is crucial since it has a tremendous effect on supply chain. For instance, the supplier may be located in Taiwan and export to Turkey. In that case, the products have to be transported through different countries and any interruption in transportation due to the conflicts between the countries the product is transported through until it is delivered to Turkey might lead to delays, which poses a significant problem especially in just-in-time production systems. Hence, the geographical location of the supplier's country must be evaluated carefully along with the route of transportation and the risk of disruption in the supply chain might be eliminated in this way.

Another important point regarding geographical location is that by sourcing from suppliers in differently located countries, the company guarantees that alternate suppliers they choose are truly divorced from the risks borne by their preferred counterparts. Take the case of a company that buys commodity semiconductor chips for use in one of its main products. Taiwan is the center of the commodity chip sector. If both the preferred and alternate suppliers are located there, the same earthquake or power failure could knock both simultaneously (Bosman, 2006). Hence, the role of the country's location is quite significant especially in multiple sourcing.

The economic environment of the supplier's country can also affect the international sourcing process since currency exchange rate, local price control, inflation rate are directly related with it. Particularly, the exchange rate of the currency may play an important role in evaluating the cost of the product as well as

transportation since different countries have their own currency and relative value of currencies change frequently (Chan et al., 2008). Carter and Vickery (1989) state that the use of exchange rate information in the supplier selection decision is important in order to achieve successful international sourcing. Due to unstable exchange rate fluctuations, two equally capable suppliers from different countries who quote the same US dollar equivalent price at a particular point in time can generate significantly different costs for the buyer over the extended life of a requirements contract (Carter and Vickery, 1989).

International trade relations of countries are also included in this sub-criterion. Each country has set its rules and regulations for international trade. While the government wants to attract buyers from other countries, they also impose high tariffs to protect its domestic suppliers. However, thanks to the globalization of trade, in order to stay competitive in the world, the governments have decreased tariff rates. Additionally, there are many countries that signed free trade agreements which enabled the importers to import a product without being imposed to tariffs. Hence, the decision maker might prefer the suppliers in countries where they do not have to pay high tariffs.

The political environment in the supplier's country and its attitude towards the business policies may affect the long-term relationship between supplier and the buyer (Chan et al., 2008). For instance, during the Beijing Olympic games in 2008, in an effort to reduce pollution and traffic congestion before, during and after the Olympic Games, the Chinese government implemented a variety of measures aimed at restricting and closing down heavy pollution industries. These measures had a detrimental effect especially on cargo transportation around that area as a result the international trade. Importers could not receive the ordered goods on time and their

relations with their own customers were also affected. This event indicates the strength of the government's power over international trade and stimulates decision makers to evaluate the political environment in a detailed way. Additionally, the differences in business policies must also be analyzed in a careful way (Chan et al., 2008) especially if the supplier and buyer are in countries where the regimes are different such as communist government in China and democratic government of India. As a result, the more stable government should be preferred since changing foreign policies may create big problems in maintaining relations with the supplier.

The social environment regarding cultural similarities within the country of the supplier and that of the buyer and the crime rate in supplier's country is also important in supplier selection process. Min (1994) states that since languages, business customs, ethics vary from country to country, the buyer should consider attributes such as cultural similarity, ethical standards in order to ensure effective communication and negotiation with the external supplier. The importance of information sharing in today's competitive environment has already mentioned while supplier's profile is discussed. However, in supplier's profile, regarding information sharing, supplier's attribute towards technology is mentioned. In this case, the ease of communication is linked with cultural similarities. Hence, cultural similarities and the supplier's tendency towards technological improvements are indispensable sides of communication ease and both should be investigated. Apart from cultural similarities, the buyer should choose the supplier situated in the area having less crime rate in order to prevent any disruption arising from country related factors.

Calculation of Criteria Weights

As the criteria, sub-criteria as well as their hierarchy are developed as a result of covering past research studies as well as conducting interviews with company decision makers, the weights of criteria are calculated further. For this purpose, a questionnaire that involves (see Appendix A) all the combinations of criteria/sub-criteria relationships and allows the decision maker to make pair-wise comparisons is formulated. Decision makers in the company especially Supply Chain Manager, Sourcing Manager as well as Production Manager are requested to compare the criteria and sub-criteria by assigning corresponding numerical values based on the relative importance of alternatives. Hence, each supplier selection criteria have first been compared against other criteria. Then, the AHP priorities using the computer software application Expert Choice is computed.

Although there are many scales that could be used for quantifying managerial judgments, the scale given in Table 2 is the standard used for AHP analysis. For example, if the buyer believes that quality is moderately more important than delivery, then this judgment is represented by a 3. On the other hand, if the buyer believes that delivery is moderately more important than quality, then a reciprocal value, which is in this example $1/3$, is assigned. Judgments are required for all the criterion comparisons, and for all the alternative comparisons for each criterion.

Table 2. Saaty’s Measurement Scale

Verbal Judgment or Preference	Numerical Rating
Extremely Preferred	9
Very Strongly Preferred	7
Strongly Preferred	5
Moderately Preferred	3
Equally Preferred	1
The intermediate values of 2, 4, 6 and 8 provide additional levels of discrimination.	

The decision maker completes various pair-wise comparison matrices for each level of the hierarchy developed in the AHP model. In each matrix, the decision maker compares the sub-factors of a criterion. For each matrix, it is adequate to fill out only the upper half of the matrix above the diagonal, since the lower part consists of the reciprocal values. The diagonal values are always “1” since at the diagonal a sub-factor is compared to itself. In filling out the entries, the decision maker asks the question “How important is criterion A compared to B in reaching the final goal?” As an example, in the matrix given below, the decision maker asks the question “How important is financial terms compared to the supplier’s profile?” in filling out the second entry of the first row. The response is “moderately preferred” which is assigned a numerical value of 3.

Rating Alternative Suppliers

This section summarizes the steps of the supplier rating model based on the work of Ghodyspour and O’Brien (1998).

If the values for alternative i and j are, respectively, w_i and w_j , the preference of alternative i to j is equal to w_i/w_j . Therefore, the pair-wise comparison matrix is

$$\begin{array}{cccc} w_1/w_1 & w_1/w_2 & \dots & w_1/w_n, \\ w_2/w_1 & w_2/w_2 & \dots & w_2/w_n, \\ & & \dots & \\ w_n/w_1 & w_n/w_2 & \dots & w_n/w_n. \end{array}$$

As this matrix is consistent, the weight of each element is its relative normalized amount:

$$\text{Weight of the } i^{\text{th}} \text{ element} = \frac{w_i}{\sum_{i=1}^n w_i}$$

The priority of alternative i to j for negative criteria, such as cost, is equal to w_j/w_i , then the pair-wise comparison matrix is

$$\begin{array}{cccc} w_1/w_1 & w_2/w_1 & \dots & w_n/w_1, \\ w_1/w_2 & w_2/w_2 & \dots & w_n/w_2, \\ & & \dots & \\ w_1/w_n & w_2/w_n & \dots & w_n/w_n. \end{array}$$

As this matrix is also consistent, the weight of elements are the normalized amounts of any columns, which is equal to the inverse normalized amount of the alternatives:

$$\text{Weight of } i^{\text{th}} \text{ element (for negative criteria)} = \frac{\left(\frac{1}{w_i}\right)}{\sum_{i=1}^n \left(\frac{1}{w_i}\right)}$$

Hence, this step can be rewritten as:

- Are criteria either qualitative or quantitative with nonlinear preferences? If yes, apply Saaty's 1-9 scale comparison to calculate their weights.
- Are criteria positive? Use their normalized amounts as their ratings.

If they are negative, apply their inverse normalized amounts as their weights.

Computation of Supplier Scores

The suppliers are evaluated by the decision makers with respect to each criterion. By multiplying the weight of each criterion with the score of the supplier for the corresponding criterion and taking the summation after all, the overall score of each supplier is calculated. As could be observed in the following section, w_i represents the final score of each supplier. If there were no supplier related constraint and the company aimed to find the best supplier (i.e. single sourcing), then the next step would be redundant. However, linear optimization model has to be built in the case of multiple sourcing.

Building the Linear Model

The linear programming (LP) model is formulated in order to select the supplier with the highest score (w_i) and to calculate the related optimal order quantities. The model is developed for single item multi-sourcing based on the availability of data.

However, it can be extended to include the multiple item case. The objective function and the constraints of this LP model are as follows:

Notations

x_i : Order quantity for the i^{th} supplier

w_i : Final preference weights for the i^{th} supplier

c_i : Unit logistics cost of the i^{th} supplier

D : Demand for the period

B : Total budget allocated for the given period

C_i : Capacity of the i^{th} supplier

Q_{imin} : Minimum order quantity of the i^{th} supplier

n : Number of suppliers

n_{min} : Minimum number of suppliers

n_{max} : Maximum number of suppliers

y_i : $\left\{ \begin{array}{l} 1 \text{ if } i^{\text{th}} \text{ supplier is selected} \\ 0 \text{ otherwise} \end{array} \right\}$

Objective function

The objective is to maximize the total value of purchasing (TVP). TVP is defined as the sum of each supplier preference value.

$$\text{Max } TVP = \sum_{i=1}^n w_i x_i$$

w_i stands for final preference weights for each supplier which is calculated by multiplying the weight of each criterion with the supplier score for the related criterion and summing them all. For instance, in order to calculate the preference weight of the first supplier, the weight of financial terms is multiplied by the supplier's rating for financial terms, the weight of supplier's delivery is multiplied by the supplier's rating for supplier's delivery and so forth. Finally, these results are

summed up and the overall score of the first supplier (w_1) is obtained. The overall score of the first supplier and the other ones can be seen in Figure 23 in Chapter VII.

Constraints

The important constraints of the problem can be defined as supplier's capacity, minimum order quantity, buyer's demand for the period, buyer's budget allocated for this item for a given period and the number of suppliers that the company aims to source from.

Capacity constraint

As supplier i can provide up to C_i units of the product, the order quantity (x_i) should be equal or less than the supplier capacity as follows:

$$x_i \leq C_i y_i \quad i = 1, 2, \dots, n.$$

On the other hand, the aggregate suppliers' capacity should be equal to or greater than the demand. Therefore,

$$\sum_{i=1}^n C_i \geq D$$

Demand constraint

The sum of the assigned order quantities allocated to n suppliers should meet the buyer's demand as stated below:

$$\sum_i x_i = D_i$$

Cost constraint

Cost plays an essential role in the international supplier selection process since the budget allocated for importing an item is not unlimited.

B is considered as total allocated budget. C_i is the unit logistics cost of the i^{th} supplier and it involves purchase price, ordering cost, freight cost and the import duties. Thus

$$\sum_i^n c_i x_i \leq B$$

Number of suppliers constraint

Understanding the trade-off between increasing the number of suppliers in order to alleviate any supply chain risk among suppliers and the additional cost of each supplier to the company, the number of suppliers constraint is defined as follows:

$$n_{\min} \leq \sum_i y_i \leq n_{\max}$$

Minimum order quantity constraint

At each order, the buyer has a minimum order limit and always gives an order above this limit which could be stated as:

$$Q_{i\min} y_i \leq x_i$$

The Linear programming model

The final integrated LP model can be shown as

$$\text{Max } TVP = \sum_{i=1}^n w_i x_i$$

Subject to: $x_i \leq C_i y_i$ $i = 1, \dots, n$

$$\sum_{i=1}^n C_i \geq D$$

$$\sum_i x_i = D$$

$$\sum_i^n c_i x_i \leq B$$

$$n_{\min} \leq \sum_i y_i \leq n_{\max}$$

$$Q_{i\min} y_i \leq x_i \quad i = 1, \dots, n$$

$$x_i \geq 0 \quad i = 1, \dots, n$$

$$y_i = 0 \text{ or } 1 \quad i = 1, \dots, n$$

The model is run to obtain the best suppliers and their optimal order quantities. Consequently, sensitivity analysis is performed in order to test the robustness of results to changes in the parameters. Analysis is based on changes in supplier evaluations and in the supplier related constraints which could be extended in the future by including changes in country related factors.

CHAPTER VI

INTER-CULTURAL EVALUATIONS OF PRIORITIZING SUPPLIER SELECTION CRITERIA

This chapter aims to discuss and compare the supplier selection evaluations of two companies in different countries by analyzing the importance given to the supplier selection criteria. Another aim is to observe the impact of globalization in different parts of the world by comparing these results with Dickson's (1966) results as well as Weber et al.'s study (1991).

In Chapter V, it is mentioned that the criteria are determined as a result of literature survey and interviews with company decision makers. In this chapter, these criteria weights assigned by different companies in different countries are compared by using AHP. Hence, the similarities as well as differences in supplier selection criteria ranking in different parts of the world are observed.

In order to achieve this purpose, two companies in two geographically distant countries; Australia and Turkey, are selected and their international supplier selection processes are investigated. The justification of country choices will be elaborated after discussing the Australian and Turkish foreign trade environment. Analyzing the international trade relations might give the tools to see the differences and similarities in sourcing process, as a result, the reasons of country selection.

The results cannot be generalized due to the number of companies analyzed. However, they can be an indication of the differences between two cultures and the changing trends in international trade. Furthermore, by utilizing the supplier selection tool developed, this study can be extended in the future and cover a whole

specific industry in both countries. Apart from Turkey and Australia, industries of different countries can also be chosen and the emphasis the decision makers put on each criterion can be compared.

General Outlook on Turkish Trade

Turkey, a country of approximately 72 million inhabitants, has an economy in transition, which is no longer highly dependent on agricultural activities in the rural areas, but more on a highly dynamic industrial complex in the major cities along with a developed services sector. The automobile and textile industries are the spearheads of Turkish foreign trade (<http://www.laposte-export-solutions.co.uk>). Although there is a rapid growth in both exports and imports, as could be analyzed from Tables 3 and 4, the country registers a high level of trade deficit because of its high energy dependence on Russia and its Middle East neighbors.

Looking at the suppliers of the Turkish market, it is widely seen that due to energy dependency of the country, Russia is the first import source for Turkey with a share of 15.5 percent. Germany is ranked the second with 9.3 percent, and China is the third with 7.8 percent. The United States is the fourth most important source of Turkish imports, with a share of 5.9 percent.

Table 3. Turkey's Top Ten Export Markets

Countries	Value (000 \$)	% share	Rank
Germany	12 958 895	9.8	1
Iraq	3 912 191	3.0	2
United Kingdom	8 168 650	6.2	3
Italy	7 816 821	5.9	4
Switzerland	2 857 127	2.2	5
France	6 622 261	5.0	6
Russia	6 481 663	4.9	7
USA	4 290 146	3.3	8
U.A.E	7 981 284	6.0	9
Spain	4 051 264	3.1	10
Total	132 002 612	100.0	

Source: <http://www.dtm.gov.tr>

Table 4. Turkey's Top Ten Import Sources

Countries	Value (000 \$)	% share	Rank
Russia	31 317 596	15.5	1
Germany	18 682 114	9.3	2
China	15 642 623	7.8	3
USA	11 971 409	5.9	4
Italy	11 008 455	5.5	5
France	9 021 719	4.5	6
Iran	8 199 594	4.1	7
Ukraine	6 106 808	3.0	8
United Kingdom	5 323 540	2.6	9
South Korea	4 089 879	2.0	10
Total	201 822 882	100.0	

Source: <http://www.dtm.gov.tr>

Trade played a minor role in the Turkish economy before 1980, but grew rapidly after economic reforms that promoted liberalization of foreign trade. These reforms were designed to remove price controls, decrease subsidies, reduce tariffs and promote exports. In addition to rapid growth in both exports and imports, the reforms

brought a change in the structure of foreign trade, and the predominant role of agricultural products came to an end with the emergence of a greater emphasis on industrial products (www.nationsencyclopedia.com/).

Turkey signed the General Agreement on Tariffs and Trade (GATT) in 1951 and became a party to the agreement. With the establishment of the World Trade Organization (WTO) as a result of the Uruguay Round in 1995, Turkey automatically became a founding member of the organization (www.dtm.gov.tr).

With the establishment of the WTO, Turkey has undertaken tariff reductions on industrial products to be implemented gradually within five years. However in the meantime, as a result of the Customs Union that covers industrial products and processed agricultural goods, established with the EU in 1995 and coming into force in 1996, Turkey began to apply the Community's Common Customs Tariffs on the imports of industrial goods which resulted in lower duty rates. The Customs Union enabled Turkey to increase its industrial production destined for exports, while at the same time to benefit from EU-origin foreign investment into the country (www.dtm.gov.tr).

Turkey is fully committed to the rules of the WTO as a founding member and actively participates in the multilateral trading system. Strengthening the WTO, through further liberalization and establishment of a fairer trading system is the essence of the external economic policy of Turkey (www.dtm.gov.tr).

The other defining aspect of Turkey's foreign relations has been its ties with the United States. Based on the common threat posed by the Soviet Union, Turkey joined NATO in 1952, ensuring close bilateral relations with Washington throughout the Cold War. In the post-Cold War environment, Turkey's geostrategic importance

shifted towards its proximity to the Middle East, the Caucasus and the Balkans (Bal, 2004, p.74).

After the late 1980s, Turkey began to increasingly cooperate with the leading economies of East Asia, particularly with Japan and South Korea, in a large number of industrial sectors ranging from the co-production of automotive and other transportation equipment such as high-speed train sets to electronic goods, home appliances, construction materials and military hardware (Bal, 2004, p.603).

The independence of the Turkic states of the Soviet Union in 1991, with whom Turkey shares a common cultural and linguistic heritage, allowed Turkey to extend its economic and political relations deep into Central Asia (Bal, 2004, p.462).

FTAs promote stronger trade and commercial ties between participating countries and open up opportunities for Australian exporters and investors to expand their business into key markets. They can speed up trade liberalization by delivering gains faster than through multilateral or regional processes.

In addition to being a World Trade Organization (WTO) member, Turkey has also entered a number of multilateral trade relationships to increase its presence in the world trade arena. It signed a free trade agreement with the European Free Trade Association (EFTA) in 1991. In 1992, Turkey and 10 other nations in the Black Sea region formed the Black Sea Economic Cooperation Organization (BSEC). Turkey is also a member of the Organization for Economic Cooperation (ECO) that covers Central Asian countries and the Organization of the Islamic Conference (OIC) (<http://www.nationsencyclopedia.com>).

Turkey signed free trade agreements (FTA) also with Israel, Romania, Macedonia, Croatia, Bulgaria, Bosnia Herzegovina, Tunisia and Palestine. It

continues to negotiate FTAs with Jordan, Lebanon, Faeroe Islands, Albania, South Africa, Mexico and Chile (<http://www.dtm.gov.tr>).

In recent years, besides its stance within the EU, the bilateral and regional perspective of Turkish foreign trade policy is equally important, considering that Turkey bridges different groups of countries with respect to their production patterns, economic and political structures, and different geographies and cultures.

Turkey devises regional oriented strategies with a view to further developing trade and investment and also contributing to the stability and welfare of the region including "The Neighboring and Surrounding Countries Strategy" and "The African Countries Strategy" initiated in 2000 and 2003 respectively (<http://www.dtm.gov.tr>). Turkey also makes efforts to achieve a liberalized world trade and beginning from its region, works to enhance its commercial and economic relations with its neighbors.

Turkey expects its trade policy to contribute to the economic and also political stability in its region. Towards that end, Turkey also pursues ambitious trade agendas from a regional perspective in organizations in which it is one of the members.

As a result of the developments observed in global arena during the last decade, the center of global economic system has started to shift to the Asia-Pacific region. This region has become an "attraction center" and 30 percent of global trade is being realized by the countries located in the region. The total trade volume of the region exceeded eight trillion dollars in 2007 (<http://www.dtm.gov.tr>). When intra-EU trade is excluded, five of the countries ranked in the first ten in the world trade league (China, Japan, South Korea, Singapore, Hong Kong) are located in this region. On the other hand, it is predicted that Asia-Pacific countries will be ranked as the first two of the world trade league and about half of the total global trade will be

intensified in this region by the year 2030. Additionally, two of the BRICs countries, which are expected to be the leader countries of the world economy in the coming decades, namely India and China, are located in this region.

Considering all these facts, Turkey has launched a trade development strategy towards the Asia Pacific region as of the beginning of the year 2005. This strategy incorporates countries of mainly the Far East and Pacific region, given the fact that the Near Eastern Asian countries are integrated within Turkey's development strategy implemented towards the neighboring and surrounding countries. In this respect, the "Agreement on Trade and Economic Cooperation", a framework agreement establishing the Joint Economic Committee (JEC) mechanism, was concluded with the Union of Myanmar and Laos (<http://www.dtm.gov.tr>). Additionally, governmental activities have also been conducted with the different countries in order to determine the ways of further promoting bilateral commercial and economic relations.

General Outlook on Australian Trade

Australia has a strong as well as competitive economy along with a stable, culturally diverse and democratic society. With a population of above 21 million, Australia is the only country to govern an entire continent. It is the earth's biggest island and the sixth-largest country in the world in land area (<http://www.mallesons.com>).

Due to the natural diversity of its large land mass, Australia is able to produce many goods internally and does not need to trade for them externally. However, international trade is considered an integral part of Australia's economic activity and it is widely perceived that despite its remoteness from large economies, Australia has

a very open economy with a commitment from the Australian Government to maintain the strong economic growth that has taken place since the early 1990s (<http://www.mallesons.com>).

In the United Nations Conference on Trade and Development (UNCTAD), Australia is ranked thirteenth among 110 countries according to the Trade and Development Index in which structural and institutional factors, trade policies and processes and the level of development of the countries are taken into consideration (<http://www.unctad.org>).

Trade liberalization, the lowering of tariffs and the removal of quotas and of restrictions on capital flows with the floating of the dollar was an integral component of the broader series of economic reforms that occurred during the 1980s and 1990s. The movements towards deregulation and trade liberalization began in the mid seventies. It accompanied large changes in the world economy, following on the breakdown of the Bretton Woods system of fixed exchange rates and the turmoil associated with the first oil price shock. These events, which were out of Australia's control, led to an increased consciousness that Australia faced an uncertain external environment. Australia needed to be competitive and responsive to maintain its place in the world. This continues to be the case today (Centre for International Economics, 2009).

Australia's tariff reductions over the 1970s, 80s and 90s have been among the major unilateral liberalizations in the world. Until the mid-1980s, Australia and New Zealand had the most protected manufacturing sectors among the members of the OECD. But in the space of generation, Australia's tariff walls were dismantled with the average level of industry protection, as measured by the effective rate of

assistance, falling from over 30 percent to under 5 percent between 1970 and 2001 (Centre for International Economics, 2009).

Since Australia exists in a continually changing world economy, it is affected by the consequences as well. The last decade has seen the rapid development of Asian countries, a massive expansion of capacity and demand occurring in China and India, a commodity price boom, expansion of world trade and the development of global production chains. Lately, the sub-prime inspired global financial crisis has experienced a substantial fall in global economic growth and rising unemployment, a large decline in world trade and the ending of the commodity price boom. Such changes have been creating challenges for its domestic industry (Centre for International Economics, 2009).

Australia has much to gain from developments over the next 20 years. With abundant reserves of mineral commodities, a highly skilled labor force and flexible economy, the structure of its economy is complementary to, rather than rival to, that of the emerging economies in its region. The economic reforms that occurred during the 1980s and 1990s have positioned Australia to take advantage of the opportunities that these developments will generate. The floating of the dollar; the deregulation of the financial markets; the reform of public enterprise; the decentralization of the industrial relations system; the introduction of competition policy and the reduction in trade barriers and industry protection have produced a much more flexible and resilient economy which is better placed than almost any other OECD country to weather the current global financial crisis (Centre for International Economics, 2009).

In history, Great Britain and the rest of Europe comprised Australia's largest trading partners due to the colonization by Great Britain, the British need for new

markets for manufactured goods as well as sources of raw materials and lastly, the cultural link between Australia and its “mother country”. However, after Great Britain joined the European Union, Australia lost many trading advantages with that country and shifted its international trade towards Asia and Pacific countries (<http://nationsencyclopedia.com>).

Table 5 and 6 indicate the trade relations between Australia and its top ten partners. It is widely seen that Australia has strong trade links especially with Southeast Asia, European Union and the United States. The exports to Japan where free trade agreements (FTA) are under negotiation, constitute the largest share of total exports. It is also worthwhile to note that the United States with which Australia signed FTA, is ranked the fourth. This indicates that the physical distance between countries is not an obstacle for trade partnership. As the imports are observed, it is seen that China is the number one import source of Australia, followed by the United States and Japan. Additionally, as Table 5 and 6 are observed, it is seen that, China, United States, United Kingdom, Germany and Korea are the common import sources of two countries.

Table 5. Australia’s Top 10 Export Markets, 2008 (AUD million)

	Goods	Services	Total	% share	Rank
Japan	50,755	2,418	53,173	19.1	1
China	32,347	4,749	37,096	13.3	2
Republic of Korea	18,391	1,843	20,234	7.3	3
United States	12,130	6,137	18,267	6.6	4
India	13,508	2,968	16,476	5.9	5
United Kingdom	9,332	4,750	14,082	5.1	6
New Zealand	9,345	3,416	12,761	4.6	7
Singapore	6,126	3,928	10,054	3.6	8
Taiwan	8,263	479	8,742	3.1	9
Thailand	5,340	965	6,305	2.3	10
Total exports	224,727	53,202	277,929	100.0	
of which: APEC	162,415	30,705	193,120	69.5	
ASEAN 10	22,924	8,519	31,443	11.3	
European Union 27	23,533	8,990	32,523	11.7	
OECD	117,730	24,503	142,233	51.2	

Source: DFAT STARS Database, 2009

Table 6. Australia's Top 10 Import Markets, 2008 (AUD million)

	Goods	Services	Total	% share	Rank
China	35,258	1,449	36,707	13.0	1
United States	26,696	9,781	36,477	12.9	2
Japan	20,238	2,601	22,839	8.1	3
Singapore	16,187	4,772	20,959	7.4	4
United Kingdom	9,955	4,411	14,366	5.1	5
Germany	11,351	1,237	12,588	4.4	6
Thailand	10,150	1,821	11,971	4.2	7
New Zealand	7,603	2,573	10,176	3.6	8
Malaysia	8,958	1,009	9,967	3.5	9
Republic of Korea	6,428	559	6,987	2.5	10
Total imports	229,114	53,783	282,897	100.0	
of which: APEC	158,517	30,215	188,732	66.7	
ASEAN 10	47,744	9,696	57,440	20.3	
European Union 27	47,468	11,273	58,741	20.8	
OECD	115,350	29,208	144,558	51.1	

Source: DFAT STARS Database, 2009

The Australian Government supports the negotiations of comprehensive Free Trade Agreements (FTAs) that are consistent with the World Trade Organization rules in addition to guidelines and which complement and reinforce the multilateral trading system.

Australia has pursued FTA with many of its regional partners like New Zealand, Singapore, Thailand, United States and Chile. The negotiations regarding agreements with China, Gulf Cooperation Council, Japan, Korea, Malaysia are still in progress. Lastly, free trade agreements with India and Indonesia are under consideration (<http://www.dfat.gov.au>).

Australia's foreign and trade policies promote the security and long-term prosperity of Australia in the global environment. The three pillars of Australia's international engagement are active participation in the institutions of global governance, including the United Nations and World Trade Organization, enhancing Australia's alliance relationship with the United States and diplomatic and economic engagement in the dynamic and diverse Asia-Pacific region (<http://www.dfat.gov.au>).

As could be observed in Tables 5 and 6, Australia has strong relations with the major states of North Asia – China, Japan and the Republic of Korea – countries which are also its major markets. Relations with India are also growing strongly. It also has active, long-standing and close bilateral ties with Indonesia and the other member nations of ASEAN in South-East Asia ([http:// www.dfat.gov.au](http://www.dfat.gov.au)).

Australia strongly supports closer regional integration and plays a key role in regional architecture. It is an active member of the Asia-Pacific Economic Cooperation (APEC), the East Asia Summit (EAS), the ASEAN Regional Forum (ARF) and the Pacific Islands Forum (PIF) ([http:// www.dfat.gov.au](http://www.dfat.gov.au)).

Beyond its region, Australia enjoys strong, economic, political and cultural ties with the United States and Canada. The United States' system of security alliances, is crucial to maintaining peace and stability in the Asia-Pacific region. Australia contributes to international peace, security and development through its participation in international security forces in Afghanistan and East Timor. Australia and Europe are building strong and long-lasting political, cultural, trade, investment and people-to-people links to advance their shared interests. Australia is committed to building a broad-based, creative partnership with the European Union, addressing the contemporary challenges of climate change, development, international trade, security and building a stronger system of international governance. Australia has significant people-to-people links and growing trade and investment interests in the strategically important Middle East. In Africa, it has long standing bilateral ties and growing trade and investment interests and people-to-people connections. Australia cooperates with Latin American countries in a range of international forums to pursue common foreign and trade policy interests (<http://www.dfat.gov.au>).

Reasons for Selection of Country

One aim of this study is to emphasize and systematically integrate the interdisciplinary criteria affecting the international supplier selection. Hence, apart from cost and quality which have been dominant factors in especially domestic supplier selection, it is aimed to indicate that the factors such as global logistics, information sharing, environmental concerns have been increasingly considered due to the impacts of globalization on firm's supply chain and the internationalization of sourcing process. However, the importance given to these factors could vary in different countries, which must be investigated. Hence, it is decided to compare a Turkish company with a company in the same sector but in very different location, Australia. By selecting these two countries, the impacts of regional proximity are aimed to be reduced. For instance, if it were decided to compare the supplier selection criteria rankings in Turkey with that of Greece, the results would not be so meaningful since they are close to each other and the impacts of globalization on their international supplier selection process would be similar.

Although there is a large geographical distance between Turkey and Australia, there are some similarities in the liberalization period of two countries' foreign trade. They have both decreased their level of protection, duty rates since the 1980s and signed free trade agreements with several countries. Moreover, both being members of WTO and OECD, they aim to promote international trade further and have both recently focused on the Asia-Pacific region as well. As the four tables in the previous sections are observed and the total trade volume of the countries is converted into US\$, it is seen that the import values and the trade deficit of those countries are quite similar.

Another similarity is that they showed their environmental concern by signing Kyoto protocol. Particularly, Australian people and organizations really concern about the environment. Even in houses, the recyclable products and the non-recyclable ones are thrown into different bins. More importantly, being located close to the ozone hole, Australians suffer the highest rates of skin cancer in the world and are more aware of the reasons of the hole. Hence, in this study, regarding the “green supply chain” concept awareness of the companies, it must be observed whether Turkish company puts as much emphasis on supplier’s environmental concern as its Australian counterpart. However, as previously mentioned, both of those countries signed Kyoto Protocol and serious restrictions and sanctions on the level of carbon content in production are going to be applied in both countries.

Since both of the companies observed in this thesis are chemical manufacturers which will be reviewed in the following section, supplier’s quality is expected to be rated highest despite the fact that many other factors except cost and quality have recently become important. In Australia, the quality control restriction mechanism is quite tight. Therefore, it is worth observing whether the Turkish company puts emphasis on supplier’s quality management as much as the Australian one.

It is also intriguing to observe the weights given by two companies to the global factors in supplier selection decision. Due to its geostrategical position, the organizations in Turkey have to follow the recent developments in countries of their trading partners. As far as sourcing is concerned, it must be noted that due to the political instabilities in Turkey’s neighbor countries, like the wars in Georgia, Iraq, the conflicts between Armenia and Azerbaijan and Turkey’s foreign policies towards those countries, especially its borders being closed with Armenia since 1993, the

companies in Turkey may have to search and source from far countries. However, sourcing from far countries might also pose a threat and disrupt the supply chain since the loaded products might have to be transported through the problematic areas of the countries in which violence, tensions take place.

Although Australia is geographically isolated, it is not as politically isolated as Turkey. The wars, conflicts between two countries or any kind of global development in the world are much more likely to affect Turkey than Australia. Additionally, as people living in those countries are compared, it is worth mentioning that there is less public sensitivity in Australia. The news on TV, the newspapers do not emphasize the ongoing developments in the world as they do in Turkey. As a result of all these facts, the Australian company is expected to rate the geographical location higher than Turkey and to rate political environment of the supplier's country less than the Turkish one.

Considering these similarities and differences, two companies in these two countries are to be observed in terms of their international supplier selection criteria ranking. It is known that comparing criteria rankings of these two companies is not sufficient to make a generalization. However, the result could be promising for the future studies in this field.

General Outlook on Companies

The first part of the study is done in an effort to compare the supplier selection criteria rankings of two companies in different countries. For this purpose, two companies, both from the chemical industry, one in Turkey and the other in Australia

are selected. By using AHP technique, the weights given by the two companies are observed and evaluated.

The role of sector in international sourcing is important. By taking this into consideration, two companies in chemical industry is chosen to be compared. Chemical industry plays a key role in countries' foreign trade. This is such a sector that the companies can cooperate with suppliers in different parts of the world. Depending on the capacity of the supplier and demand of the buyer, the same product can be ordered from various external suppliers. Additionally, as can be seen from Tables A.2 and A.3, there is an upward trend on the import of chemicals in both countries.

One of the companies that the developed model is applied is a leading Australian manufacturer of private label cosmetics, toiletries and therapeutic goods and is located in Tullamarine, Victoria. It specializes in formulating and producing high quality products for leading retailers and major local and international brands. The second company is a Turkish chemical company that is a worldwide supplier of innovative specialty chemicals and nutritional ingredients. The company, located in İzmit, delivers natural source raw materials and ingredients for nutrition and healthcare markets, cosmetics, detergents and cleaner industries.

In order to know the company better and acquire related data, there have been a number of company visits. The aim of the project has been explained to the company's Sourcing Division manager. Their sourcing strategy and supplier selection procedure are reviewed in detail. The supplier selection criteria of the developed AHP model are discussed with the Sourcing manager, Supply Chain manager of the company. As elaborated in Chapter V, a structured questionnaire where the criteria and sub-criteria are placed in a hierarchical order and the decision

maker can make pair-wise comparison in accordance with their supplier selection procedure is designed and they are requested to fill it out. The results obtained using AHP will be discussed in the following section.

AHP Results

In this section, the Australian and Turkish chemical companies are compared based on decision maker's preferences related to the criteria developed in AHP model. The significant similarities and differences between the rankings of the companies are pointed out.

By incorporating decision maker's pair-wise comparison data into Expert Choice Software, the weights of criteria as well as sub-criteria are calculated. Related to the AHP method, an inconsistency ratio is defined to test how consistent the responses of the decision maker and a ratio of 0.1 is proposed by Saaty (1990). For the accuracy of this application, the inconsistency ratio is taken into consideration and it is seen that a satisfactory degree of consistency is reached since the ratio is less than 0.10 in almost all of the comparisons.

The evaluations will be done in three level. First, evaluations of main criteria with respect to goal will be compared. Second, in order to indicate the differences in sourcing trend, evaluations of sub-criteria with respect to goal will be discussed. Third, evaluations of sub-criteria with respect to relevant criteria will be observed.

The weights of the main criteria (Fig 9, Fig 10) demonstrate that the two companies differ significantly in terms of their emphasis on each supplier selection criterion. While only one extremely important and some moderately important factors are observed in the Australian company's criteria ranking, there exists some

strongly important and some moderately important criteria in the Turkish company's ranking.

For the Australian company, supplier's quality management is found to be the most important factor for the international supplier selection with 51.6 percent. This is a significant ratio since it equates with the total percentage of other criteria and might be a reflection of tight quality control mechanism in the country.

The supplier's delivery, which directly affects the just-in-time production strategy of the manufacturing company and the relationships with its own customers is ranked the second, with 13.3 percent. Financial terms criterion is rated almost as important as delivery. Similarly, supplier's safety and environmental concerns and the global factors are rated equally and it is clear that there is not a significant difference in the weights of these four criteria. This indicates that the recent developments in the global arena have been found to be an important factor in international sourcing. The supplier's profile constitutes the lowest percentage among them which means that the buyer does not necessarily investigate the background of the supplier as long as the supplier satisfies their essential requirements.

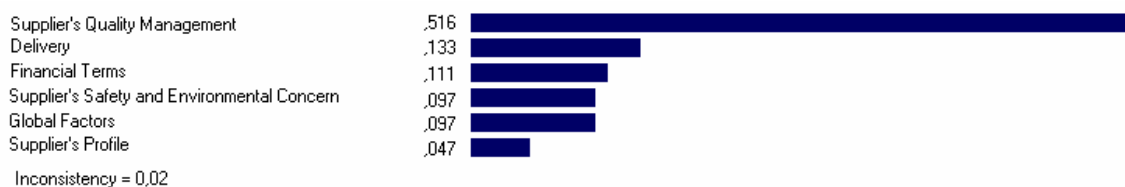


Figure 9. Overall criteria ranking of Australian company

On the other hand, the Turkish company emphasizes delivery and financial terms much more than quality which surprisingly constitutes the smallest percentage. On

the other hand, supplier's profile is found to be the third important criteria. The difference between supplier's profile weights of two companies may arise from the past experiences of the companies with their suppliers as well as the difference in the level of trust that the companies have for their suppliers. This is consistent with the fact that the level of risk is high and trust level is lower in a Turkish business environment. Additionally, the Turkish company might have experienced a serious problem with one or more of its suppliers and the level of trust might have been lowered which may result in searching for the supplier's past history more carefully.

The weight of global factors is found to be slightly higher than that of Australian company. However, a weight of 12.7 percent might indicate that the global environment in the supplier's countries is still not much concerned with international sourcing decision. Additionally, supplier's safety and environmental concern is rated even much lower which shows that although the Turkish company considers global factors more than its Australian counterpart, it still does not place as much emphasis on protection of environment as its counterpart.



Figure 10. Overall criteria ranking of Turkish company

As a next step, analysis is made at sub-criteria level for the two companies. Figure 11 shows that product quality, quality control and response to customer complaints are the most important factors among 27 sub-criteria for the Australian company that emphasizes especially the importance of product quality. Furthermore, the highest

ranked ten sub-criteria are found to be among all the main criteria except supplier's profile. The most important sub-criteria regarding profile is observed to be collaboration duration, followed by information sharing. As far as the global factors are concerned, it is seen that the social environment is ranked quite lower than economic and political environment and it accounts for the lowest percentage along with flexibility, market reputation as well as financial strength.

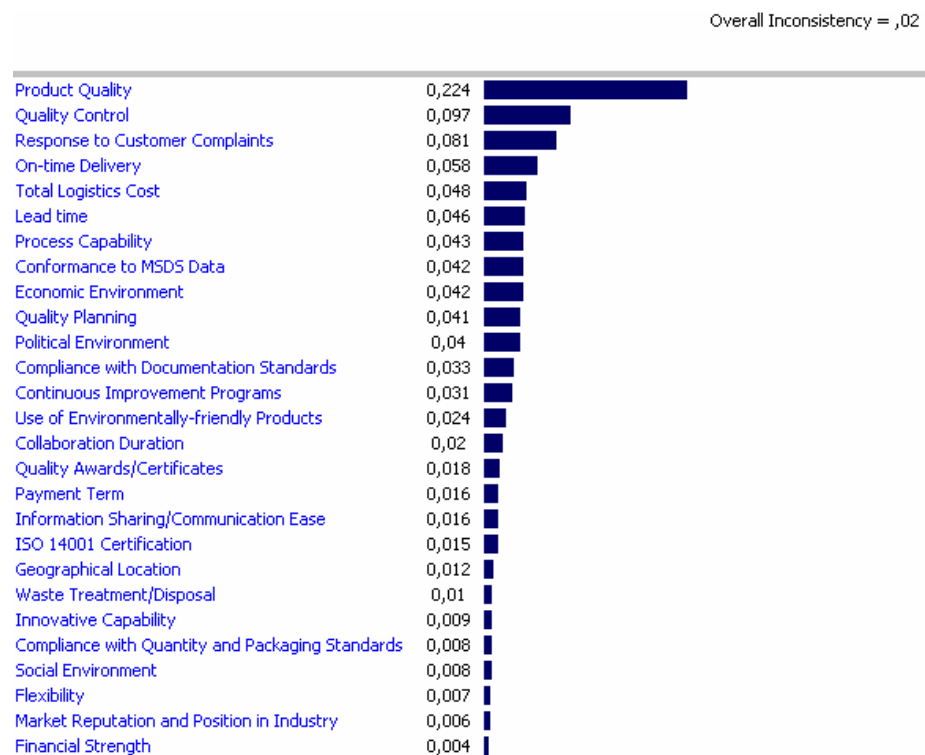


Figure 11. Overall sub-criteria ranking of Australian company

On the other hand, the Turkish company's ranking shows that delivery is the greatest determinant in international supplier selection. Unlike its counterpart, the Turkish company pays great attention to flexibility which reflects the general business environment in Turkey. It is considered as one of the least significant factors by the Australian company. As the highest ranked ten sub-criteria are observed, it is seen

that all the criteria's sub-criteria except supplier's quality management exist. Additionally, although financial terms is ranked higher than supplier's profile and global factors, the number of sub-criteria of these two criteria in top ten is higher than that of financial terms. Unlike past research results in the literature, total logistics cost and product quality are ranked fourteenth and fifteenth respectively (see Figure 12). The relative importance given by the company to the environment can also be observed in the following figure since ISO 14001 Certification and Waste treatment/disposal are the ones that are rated almost the lowest. However, conformance to MSDS Data which is a significant part of supplier's safety concern is ranked among top ten.

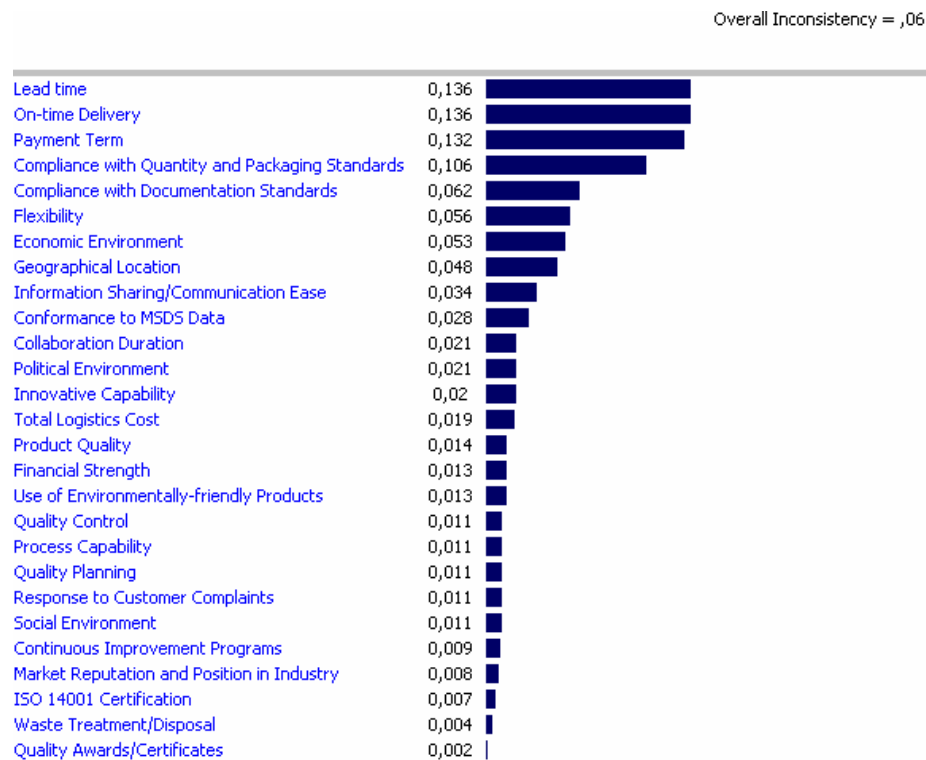


Figure 12. Overall sub-criteria ranking of Turkish company

In this part, companies' evaluation of sub-criteria with respect to relevant criteria is discussed. The sub-criteria under financial terms are ranked differently by the two companies (Fig 13, Fig 14). There is a 1 to 3 ratio between payment term and cost for the Australian company whereas this ratio is 7 to 1 for the Turkish one. This indicates that the Turkish company does not want to tie up its capital and wants to choose the supplier that offers it the longest time interval to make the payment.



Figure 13. Australian company's ranking of sub-criteria under financial terms



Figure 14. Turkish company's ranking of sub-criteria under financial terms

It is also seen that there is no significant difference between the two companies' view regarding sub-criteria under delivery, supplier's quality management and supplier's safety & environmental concern which matches with the expectations.

Despite its remoteness from other countries, the Australian company does not consider geographical location of the supplier's country as much as the Turkish company. This might be due to tensions and conflicts between the neighbor countries of Turkey and the possibility of supply chain disruption especially in transportation of the products. In this respect, the mode and route of transportation creates a significant difference in decision maker's preference regarding location. Since the

mode of transportation for the Australian company does not necessitate ground transportation as much as the Turkish one, it might not have considered location as much as its counterpart.

Interestingly, the Australian company considers economic and political environment more than geographical location (see Figure 15). The weights given to the political environment by the two companies is surprising since Turkish company was expected to rate higher due to the less public sensitivity observed in Australia towards the political developments in other countries. However, the results show that the weight given by the Turkish company is almost half of that of the Australian company. In addition, like Turkish company, social environment in the supplier's country is found to be the least significant factor among other constituents of global factors.



Figure 15. Australian company's ranking of sub-criteria under global factors

The emphasis given to economic environment of the supplier's country by the two companies is quite similar which may result from the similarities in the economic as well as trade indicators of two countries such as exchange currency rates, tariff rates, import values, GDP ratios.



Figure 16. Turkish company's ranking of sub-criteria under global factors

Figure 17 shows that for the Australian company, collaboration duration is the utmost important factor related with supplier's profile. This may imply that in case of supplier selection in a multiple-sourcing environment, the company cannot disregard the existing suppliers if they have been cooperating for a long time and there is a mutual gain and satisfactory relationship between the supplier and the company. On the other hand, for the Turkish company, supplier's response to changes in demand and order frequency is an utmost critical factor. It is also worth to note that neither company takes into account market reputation and financial strength as much as the other factors.

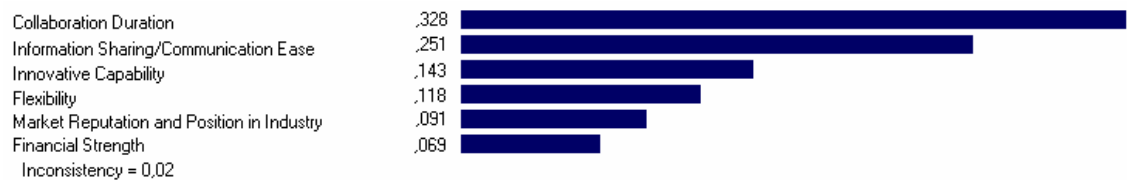


Figure 17. Australian company's ranking of sub-criteria under supplier's profile



Figure 18. Turkish company's ranking of sub-criteria under supplier's profile

The differences between the weights given to the criteria by the Australian and Turkish companies are discussed in detail. Although the results cannot be generalized due to small sample size, they can be an indication of the differences between two cultures and the challenging trends in international trade.

In order to observe the impacts of globalization on international supplier selection, the results of this study are compared with the findings of Dickson (1966) and Weber et al. (1991) discussed in Chapter IV. For this purpose, the changes in the criteria as well as their weights and rankings in each study are compared and contrasted.

The important criteria which are identified, ranked as a result of Dickson's study (1966) and reprioritized by Weber et al. (1991) are reevaluated. As Table 1 in Chapter IV demonstrates, the quality is ranked the highest followed by the delivery criterion in 1966. Net price is ranked sixth after the factors mostly related with supplier's profile. Geographical location is ranked twentieth among the 23 criteria due to the locality of the sourcing decisions in those years. As observed in Dickson's study, since sourcing was considered a purchasing process in those years, apart from delivery, quality, price, the defined criteria are almost related to the content of the contract, supplier's profile such as financial position, labor relations records, training aids. The factors that are mentioned in that study appeals to domestic purchasing, rather than international sourcing, however, it is quite useful to make a comparison in order to indicate the changes.

In 1991, Weber et al. reprioritize these criteria. The results show that net price, which has changed over time in definition and meaning and replaced by total logistics cost, is ranked the highest. Net price is followed by delivery and quality respectively. The factors related with contracts have lost their importance. For

instance, warranties and claim policies, which was fourth in Dickson's (1966) study is ranked the least. Bidding procedural compliance is ranked sixteenth while it is ranked ninth in 1966. Another important point is that geographical location, which is one of the criteria related with international sourcing, is ranked fifth whereas it is ranked twentieth in Dickson's study (1966).

These changes reflect the effect of globalization on sourcing in a very clear way. The idea of purchasing from the local supplier at a very reasonable price, at a high quality and focusing heavily on the contract, procedural activities started to be replaced with the idea of coordinated and well-planned sourcing from the external suppliers taking into consideration all global developments. These results imply that the supplier selection criteria have substantially changed over time.

As Weber et al.'s results (1991) are compared with the findings in this study, it is seen that quality, price and delivery are the common factors used in both studies and they are still the highest ranking factors.

The Turkish company puts emphasis on global factors especially economic as well as political environment more than total logistics cost which is ranked fourteenth. The results also show that both companies integrate country-specific factors except social environment well into their selection process. Geographical location, which is ranked fifth in Weber et al.'s study, is ranked eighth by the Turkish company, which shows that it is one of the top ten important sub-criteria in international supplier selection.

Another important difference in the results of this study is that factors related to supplier profile are inferior compared to other factors as before.

CHAPTER VII

OPTIMAL ORDER ALLOCATION DECISION

This part constitutes the application of the methodology discussed in Chapter V to the Australian company. Hence, the best suppliers will be determined among various international suppliers and orders will be allocated among selected suppliers by using the hybrid model discussed previously.

As mentioned in Chapter III, the study aims to assist any manufacturing or trading company in sourcing a direct material internationally by considering all the factors that could be effective in the decision making process. By incorporating the multi-criteria approach with the multiple sourcing concept, it is aimed to minimize the supply chain risk and support the organizations to give the most effective decision.

This chapter discusses the data collection and the implementation of the hybrid model which is a combination of AHP and LP models. The results will be evaluated and sensitivity analysis will be performed to test the robustness of results to changes in parameters.

Data Collection

In this implementation section, the order allocation among the suppliers will be achieved by using Linear Programming (LP). The objective function aims to maximize total value of purchasing (TVP) as defined in detail in Chapter V. For this

purpose, pair-wise comparison results calculated in Chapter VI as well as other quantitative data will be used as an input to the LP model.

Before discussing the data, information will be given about the company that the model is implemented on and the specific direct material that will be sourced externally by the company.

The company is the Australian chemical company, discussed in Chapter VI, and the raw material is used by this company for cosmetics production. This product is selected mainly because it does not naturally exist in Australia and the buyers have to import from different suppliers who are traders or manufacturers. It is one of the major raw materials that constitutes the highest purchasing cost. The same study could have been implemented on its Turkish counterpart, however, due to data unavailability in especially freight costs, only the Australian company is chosen for implementation purposes.

In order to select the best suppliers and allocate the optimum order quantity among them, buyer's previous, existing and potential raw material suppliers are investigated. The supplier related data is collected during the internship period in the Australian company by using SAP modules of the company, face-to-face interviews with the freight forwarders and by the assistance of Sourcing Manager. SAP enables to observe purchasing prices of the product that will be sourced from different suppliers. The offers from those suppliers were already requested and prices as well as supplier's capacities were already recorded by the company staff. In order to compute import duties, freight costs are required to be determined. Freight cost and duty rates are acquired as a result of interviews with the freight forwarders. Hence, total logistics cost, which is a combination of these costs and purchasing price, is

calculated. However, the ordering cost is not included in this study since it is negligible compared to total logistics cost.

Lead time data is obtained from both company staff and freight forwarders. The allocated budget and demand for this product are discussed with the Production Manager. The detailed supplier-specific data and the method of computation is given in Appendix B. It must be noted that in Table A.1 the supplier country names are presented rather than company names for confidentiality purposes.

On the other hand, as the country-related data are concerned, it must be noted that KOF Index of Globalization (2009) which covers the economic, social and political dimensions of globalization is used as a secondary source. In this index, economic globalization dimension is characterized as long distance flows of goods, capital and services as well as information and perceptions that accompany market exchanges. Political globalization is characterized by a diffusion of government policies whereas social globalization is expressed as the spread of ideas, cultures, information, images and people.

The globalization scores of various countries is given in Appendix D. KOF index does not include one of the supplier countries which is Taiwan. Therefore, Taiwan's score is replaced with the globalization score of Malaysia which is an economically, politically, geographically similar country for analysis purpose in this study.

Hybrid Model Implementation

Suppliers are ranked using criteria weights and decision maker's pair-wise supplier evaluations for each criterion. Suppliers' data restrictions force the evaluations to be

at criteria level rather than sub-criteria level of the developed AHP model (Figure 7). So the evaluation criteria are financial terms, supplier's delivery, supplier's quality management, supplier's environmental concern, profile and global factors. Financial terms is represented by total logistics cost results and delivery by the lead time. As far as the other factors are concerned, pair-wise ranking of supplier's quality management, supplier's environmental concern as well as supplier's profile and globalization index data (KOF) are taken into consideration. In case of data availability, the same procedure can be easily applied at sub-criteria level.

The suppliers' weights according to each criterion is given in the following figures. Figures 19 and 20 show that the supplier in Thailand is found to be the best one as far as financial terms and supplier's profile are concerned. Apart from supplier's safety and environmental concern, the supplier in the USA is scored high. Suppliers in Mexico and Brazil are scored the lowest in terms of almost all criteria.

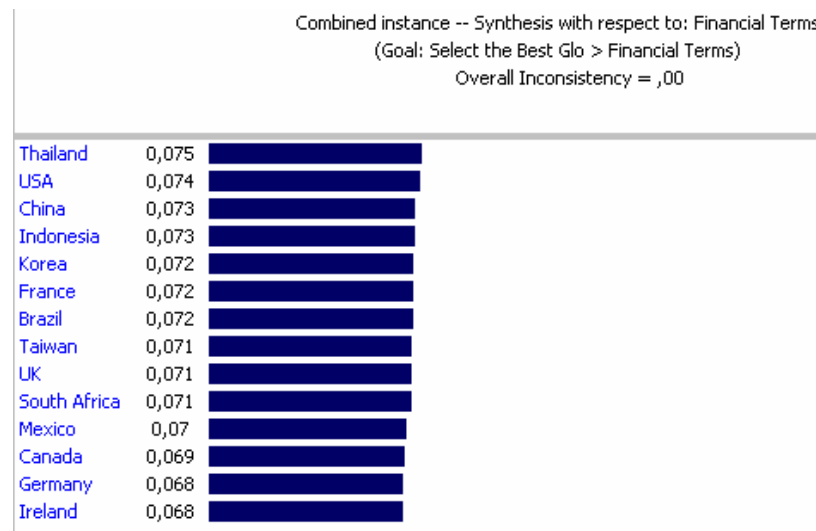


Figure 19. 'Financial terms' weights for suppliers

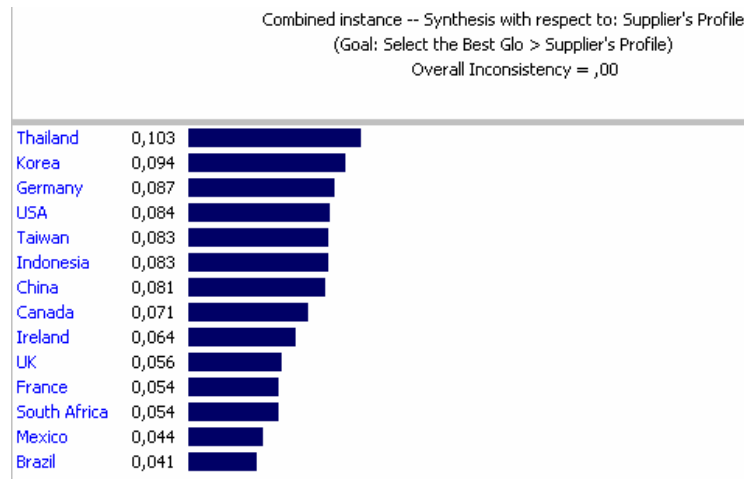


Figure 20. 'Supplier's profile' weights for suppliers

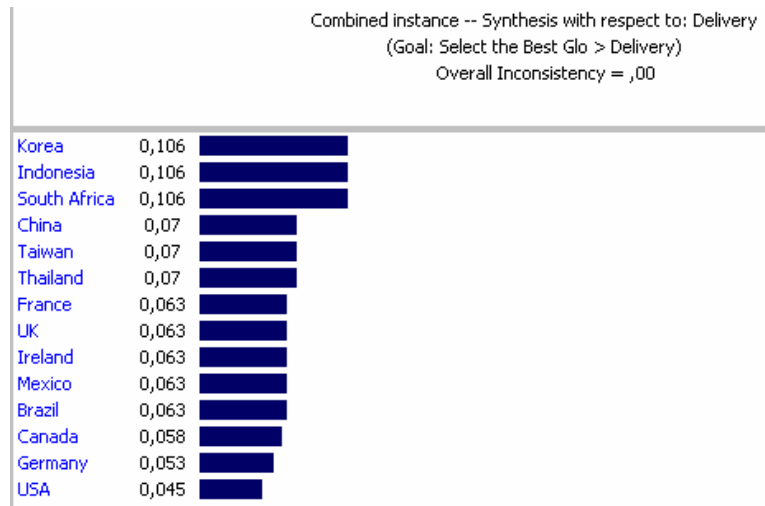


Figure 21. 'Delivery weights' for suppliers

Since the weight of supplier's quality management factor is quite high compared to others, the supplier whose quality management is rated highest is likely to be the best supplier at the end. Although Korea's globalization score is quite low, the supplier's success in quality management as well as delivery makes it the best one among all (see Figures 21 and 22).

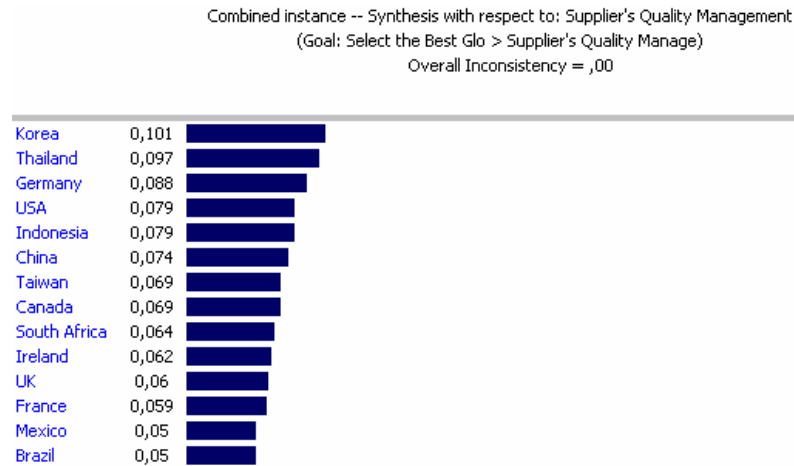


Figure 22. 'Supplier's quality management' weights for suppliers

Figure 23 indicates that the supplier located in South Korea is the best one as all factors affecting global supplier selection are considered. Interestingly, supplier in Germany, which is located very far from the Australian company is ranked the third.

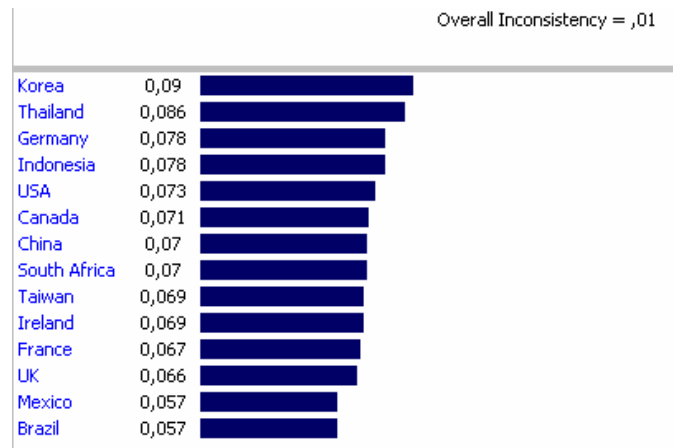


Figure 23. Suppliers' overall preferability weights

After determining the best suppliers along with their overall preferability weights, the next step is to allocate order among those suppliers. In an effort to do this, supplier's overall ratings that are obtained by AHP, are used as coefficients of the LP

objective function. As mentioned previously, the objective function aims to maximize the total value of purchasing (TVP). Suppliers' overall scores can be interpreted as the utility they provide to the Australian company. Final utility of suppliers, demonstrated by w_i are placed in the model as objective function coefficients. The specific LP model is given in Appendix B.

The model is solved using information technology facilities and WinQSB software. Figure 24 shows the best suppliers and the optimum order allocations. The best ones can be defined as the suppliers that decision maker prefers the most in terms of their expectations' match with suppliers' attributes and the country related factors.

Decision Variable	Solution Value	Unit Cost or Profit c(j)	Total Contribution	Reduced Cost	Basis Status	Allowable Min. c(j)	Allowable Max. c(j)
Korea	7,000,0000	0,0900	630,0000	0	basic	0,0860	M
Thailand	1,000,0000	0,0860	86,0000	0	basic	0,0780	0,0900
Germany	1,000,0000	0,0780	78,0000	0	basic	0,0730	0,0780
Indonesia	1,000,0000	0,0780	78,0000	0	basic	0,0780	0,0900
USA	0	0,0730	0	-0,0050	at bound	-M	0,0780
Canada	0	0,0710	0	-0,0070	at bound	-M	0,0780
China	0	0,0700	0	-0,0080	at bound	-M	0,0780
South Africa	0	0,0700	0	-0,0080	at bound	-M	0,0780
Taiwan	0	0,0690	0	-0,0090	at bound	-M	0,0780
Ireland	0	0,0690	0	-0,0090	at bound	-M	0,0780
France	0	0,0670	0	-0,0110	at bound	-M	0,0780
UK	0	0,0660	0	-0,0120	at bound	-M	0,0780
Mexico	0	0,0570	0	-0,0210	at bound	-M	0,0780
Brazil	0	0,0570	0	-0,0210	at bound	-M	0,0780

Figure 24. Optimum order quantities according to LP results

By taking into consideration all the supplier-specific and country-specific factors that will be effective in their decision making process, and their existing as well as potential suppliers for the raw material, optimal order allocation is achieved. When the total logistics cost of the proposed is calculated and compared with the actual

cost the Australian company incurs, it is seen that significant cost-saving will be made by allocating orders among the best suppliers.

Sensitivity Analysis

Further analyses are conducted on the optimal solution in order to depict the effects of strategic, internal and external environment related changes. Sensitivity analyses are also conducted to investigate the impacts of changes in the priority of supplier selection criteria as well as on order allocation.

Ghodyspour and O'Brien (1998) summarize the sequences of changes and illustrate as shown in Figure 25. When the priority of each criteria changes, overall weights of each supplier are directly affected, as a result the order allocation among the suppliers are expected to change accordingly.

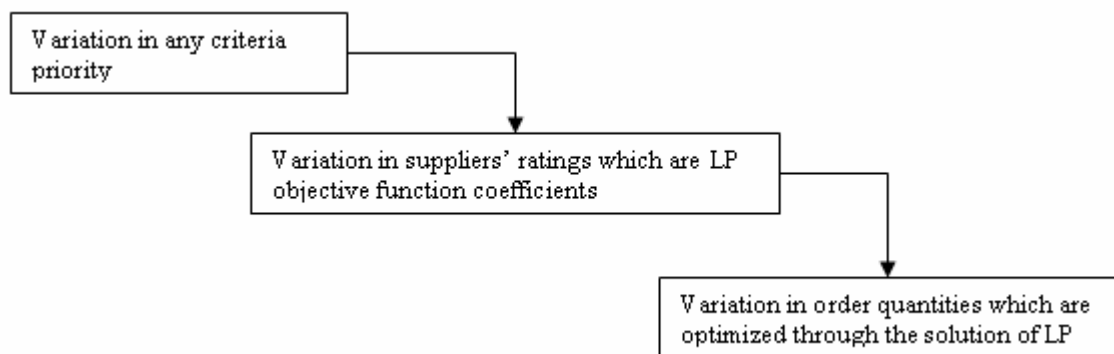


Figure 25. Sequence of variation in sensitivity analysis (Source: Ghodyspour and Brien,1998)

In an effort to observe the impacts of changes in the priority of criteria, Expert Choice software is employed. Dynamic sensitivity analysis is used to dynamically

change the priorities of the factors to determine how these changes affect the priorities of the alternative choices. Figure 26 shows the original weights of the criteria and the original priorities of the suppliers. Since supplier's quality management constitutes the highest importance weight (51.6 percent), it is meaningful to observe if there will be any change in the optimal solution when the weight of this factor changes. By decreasing supplier's quality management priority from 51.6 percent to 30.0 percent, the priorities of the remaining objectives increase in proportion to their original weights. Therefore, there will be a change in supplier rankings. In the new ranking (Figure 27), suppliers in Korea and Thailand are still the best ones. However, suppliers from Germany and USA which previously ranked as the third and the fourth respectively, fall behind Indonesia in the new solution. Due to the slight change in the ranking of the suppliers, it is concluded that the result is not very sensitive to changes in quality factor.

The same analysis is done also for the other factors and it is seen that although there are some minor changes in suppliers' preference scores, this does not make a substantial difference in their ranking. This may result from the fact that suppliers are ranked on criteria level rather than sub-criteria level due to data restrictions. The solutions might change significantly for other companies and/or suppliers.

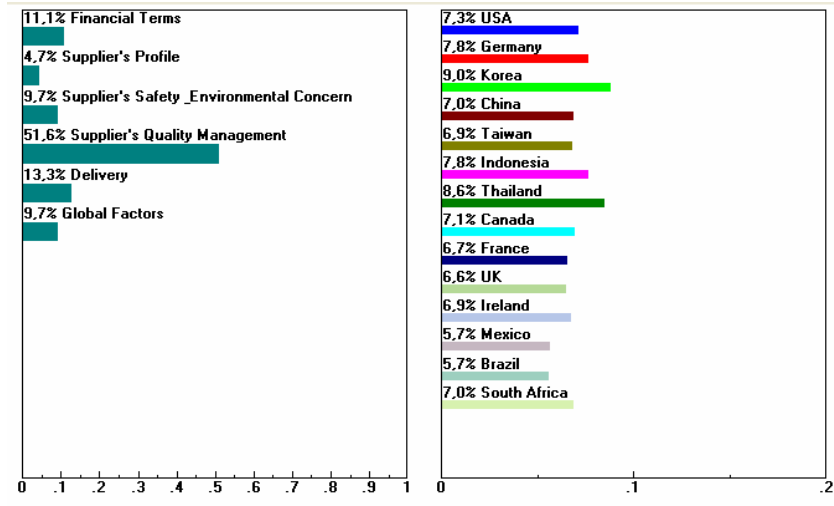


Figure 26. Criteria importance and country preference weights (original)

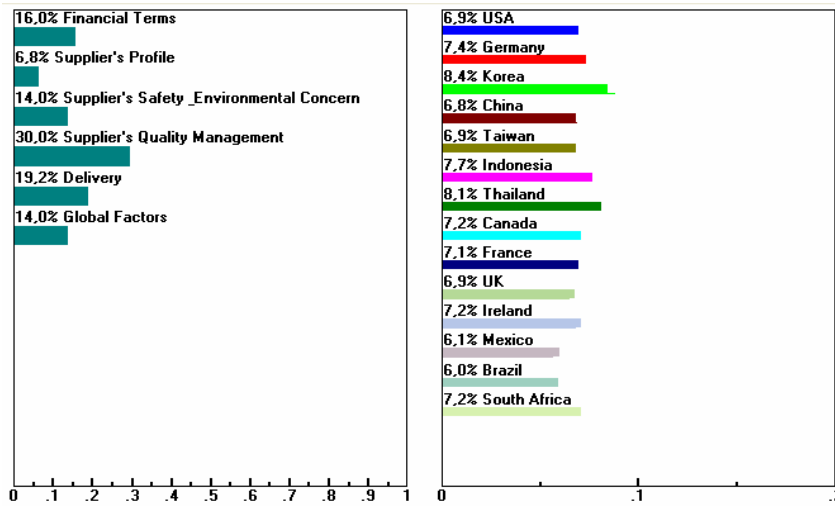


Figure 27. Criteria importance and country preference weights (when there is a change on quality weights)

Optimization models such as LP use deterministic data which imply absolute certainty in the data and relationships of a problem. Due to this fact, adaptations may be required to catch up with the changes in the real world. Hence, by conducting sensitivity analysis, potential changes in the company's sourcing policy and criteria importance weights will be observed. As a result, LP solutions become more realistic and insightful.

As a first step, changes in supplier evaluations will be discussed. In the optimal solution report (Figure 24), additional information can be obtained related with sensitivity analysis. The weight of the first (Korean) supplier is 0.090, which is indicated as the unit profit in the output. The lower bound and the upper bound of this weight imply that the current solution remains the same unless the weight of the Korean supplier is decreased to a value below 0.086. On the other hand, as the other three selected suppliers especially the German one are observed, it can be seen that the allowable minimum and maximum values are close to each other. If any of the weights of these suppliers are increased or decreased above or below these limits, not only the total value of purchasing (TVP) but also the optimal solution will change. Hence, the managers must observe the suppliers from Thailand, Germany and Indonesia much more carefully while determining the weights by using AHP.

In addition to the analyses above, linear programming optimal outputs are observed to detect the sensitivity of the optimal solution to changes in criteria such as supplier's utility scores. It must be noted that, in sensitivity analysis, a change can be made to one supplier's utility score at one time, and the current solution remains optimal as long as the change is between the upper and lower bounds. Parametric analysis shows the rate of change in the objective function value for all possible values of the related variable.

Additionally, as the weights of the criteria are observed, it can be seen that the weight of supplier's quality management constitutes more than 50 percent of the overall weight (Fig. 26), so, if there is any decrease in the weight of quality, or any decrease in the quality management rating of Korean supplier, the supplier's overall preferability weight may decrease below allowable minimum value and the optimal solution values and the TVP value will both change (Fig. 28). The same result will be

observed when there is a change in country related factors in any of these fourteen countries. It must be noted that, in sensitivity analysis, a change can be made to one supplier's preference score at one time, and the current solution remains optimal as long as the change is between the upper and lower bounds.

Range	From Coeff. of Korea	To Coeff. of Korea	From OBJ Value	To OBJ Value	Slope
1	0,0900	M	872,0000	M	7,000,0000
2	0,0900	0,0860	872,0000	844,0000	7,000,0000
3	0,0860	0,0780	844,0000	836,0000	1,000,0000
4	0,0780	0,0730	836,0000	831,0000	1,000,0000
5	0,0730	-M	831,0000	831,0000	0

Figure 28. Parametric analysis for the Korean supplier

Figure 28 indicates that there is a significant decline in TVP if the preference score of the Korean supplier decreases by 0.004. The performance analysis is done also for the other three best suppliers but no significant range as observed in Korean supplier has been found.

As a second step, the changes in supplier-related and company related constraints are observed. This part is not related to the results obtained in AHP but with the supplier based or company oriented changes in the constraints which may directly change the optimal solution.

Figure 29 provides a detailed outlook on solution's sensitivity to changes in constraint right hand sides. Shadow price shows the marginal change of TVP as a result of a marginal change in the right hand side.

Objective	Function	(Max.) =	872,0000				
Constraint	Left Hand Side	Direction	Right Hand Side	Slack or Surplus	Shadow Price	Allowable Min. RHS	Allowable Max. RHS
Supplier's upper bound	4,0000	<=	7,0000	3,0000	0	4,0000	M
Supplier's lower bound	4,0000	>=	4,0000	0	-12,0000	3,0000	4,0000
Capacity of Korean supplier	-8,000,0000	<=	0	8,000,0000	0	-8,000,0000	M
Capacity of Thai supplier	-9,000,0000	<=	0	9,000,0000	0	-9,000,0000	M
Capacity of German supplier	-29,000,0000	<=	0	29,000,0000	0	-29,000,0000	M
Capacity of Indonesian supplier	-9,000,0000	<=	0	9,000,0000	0	-9,000,0000	M
Capacity of American supplier	0	<=	0	0	0	0	M
Capacity of Canadian supplier	0	<=	0	0	0	0	M
Capacity of Chinese supplier	0	<=	0	0	0	0	M

Figure 29. TVP and the constraints

The first two constraints, which limit the minimum and maximum number of suppliers, is determined by decision makers considering criteria such as the costs for setting up, keeping in contact, ordering, auditing. Figure 29 and 30 show that if the minimum number of supplier becomes 3, the TVP value will increase by 12. On the other hand, the parametric analysis (Figure 30) indicate that if the fifth supplier is also considered to source from, the amount of decrease in TVP is 17 units.

Range	From RHS of Supplier's lower bound	To RHS of Supplier's lower bound	From OBJ Value	To OBJ Value	Slope
1	4,0000	4,0000	872,0000	872,0000	-12,0000
2	4,0000	5,0000	872,0000	855,0000	-17,0000
3	5,0000	6,0000	855,0000	836,0000	-19,0000
4	6,0000	7,0000	836,0000	816,0000	-20,0000
5	7,0000	Infinity	Infeasible		
6	4,0000	3,0000	872,0000	884,0000	-12,0000
7	3,0000	2,0000	884,0000	896,0001	-12,0000
8	2,0000	1,0000	896,0001	900,0001	-4,0000
9	1,0000	-M	900,0001	900,0001	0

Figure 30. Parametric analysis for suppliers' lower bound constraint

Performing sensitivity analysis on the raw material budget of the company, it is observed that a marginal decrease in the budget results in a decrease in the TVP score. This amount is approximately 20.000 for the budget change given in range 4 of Figure 31.

Range	From RHS of C17	To RHS of C17	From OBJ Value	To OBJ Value	Slope
1	200.000,0000	M	872,0000	872,0000	0
2	200.000,0000	182.890,0000	872,0000	872,0000	0
3	182.890,0000	181.420,0000	872,0000	867,0000	0,0034
4	181.420,0000	177.400,0000	867,0000	843,0001	0,0060
5	177.400,0000	177.400,0000	843,0001	843,0001	0,0135
6	177.400,0000	177.350,0000	843,0001	835,9999	0,1400
7	177.350,0000	177.350,0000	835,9999	836,0001	0,2714
8	177.350,0000	177.330,0000	836,0001	824,0013	0,6000
9	177.330,0000	-Infinity	Infeasible		

Figure 31. Parametric analysis for the budget constraint

The changes in weights of supplier as well as in constraints are analyzed. To summarize, it is seen that there is no substantial change in supplier's ranking as the weight of the Korean supplier is decreased to by approximately 20 percent. This may result from the fact that suppliers are ranked on criteria level rather than sub-criteria level due to data restrictions. However, although the ranking remains constant, LP parametric analysis indicates that there is a significant decline in TVP if the preference score of the Korean supplier decreases by 0.004. Similar analysis is done for the other three best suppliers but no significant range has been found.

Second, the changes in supplier-related and company related constraints are observed. It is observed that if the minimum number of supplier becomes 3, the TVP value will increase by 12 whereas the amount of decrease in TVP is 17 units if the fifth supplier is also considered to source from. Hence, there is a trade-off between risk alleviation by increasing the number of suppliers and loss in TVP.

Third, performing sensitivity analysis on the raw material budget of the company shows that a marginal decrease in the budget results in a decrease in the TVP score.

The sensitivity analysis presented above shows that a change in supplier's attributes might affect their overall preference scores as well as the supplier or buyer related constraints all of which might result in a new optimal solution. Tracing the sensitivity of the optimal solution to such changes aids the decision maker in his decisions as well as making a trade-off between risk and the TVP.

CHAPTER VIII

CONCLUSION

This thesis aims to provide a better understanding about international sourcing through an integrated approach to international supplier selection and order allocation problem. By extending the literature and incorporating country-specific as well as supplier-specific factors into the selection decision, it seeks to emphasize and systematically integrate the interdisciplinary criteria affecting international supplier selection and to contribute to the supply chain development of internationally sourcing companies. Additionally, it investigates the impacts of globalization on international supplier selection by benchmarking the importance given to the selection criteria by the two companies in two geographically distant countries; Australia and Turkey.

This thesis focuses on international trade and international supplier selection with the objective of making more effective decisions through the use of optimization techniques.

Employing the Analytic Hierarchy Process (AHP), in consideration of both tangible and intangible criteria, a set of candidate suppliers are identified. Consequently, a linear programming (LP) model with the objective of maximizing the total value of purchasing subject to a set of constraints, is then formulated and solved to allocate the optimal order quantities among the selected suppliers.

The integrated AHP-LP model offers a systematic, straightforward approach to the international supplier selection problem. It enables the decision makers to include their own subjective ideas when they deal with the multiple sourcing issue.

In this respect, the role of AHP is crucial in operationalizing and evaluating both tangible and intangible factors.

In this thesis, AHP is used to model the related criteria and sub-criteria in order to maximize buyer's total value of purchasing (TVP). As a first step, the comprehensive as well as unique selection criteria are determined. Conducting a literature survey along with face-to-face interviews with company managers, this thesis extends and defines the decision criteria as financial terms, supplier's quality management, supplier's profile, supplier's safety and environmental concerns, supplier's delivery and the global factors in order to reach the goal of selecting the best external suppliers in a multiple sourcing environment. Additionally, it defines 27 sub-criteria in order to evaluate the criteria in detail. The criteria and sub-criteria are compiled in a hierarchy using AHP.

Second, the weights of the criteria are calculated using AHP which allows making intercultural evaluations of prioritizing supplier selection criteria due to the differences in companies' sourcing strategies. Third, the suppliers are rated based on the decision maker's pair-wise comparison in addition to real quantitative data. The overall weights of each supplier are reached by incorporating the weight of each criterion with the supplier's rating. Finally, in order to maximize TVP, the orders are allocated among the best suppliers by employing the Linear Programming (LP) technique. For this purpose, the supplier ratings obtained by employing AHP are used as coefficients of the objective function in LP to allocate order quantities to the suppliers such that the total value of purchasing (TVP) becomes maximum.

The first implementation part of the study is done in an effort to compare the supplier selection criteria rankings of two companies in different countries. For this purpose, two companies both from the chemical industry, one in Turkey and one in

Australia are selected. By using AHP technique, the weights given by two companies are observed and evaluated.

For the Australian company's international supplier selection process, supplier's quality management is found to be the most important factor with 51.6 percent which is actually higher than the total percentage of remaining criteria. This result might arise from the fact that the company is in chemical industry which requires minimizing the defect ratio and any other parameters related to quality. Additionally, this might be a reflection of tight quality control mechanism in the country.

Supplier's delivery is ranked the second with 13.3 percent. Similarly, supplier's safety and environmental concerns and the global factors are rated equally and it is clear that there is not a significant difference in the weights of these four criteria. This indicates that the recent developments in the global arena have been found to be as important as other common factors in international sourcing. Supplier's profile constitutes the lowest percentage among them which means that the buyer does not necessarily investigate the background of the supplier as long as the supplier satisfies their essential requirements.

On the other hand, the Turkish company emphasizes delivery and financial terms much more than quality which surprisingly constitutes the smallest percentage. Supplier's profile is found to be the third important criteria for the Turkish company. The difference between supplier's profile weights of two companies may arise from the past experiences of the companies with their suppliers as well as the difference in the level of trust that the companies have for their suppliers. This is consistent with the fact that the level of risk is high and trust level is lower in Turkish business environment.

The weight of global factors is found to be slightly higher than that of Australian company. However, a weight of 12.7 percent might indicate that the global environment in the supplier's countries is still not considered in international sourcing decision as much as the common criteria like financial terms and delivery.

Additionally, supplier's safety and environmental concern is rated even much lower which shows that although the Turkish company considers global factors more than its Australian counterpart, it still does not place as much emphasis on protection of environment as its counterpart.

As a next step, analysis is made at sub-criteria level for the two companies. Product quality, quality control and response to customer complaints are the most important factors among 27 sub-criteria for the Australian company that emphasizes especially the importance of product quality. Furthermore, the highest ranked ten sub-criteria are found to be among all the main criteria except supplier's profile. The most important sub-criteria regarding profile is observed to be collaboration duration, followed by information sharing. As far as the global factors are concerned, it is seen that the social environment is ranked quite lower than economic and political environment and it accounts for the lowest percentage along with flexibility, market reputation as well as financial strength.

On the other hand, the Turkish company's ranking shows that delivery is the greatest determinant in international supplier selection. Unlike its counterpart, the Turkish company pays great attention to flexibility which reflects the general business environment in Turkey. It is considered as one of the least significant factors by the Australian company. As the highest ranked ten sub-criteria are observed, it is seen that all the criteria's sub-criteria except supplier's quality

management exist. Unlike past research results in the literature, total logistics cost and product quality are ranked fourteenth and fifteenth respectively.

As far as the relative importance given by the company to the environment are considered, it can be seen that ISO 14001 Certification and Waste treatment/disposal are the ones that are rated almost the lowest. However, conformance to MSDS Data which is a significant part of supplier's safety concern is ranked among top ten.

Companies' evaluation of sub-criteria with respect to relevant criteria is also discussed. The most substantial difference is observed to occur in the rankings of sub-criteria under financial terms. There is a 1 to 3 ratio between payment term and cost for the Australian company whereas this ratio is 7 to 1 for the Turkish one. This indicates that the Turkish company does not want to tie up its capital and wants to choose the supplier that offers him the longest time interval to make the payment.

The results show that despite its remoteness from other countries, the Australian company does not consider geographical location of the supplier's country as much as the Turkish company. This might be due to tensions and conflicts between the neighbor countries of Turkey and the possibility of supply chain disruption especially in transportation of the products. In this respect, the mode and route of transportation creates a significant difference in decision maker's preference regarding location. Since the mode of transportation for the Australian company does not necessitate ground transportation as much as the Turkish one, it might not have considered geographical location as much as its counterpart.

Interestingly, the Australian company considers economic and political environment more than geographical location. The importance given to the political environment by the two companies is surprising since Turkish company is expected

to rate higher due to the less public sensitivity observed in Australia towards the political developments in other countries. However, the results show that the weight given by the Turkish company is almost half of that of the Australian company. In addition, like Turkish company, social environment in the supplier's country is found to be the least significant factor among other constituents of global factors.

The emphasis given to economic environment of the supplier's country by the two companies is quite similar which may result from the similarities in the economic as well as trade indicators of two countries such as exchange currency rates, tariff rates, import values, GDP ratios.

After benchmarking the two companies' criteria ranking, these results are compared with the result of Dickson's study (1966) which is reprioritized by Weber et al.'s (1991) study in order to investigate the impacts of globalization on supplier selection. In Dickson's study (1966), the quality is ranked the highest followed by the delivery. Net price is ranked sixth after the factors mostly related with supplier's profile. Geographical location is ranked twentieth among the 23 criteria due to the locality of the sourcing decisions in those years. As the study is observed, since sourcing was considered as a purchasing process in those years, apart from delivery, quality, price, the defined criteria are related almost with the content of the contract, supplier's profile such as financial position, labor relations records, training aids. The factors that are mentioned in that study appeals to domestic purchasing, rather than international sourcing, however, it is quite useful to make a comparison in order to indicate the changes.

In 1991, Weber et al. reprioritize these criteria. The results show that net price, which has changed over time in definition and meaning and replaced by total logistics cost, is ranked the highest. Net price is followed by delivery and quality

respectively. The factors related with contracts have lost their importance. For instance, warranties and claim policies, which was fourth in Dickson's (1966) study is ranked the least. Bidding procedural compliance is ranked the sixteenth while it is ranked ninth in 1966. Another important point is that geographical location, which is one of the criteria related with international sourcing, is ranked fifth whereas it is ranked twentieth in Dickson's study (1966).

These changes reflect the effect of globalization on sourcing in a very clear way. The idea of purchasing from the local supplier at a very reasonable price, at a high quality and focusing heavily on the contract, procedural activities started to be replaced with the idea of coordinated and well-planned sourcing from the external suppliers taking into consideration all global developments. These results imply that the supplier selection criteria have substantially changed over time.

As Weber et al.'s results (1991) are compared with the findings in this study, it is seen that quality, price and delivery are the common factors used in both studies and they are still the highest ranking factors.

The Turkish company puts emphasis on global factors especially economic as well as political environment more than total logistics cost which ranks the fourteenth. The results also show that both companies integrate country-specific factors well into their selection process except social environment. Geographical location, which is ranked fifth in Weber et al.'s study, is ranked eighth by the Turkish company, which shows that it is one of the top ten important sub-criteria in international supplier selection.

Another important difference in the results of this study is that factors related with supplier profile have lost their importance relative to other factors and are not much concerned as they were before.

The results cannot be generalized due to the number of companies analyzed, however, they can be an indication of the differences between two cultures and the changing trends in international trade. Furthermore, by utilizing the supplier selection tool developed, this study can be extended in the future and cover a whole specific industry in both countries. Apart from Turkey and Australia, industries of different countries can also be chosen and the emphasis the decision makers put on each criterion can be compared.

In the second implementation part of the study, the LP section of the hybrid model is applied to the Australian company. Suppliers are ranked using criteria weights calculated with AHP model and decision maker's pair-wise supplier evaluations for each criterion. Suppliers' data restrictions force the evaluations to be at criteria level rather than sub-criteria level of the developed AHP model. However, in case of data availability, the same procedure can be easily applied at sub-criteria level.

Since the weight of supplier's quality management factor is quite high compared to others, the supplier whose quality management is rated highest is likely to be the best supplier. Although Korea's globalization score is quite low, the supplier's success in quality management as well as delivery makes it the best one among all.

By considering all factors affecting international supplier selection decision, supplier in Korea is found to be the best one followed by the supplier in Thailand which is found to be the best one as far as financial terms and supplier's profile are concerned. Supplier in Germany, which is located very far from the Australian company, is ranked third.

By taking into consideration all the supplier-specific and country-specific factors that will be effective in their decision making process, and their existing as well as potential suppliers for the raw material, optimal order allocation is achieved. When the total logistics cost of the proposed is calculated and compared with the actual cost the Australian company incurs, significant cost-saving will be achieved by allocating orders among the best suppliers.

Further analyses are conducted on the optimal solution in order to depict the effects of strategic, internal and external environment related changes. Sensitivity analyses are also conducted to investigate the impacts of changes in the priority of supplier selection criteria as well as on order allocation.

As a result of this sensitivity analysis, it is seen that if there is a change in supplier's attributes, which might affect their overall preferability scores, supplier or buyer related constraints, a new optimal solution can easily be achieved. The analysis also aids the decision maker in making a tradeoff between risk and the TVP.

This study aims to assist any manufacturing or trading company in sourcing a direct material internationally by considering all the country related as well as supplier-specific factors that could be effective in the decision making process. By incorporating the multi-criteria approach with the multiple sourcing concept, it is aimed to minimize the supply chain risk and support the organizations to give the most effective decision. The hybrid model will be used by manufacturers as well as traders who aim to source a direct material from multiple external suppliers. Although it deals with a single item, depending on the availability of data, it can easily be converted to handle multi-items.

The analysis can be further extended to support outsourcing decisions of companies by implementing the ranking of suppliers at sub-criteria level. Similar

studies can be conducted for service industries as well. Additionally, the model can be used to analyze a whole industry in various countries to obtain cross-cultural results that can be generalized. Finally, the optimization model can be extended further to include multiple products, multiple objectives.

APPENDICES

APPENDIX A. Factor Evaluation Questionnaire

QUESTIONNAIRE	
This questionnaire is directed to determine the priority weight of each factor used for vendor evaluation within the context of Analytic Hierarch Process (AHP). The factors are to be rated by pair-wise comparison (Saaty, 1990) where the preferences of a factor over the other is given a numerical value. The measures scale is presented in the table below.	
Measurement Scale	
Verbal Judgment or Preference	Numerical Rating
A is extremely Preferred over B	9
Very strongly Preferred	7
Strongly Preferred	5
Moderately Preferred	3
Equally Preferred	1
The values of 2, 4, 6, 8 provide intermediate levels of discrimination.	
If B is more preferred over A, reciprocal values are assigned.	

The questionnaire for the external suppliers that is filled out by the Sourcing Manager of the Turkish company and the AHP results are as follows:

Overall Relationship Among Criteria

B → A ↓	Financial Terms	Supplier's Profile	Supplier's Safety & Environmental Concern	Supplier's Quality Management	Delivery	Global factors	AHP Results
Financial Terms	1	3	5	7	1	3	0.315
Supplier's Profile		1	3	5	1/3	1	0.134
Supplier's Safety & Environmental Concern			1	3	1/3	1/3	0.067
Supplier's Quality Management				1	1/5	1/5	0.034
Delivery					1	5	0.323
Global Factors						1	0.127

Financial Terms Criterion

B →	Logistics Cost	Payment Term	AHP Results
A ↓			
Logistics Cost	1	1/7	0.125
Payment Term		1	0.875

Supplier's Profile

B →	Financial Strength	Market Reputation and Position in Industry	Flexibility	Innovative Capability	Information Sharing / Communication Ease	Collaboration Duration	AHP Results
A ↓							
Financial Strength	1	3	1/4	1/3	1/5	1	0.083
Market Reputation		1	1/5	1/2	1/3	1/3	0.051
Flexibility			1	3	2	5	0.372
Innovative Capability				1	1	1/3	0.131
Information Sharing / Communication Ease					1	3	0.227
Collaboration Duration						1	0.137

Supplier's Quality Management

<div style="text-align: center;"> B → A ↓ </div>	Product Quality	Quality Awards / Certificates	Quality Control	Process Capability	Continuous Improvement Programs	Quality Planning	Response to Customer Complaints	AHP Results
Product Quality	1	7	1	1	3	1	1	0.204
Quality Awards / Certificates		1	1/5	1/5	1/3	1/5	1/5	0.032
Quality Control			1	1	1	1	1	0.158
Process Capability				1	1	1	1	0.158
Continuous Improvement Programs					1	1	1	0.130
Quality Planning						1	1	0.158
Response to Customer Complaints							1	0.158

Supplier's Safety & Environmental Concern

<div style="text-align: center;"> B → A ↓ </div>	ISO 14001 Certification	Use of Environmentally-friendly materials	Conformance to MSDS Data	Waste treatment/ Disposal	AHP Results
ISO 14001 Certification	1	1/3	1/5	3	0.133
Use of environmentally-friendly materials		1	1/3	3	0.252
Conformance to MSDS Data			1	4	0.535
Waste treatment/ Disposal				1	0.080

Delivery

<div style="text-align: center;">B</div> <div style="text-align: center;">→</div> <div style="text-align: center;">A</div> <div style="text-align: center;">↓</div>	Lead time	On-time delivery	Compliance with Quantity and Packaging Standards	Compliance with Documentation Standards	AHP Results
Lead time	1	1	1	3	0.309
On-time delivery		1	1	3	0.309
Compliance with Quantity and Packaging Standards			1	1	0.241
Compliance with Documentation Standards				1	0.142

Global Factors

<div style="text-align: center;">B</div> <div style="text-align: center;">→</div> <div style="text-align: center;">A</div> <div style="text-align: center;">↓</div>	Geographical Location	Political Environment	Economic Environment	Social Environment	AHP Results
Geographical Location	1	3	1	3	0.360
Political Environment		1	1/3	3	0.159
Economic Environment			1	5	0.399
Social Environment				1	0.081

The questionnaire for the external suppliers is filled out by the Supply Chain Manager of the Australian company and the AHP results are as follows:

Overall Relationship Between Criteria

B → A ↓	Financial Terms	Supplier's Profile	Supplier's Safety & Environmental Concern	Supplier's Quality Management	Delivery	Global factors	AHP Results
Financial Terms	1	1	1/3	1/5	1	1	0.081
Supplier's Profile		1	1/3	1/5	1	1	0.081
Supplier's Safety & Environmental Concern			1	1/3	3	3	0.223
Supplier's Quality Management				1	5	5	0.454
Delivery					1	1	0.081
Global Factors						1	0.081

Financial Terms Criterion

B → A ↓	Logistics Cost	Payment Term	AHP Results
Logistics Cost	1	1	0.500
Payment Term		1	0.500

Supplier's Profile

<div style="text-align: center;">B</div> <div style="text-align: center;">→</div> <div style="text-align: center;">A</div> <div style="text-align: center;">↓</div>	Financial Strength	Market Reputation and Position in Industry	Flexibility	Innovative Capability	Information Sharing / Communication Ease	Collaboration Duration	AHP Results
Financial Strength	1	1	3	3	1/3	1/3	0.115
Market Reputation		1	3	3	1/3	1/3	0.115
Flexibility			1	1	1/9	1/9	0.038
Innovative Capability				1	1/9	1/9	0.038
Information Sharing / Communication Ease					1	1	0.346
Collaboration Duration						1	0.346

Supplier's Quality Management

<div style="text-align: center;">B</div> <div style="text-align: center;">→</div> <div style="text-align: center;">A</div> <div style="text-align: center;">↓</div>	Product Quality	Quality Awards / Certificates	Quality Control	Process Capability	Continuous Improvement Programs	Quality Planning	Response to Customer Complaints	AHP Results
Product Quality	1	7	3	3	7	3	3	0.383
Quality Awards / Certificates		1	1/2	1/2	1	1/2	1/2	0.060
Quality Control			1	1	3	1	1	0.130
Process Capability				1	3	1	1	0.130
Continuous Improvement Programs					1	1/2	1/2	0.054
Quality Planning						1	1	0.122
Response to Customer Complaints							1	0.122

Supplier's Safety & Environmental Concern

B → A ↓	ISO 14001 Certification	Use of Environmentally-friendly materials	Conformance to MSDS Data	Waste treatment/ Disposal	AHP Results
ISO 14001 Certification	1	1	1	1	0.250
Use of environmentally-friendly materials		1	1	1	0.250
Conformance to MSDS Data			1	1	0.250
Waste treatment/ Disposal				1	0.250

Delivery

B → A ↓	Lead time	On-time delivery	Compliance with Quantity and Packaging Standards	Compliance with Documentation Standards	AHP Results
Lead time	1	1/5	3	1/3	0.112
On-time delivery		1	9	2	0.522
Compliance with Quantity and Packaging Standards			1	1/9	0.043
Compliance with Documentation Standards				1	0.323

Global Factors

B → A ↓	Geographical Location	Political Environment	Economic Environment	Social Environment	AHP Results
Geographical Location	1	1/3	1/5	1	0.099
Political Environment		1	1/2	3	0.284
Economic Environment			1	5	0.518
Social Environment				1	0.099

The questionnaire for the external suppliers is filled out by the Sourcing Manager of the Australian company and the AHP results are as follows:

Overall Relationship among Criteria

B → A ↓	Financial Terms	Supplier's Profile	Supplier's Safety & Environmental Concern	Supplier's Quality Management	Delivery	Global factors	AHP Results
Financial Terms	1	9	7	1/7	1/2	1	0.134
Supplier's Profile		1	1/3	1/9	1/7	1/5	0.024
Supplier's Safety & Environmental Concern			1	1/9	1/7	1/3	0.037
Supplier's Quality Management				1	4	7	0.524
Delivery					1	2	0.184
Global Factors						1	0.096

Financial Terms Criterion

B →	Logistics Cost	Payment Term	AHP Results
A ↓			
Logistics Cost	1	9	0.900
Payment Term		1	0.100

Supplier's Profile

B →	Financial Strength	Market Reputation and Position in Industry	Flexibility	Innovative Capability	Information Sharing / Communication Ease	Collaboration Duration	AHP Results
A ↓							
Financial Strength	1	1/3	1/5	1/8	1/6	1/9	0.028
Market Reputation		1	1/5	1/7	1/5	1/4	0.047
Flexibility			1	1	3	1	0.238
Innovative Capability				1	3	4	0.360
Information Sharing / Communication Ease					1	1/3	0.122
Collaboration Duration						1	0.206

Supplier's Quality Management

<div style="text-align: center;"> B → A ↓ </div>	Product Quality	Quality Awards / Certificates	Quality Control	Process Capability	Continuous Improvement Programs	Quality Planning	Response to Customer Complaints	AHP Results
Product Quality	1	9	4	7	6	8	5	0.431
Quality Awards / Certificates		1	1/7	1/5	1/7	1/5	1/9	0.018
Quality Control			1	5	7	8	2	0.228
Process Capability				1	1/2	1	1/4	0.046
Continuous Improvement Programs					1	1	1/6	0.058
Quality Planning						1	1/7	0.044
Response to Customer Complaints							1	0.175

Supplier's Safety & Environmental Concern

<div style="text-align: center;"> B → A ↓ </div>	ISO 14001 Certification	Use of Environmentally-friendly materials	Conformance to MSDS Data	Waste treatment/ Disposal	AHP Results
ISO 14001 Certification	1	1/3	1/9	3	0.083
Use of environmentally-friendly materials		1	1/5	7	0.208
Conformance to MSDS Data			1	9	0.669
Waste treatment/ Disposal				1	0.041

Delivery

<div style="text-align: center;">B</div> <div style="text-align: center;">→</div> <div style="text-align: center;">A</div> <div style="text-align: center;">↓</div>	Lead time	On-time delivery	Compliance with Quantity and Packaging Standards	Compliance with Documentation Standards	AHP Results
Lead time	1	5	8	6	0.635
On-time delivery		1	5	3	0.210
Compliance with Quantity and Packaging Standards			1	1/4	0.046
Compliance with Documentation Standards				1	0.110

Global Factors

<div style="text-align: center;">B</div> <div style="text-align: center;">→</div> <div style="text-align: center;">A</div> <div style="text-align: center;">↓</div>	Geographical Location	Political Environment	Economic Environment	Social Environment	AHP Results
Geographical Location	1	1/5	1/3	3	0.127
Political Environment		1	2	5	0.502
Economic Environment			1	5	0.306
Social Environment				1	0.065

APPENDIX B. Input Data and LP Model

Table A.1. Quantitative Data for Each Supplier

Suppliers Country	Purchase price (USD/kg)	Freight cost (USD/kg)	Import Duty (USD/kg)	Total Cost (USD/kg)	Lead time (days)	Capacity (kg/year)
USA	17.65	0.166	0.00*	17.86	70	15000
Germany	18.22	0.153	0.91	19.33	60	10000
Korea	17.27	0.069	0.86	18.25	30	30000
China	17.22	0.056	0.86	18.18	45	10000
Taiwan	17.57	0.041	0.88	18.53	45	60000
Indonesia	17.27	0.053	0.86	18.23	30	10000
Thailand	17.49	0.047	0.00*	17.58	45	20000
Canada	17.93	0.197	0.90	19.07	55	1000
France	17.30	0.178	0.86	18.38	50	7500
UK	17.50	0.172	0.88	18.59	50	3000
Ireland	18.25	0.222	0.91	19.42	50	5000
Mexico	17.76	0.197	0.89	18.89	50	15000
Brazil	17.26	0.216	0.86	18.38	50	3000
South Africa Republic	17.45	0.184	0.87	18.55	30	1000

*Import duty is 0 since Australia has free trade agreement (FTA) with the United States and Thailand.

Import duties are calculated by multiplying the purchase price with duty rates which is 0.05 for this raw material. Total logistics cost is the sum of purchase price, freight cost, local charges (including customs clearance, delivery to warehouse cost) and import duties. Local charge is 0.043 USD/kg for each supplier.

Budget and demand are determined to be 200,000 USD/year and 10,000 kg/year respectively.

In order to determine the supplier's weight with respect to 'financial terms', 'financial terms' weight is multiplied by the inverse normalized amount of supplier's total logistics cost. Supplier's weight with respect to 'delivery' is calculated by multiplying 'supplier's delivery' weight by the inverse normalized lead time of the supplier. Supplier's weight with respect to 'global factors' is obtained by multiplying global factors weight by the countries' normalized index score according to KOF Index of Globalization. Supplier's weight with respect to 'supplier's profile', 'supplier's quality management', 'supplier's safety and environmental concern' are

obtained by pair-wise comparison of each supplier according to each criterion.

Supplier's overall weights are derived by summing up supplier's ratings with respect to each criterion.

The specific LP model is as follows:

$$\text{Max } TVP = \sum_{i=1}^{14} w_i x_i = 0.090 \times x_1 + 0.086 \times x_2 + 0.078 \times x_3 + \dots + 0.570 \times x_{14}$$

Subject to:

$$\sum_{i=1}^n x_i = 10000 \quad (\text{Demand constraint})$$

$$\sum_{i=1}^n c_i x_i \leq 200000 \text{ USD} \quad (\text{Budget constraint})$$

$$C_i y_i \geq x_i \quad (\text{Capacity constraint})$$

$$\sum_{i=1}^n C_i \geq D \quad (\text{Demand constraint})$$

$$Q_{i\min} y_i \leq x_i \quad (\text{Order constraint})$$

$$4 \leq \sum_{i=1}^n y_i \leq 7 \quad (\text{Suppliers' upper and lower bound constraint})$$

$$x_i \geq 0$$

$$y_i = 0 \text{ or } 1$$

APPENDIX C. Countries' Merchandise Imports by Commodities

Table A.2 Turkey's Merchandise Imports by Commodity

	Million \$			% Change		% Share		
	2006	2007	2008	07/06	08/07	2006	2007	2008
<i>i-Iron and steel</i>	8 141	11 341	15 034	39.3	32.6	5.8	6.7	7.4
<i>ii-Chemicals</i>	18 408	22 107	25 542	20.1	15.5	13.2	13.0	12.6
Plastics	6 221	7 870	8 486	26.5	7.8	4.5	4.6	4.2
Pharmaceutical products	3 343	3 838	4 738	14.8	23.4	2.4	2.3	2.3
Other chemicals	8 843	10 398	12 317	17.6	18.5	6.3	6.1	6.1
<i>iii-Other semi-finished products</i>	7 042	8 313	9 074	18.1	9.1	5.0	4.9	4.5
Paper	1 882	2 286	2 409	21.5	5.4	1.3	1.3	1.2
Rubber, wood, leather made products	1 721	2 139	2 236	24.3	4.5	1.2	1.3	1.1
Mineral products excluding metals	1 365	1 456	1 431	6.7	-1.7	1.0	0.9	0.7
Metals	2 074	2 434	2 998	17.3	23.2	1.5	1.4	1.5
<i>iv- Machines and transportation vehicles</i>	43 302	49 858	51 595	15.1	3.5	31.0	29.3	25.5
Automotive industry products	12 957	14 684	15 155	13.3	3.2	9.3	8.6	7.5
Office machinery and communication devices	7 668	8 724	8 119	13.8	-6.9	5.5	5.1	4.0
Energy producing machines	990	1 376	2 353	39.0	71.0	0.7	0.8	1.2
Other nonelectrical devices	12 798	15 263	14 770	19.3	-3.2	9.2	9.0	7.3
Other transportation vehicles	3 444	3 458	4 327	0.4	25.1	2.5	2.0	2.1
Electrical machines	5 445	6 354	6 871	16.7	8.1	3.9	3.7	3.4
<i>v-Wovens</i>	4 816	6 152	5 801	27.7	-5.7	3.5	3.6	2.9
<i>vi- Garment industry</i>	1 098	1 567	2 216	42.7	41.5	0.8	0.9	1.1
<i>vii - Other consumable goods</i>	6 449	8 056	8 967	24.9	11.3	4.6	4.7	4.4
Lightening materials	523	568	645	8.6	13.6	0.4	0.3	0.3
Furniture	514	681	734	32.4	7.8	0.4	0.4	0.4
Travelling equipment	296	391	406	31.8	3.8	0.2	0.2	0.2
Shoes	515	570	673	10.7	18.1	0.4	0.3	0.3
Scientific measurement devices	1 804	2 100	2 407	16.4	14.6	1.3	1.2	1.2
Other consumable products	2 797	3 748	4 104	34.0	9.5	2.0	2.2	2.0
Total Merchandise Imports	89 255	107 394	118 229	20.3	10.1	63.9	63.1	58.5
Total Import	139 576	170 063	201 964	21.8	18.8	100.0	100.0	100.0

(Source: www.dtm.gov.tr)

Table A.3 Australia's Merchandise Imports by Commodity (A\$ million)

	Imports						
0 Food & live animals, chiefly for food	5,171	5,272	5,772	6,390	7,193	8,286	10.2%
1 Beverages & tobacco	960	949	1,031	1,277	1,429	1,657	12.7%
2 Crude materials, inedible (excl fuels)	1,938	1,892	1,954	2,216	2,473	2,878	8.7%
3 Mineral fuels, lubricants, etc	10,031	12,863	17,219	23,183	24,442	35,364	27.6%
4 Animal & vegetable oils, fats & waxes	356	381	369	479	536	605	11.9%
Total primary products (Sections 0-4)	18,456	21,357	26,345	33,545	36,073	48,790	21.0%
5 Chemicals & related products, nes	14,935	16,359	18,089	18,978	20,432	23,853	9.1%
6 Manufactured goods classified chiefly by material	15,809	16,723	18,141	19,450	21,251	25,106	9.3%
7 Machinery & transport equipment	59,167	64,232	68,938	74,905	79,049	88,039	8.0%
8 Miscellaneous manufactured articles	18,347	19,868	21,247	23,216	24,491	27,860	8.3%
Total manufactures (Sections 5-8)	108,258	117,182	126,415	136,549	145,223	164,858	8.4%
9 Commodities & transactions of merchandise trade not elsewhere classified	3,270	2,707	2,967	5,995	6,579	12,186	32.9%
Total merchandise imports	129,983	141,246	155,726	176,090	187,874	225,833	11.3%

(Source: DFAT Statistics, 2008)

APPENDIX D. KOF Index of Globalization

2009 KOF Index of Globalization*

Globalization Index		Economic Globalization		Social Globalization		Political Globalization	
country	Index	country	Globalization	country	Globalization	country	Globalization
1. Belgium	91.51	1. Singapore	96.67	1. Luxembourg	93.87	1. France	98.03
2. Ireland	91.02	2. Luxembourg	93.43	2. Switzerland	93.85	2. Italy	97.04
3. Netherlands	89.92	3. Ireland	92.63	3. Ireland	91.96	3. Belgium	97.01
4. Switzerland	89.87	4. Malta	92.63	4. Antigua and Barbuda	91.90	4. Austria	96.85
5. Austria	89.14	5. Belgium	91.63	5. Cyprus	91.72	5. Sweden	96.64
6. Sweden	88.68	6. Netherlands	91.30	6. Puerto Rico	90.66	6. Spain	95.22
7. Denmark	87.37	7. Estonia	90.35	7. Singapore	90.65	7. Switzerland	95.11
8. Canada	86.32	8. Hungary	90.22	8. Austria	90.62	8. Canada	94.90
9. Luxembourg	86.28	9. Bahrain	88.37	9. Grenada	88.53	9. United States	94.05
10. Hungary	85.15	10. Sweden	88.11	10. Belgium	88.12	10. Poland	93.88
11. Czech Republic	84.65	11. Cyprus	86.74	11. Malta	87.99	11. Netherlands	93.61
12. New Zealand	84.55	12. Czech Republic	86.58	12. New Zealand	87.24	12. Egypt, Arab Rep.	93.35
13. Finland	84.19	13. Denmark	85.49	13. Canada	87.22	13. Denmark	93.13
14. Singapore	84.07	14. Chile	85.48	14. Slovenia	86.51	14. Germany	92.80
15. Portugal	83.92	15. New Zealand	85.20	15. Netherlands	86.37	15. Argentina	92.78
16. France	83.68	16. Portugal	84.96	16. Denmark	85.81	16. Greece	92.20
17. Estonia	83.45	17. Israel	84.96	17. Sweden	84.52	17. Brazil	92.15
18. Spain	82.94	18. Finland	84.69	18. Estonia	84.13	18. Portugal	92.11
19. Cyprus	82.70	19. Slovak Republic	84.13	19. United Kingdom	83.65	19. Turkey	91.72
20. Slovenia	82.40	20. Austria	83.04	20. Bahamas, The	82.97	20. India	91.65
21. Norway	82.27	21. Iceland	82.90	21. Iceland	82.72	21. Hungary	91.63
22. Germany	81.75	22. Switzerland	82.73	22. New Caledonia	82.59	22. Romania	90.88
23. Malta	81.24	23. Latvia	82.60	23. Croatia	82.57	23. Australia	90.65
24. Slovak Republic	81.24	24. Panama	81.65	24. Germany	82.37	24. Nigeria	89.95
25. Croatia	80.61	25. Spain	80.95	25. Norway	81.98	25. Finland	89.92
26. Australia	80.49	26. Canada	80.29	26. Latvia	81.73	26. Japan	89.42
27. United Kingdom	79.31	27. Slovenia	80.26	27. French Polynesia	81.24	27. Norway	89.26
28. Italy	78.80	28. Lithuania	80.24	28. France	81.22	28. Morocco	89.25
29. Lebanon	78.56	29. United Kingdom	79.30	29. Czech Republic	80.43	29. Pakistan	88.81
30. Poland	77.96	30. Jamaica	78.51	30. Finland	80.29	30. Czech Republic	88.53
31. Lithuania	77.24	31. Norway	78.37	31. United Arab Emirates	79.80	31. Chile	87.23
32. Greece	77.00	32. Croatia	78.28	32. Lebanon	78.49	32. Bulgaria	87.16
33. Malaysia	76.24	33. Australia	78.04	33. Portugal	78.03	33. Senegal	87.09
34. Latvia	76.14	34. Malaysia	78.03	34. Spain	77.62	34. Tunisia	87.00
35. Iceland	76.12	35. France	77.57	35. Slovak Republic	77.44	35. South Africa	86.90
36. Jordan	75.51	36. Bulgaria	76.08	36. Seychelles	77.16	36. Ireland	86.72
37. Chile	74.99	37. Poland	74.93	37. Australia	76.89	37. Korea, Rep.	86.64
38. United States	74.93	38. Germany	74.50	38. Brunei Darussalam	76.53	38. China	86.36
39. Bulgaria	74.85	39. Italy	74.37	39. Samoa	76.46	39. Jordan	85.50
40. Israel	74.69	40. Kazakhstan	73.98	40. Hungary	76.27	40. Peru	85.28
41. Bahrain	72.89	41. Greece	73.54	41. Lithuania	76.13	41. Algeria	85.28
42. Panama	70.88	42. Jordan	73.25	42. Barbados	75.98	42. Kenya	84.60
43. Bosnia and Herzegovina	70.81	43. Trinidad and Tobago	72.71	43. Maldives	75.94	43. Russian Federation	84.60
44. Romania	70.58	44. Oman	72.30	44. Kuwait	75.72	44. Indonesia	84.59
45. Antigua and Barbuda	70.52	45. Moldova	71.31	45. Qatar	75.69	45. Uruguay	84.52
46. Jamaica	69.76	46. Botswana	70.57	46. Mauritius	75.64	46. Philippines	84.17
47. Ukraine	69.30	47. Bosnia and Herzegovina	70.50	47. Macao, China	74.40	47. Malaysia	83.73
48. United Arab Emirates	69.26	48. Uruguay	69.93	48. Bahrain	74.31	48. Ghana	83.30
49. Mauritius	69.26	49. Costa Rica	69.64	49. Macedonia, FYR	74.03	49. Ukraine	83.14
50. Uruguay	69.14	50. Thailand	69.43	50. Italy	72.38	50. Slovak Republic	82.81
51. Grenada	68.95	51. Georgia	69.43	51. Jordan	71.82	51. Ethiopia	82.02
52. Kuwait	68.02	52. Armenia	69.11	52. Poland	71.52	52. Thailand	81.22
53. Costa Rica	67.56	53. Guyana	68.88	53. Greece	71.41	53. Croatia	81.22
54. South Africa	67.06	54. Honduras	68.70	54. Belarus	71.16	54. Guatemala	80.40
55. El Salvador	66.52	55. Mongolia	68.30	55. Costa Rica	70.95	55. Ecuador	79.84
56. Thailand	66.49	56. Vanuatu	68.24	56. United States	70.90	56. Slovenia	79.07
57. Turkey	66.42	57. Romania	68.14	57. Israel	70.89	57. New Zealand	78.92
58. Samoa	66.15	58. South Africa	67.97	58. Malaysia	70.02	58. Lebanon	78.68
59. Korea, Rep.	65.87	59. United States	67.56	59. Bosnia and Herzegovina	69.60	59. Bolivia	77.31
60. Qatar	65.51	60. Turkey	67.15	60. Guyana	69.38	60. Zambia	76.99
61. Russian Federation	65.24	61. Mauritius	66.95	61. Ukraine	68.40	61. El Salvador	76.15
62. Moldova	65.20	62. Cambodia	66.14	62. Swaziland	67.96	62. Guinea	75.81
63. Argentina	65.15	63. Peru	66.12	63. Panama	67.83	63. Paraguay	75.46
64. Tunisia	65.12	64. Angola	66.08	64. Oman	66.36	64. Mali	75.18
65. Mexico	64.11	65. El Salvador	65.86	65. Bulgaria	66.32	65. Bangladesh	75.06
66. Guyana	64.09	66. Tunisia	64.98	66. Moldova	65.96	66. Sri Lanka	74.72
67. Honduras	63.85	67. Indonesia	64.96	67. Saudi Arabia	65.42	67. Lithuania	74.10
68. Dominican Republic	63.83	68. Kuwait	64.91	68. Belize	63.17	68. Cote d'Ivoire	74.10
69. Peru	63.55	69. Bolivia	64.48	69. Mexico	62.02	69. Niger	73.53
70. Japan	63.54	70. Macedonia, FYR	63.84	70. Russian Federation	61.89	70. Burkina Faso	73.47
71. Oman	63.30	71. Belize	62.75	71. Fiji	61.89	71. Benin	73.45
72. Kazakhstan	63.18	72. Nicaragua	62.71	72. Armenia	61.56	72. Bosnia and Herzegovina	73.35
73. Seychelles	63.13	73. Nigeria	62.34	73. Kazakhstan	61.52	73. Togo	73.30
74. Ecuador	63.02	74. Dominican Republic	62.29	74. El Salvador	61.46	74. Dominican Republic	73.18
75. Saudi Arabia	62.87	75. Namibia	62.28	75. Suriname	61.07	75. Cameroon	72.62
76. Barbados	62.84	76. Azerbaijan	62.16	76. Serbia	60.96	76. Zimbabwe	72.36
77. Morocco	62.64	77. Barbados	62.09	77. Romania	60.95	77. United Kingdom	72.01
78. Egypt, Arab Rep.	62.20	78. Ukraine	61.93	78. Korea, Rep.	60.36	78. Jamaica	71.63
79. Brazil	61.74	79. Mexico	61.85	79. Jamaica	59.98	79. Gabon	71.55
80. Trinidad and Tobago	61.65	80. Mozambique	61.69	80. Dominican Republic	59.81	80. Mexico	71.40
81. Armenia	61.19	81. Philippines	60.53	81. Argentina	59.55	81. Albania	70.99
82. Namibia	60.80	82. Brazil	60.48	82. Uruguay	59.24	82. Uganda	70.95
83. Bahamas, The	60.84	83. China	60.47	83. Georgia	58.94	83. Estonia	70.76
84. Kyrgyz Republic	60.64	84. Kyrgyz Republic	60.17	84. Japan	58.42	84. Honduras	70.36
85. Philippines	60.63	85. Ecuador	59.76	85. Trinidad and Tobago	58.15	85. Iran, Islamic Rep.	69.75
86. Guatemala	60.48	86. Colombia	59.15	86. Nicaragua	57.66	86. Nepal	69.02
87. Vanuatu	60.43	87. Korea, Rep.	59.00	87. Kyrgyz Republic	57.60	87. Venezuela, RB	67.95
88. Fiji	60.41	88. Paraguay	58.71	88. Colombia	57.38	88. Mongolia	67.92
89. Macedonia, FYR	60.08	89. Zambia	58.00	89. Cape Verde	57.38	89. Serbia	67.56
90. Georgia	60.01	90. Papua New Guinea	57.60	90. Chile	57.33	90. Namibia	67.25
91. China	59.85	91. Russian Federation	57.04	91. Morocco	57.29	91. Fiji	67.06
92. Colombia	59.56	92. Egypt, Arab Rep.	56.91	92. Ecuador	56.27	92. Madagascar	67.04
93. Paraguay	59.56	93. Mali	56.62	93. Namibia	55.74	93. Kyrgyz Republic	66.57

country	Globalization Index	country	Economic Globalization	country	Social Globalization	country	Political Globalization
94. Angola	59.55	94. Venezuela, RB	56.59	94. Azerbaijan	55.31	94. Djibouti	65.73
95. Nicaragua	59.34	95. Albania	55.92	95. Honduras	55.16	95. Gambia, The	65.45
96. Belize	58.44	96. Vietnam	55.67	96. Thailand	54.83	96. Mozambique	65.26
97. Venezuela, RB	58.38	97. Congo, Rep.	55.65	97. Venezuela, RB	54.48	97. Chad	64.12
98. Gambia, The	58.33	98. Guatemala	55.48	98. South Africa	54.39	98. Rwanda	64.12
99. Bolivia	57.74	99. Fiji	54.96	99. Gambia, The	54.11	99. Israel	63.93
100. Indonesia	57.66	100. Swaziland	54.42	100. Turkmenistan	53.88	100. Colombia	63.92
101. Maldives	57.40	101. Argentina	54.26	101. Guatemala	53.62	101. Sierra Leone	63.76
102. Azerbaijan	57.37	102. Togo	54.22	102. Gabon	52.29	102. Malawi	63.18
103. Albania	56.29	103. Mauritania	53.40	103. Tunisia	52.27	103. Yemen, Rep.	63.12
104. Gabon	56.15	104. Japan	53.23	104. Paraguay	50.96	104. Mauritius	62.37
105. Zambia	56.11	105. Lesotho	53.05	105. Turkey	50.70	105. Luxembourg	61.54
106. Swaziland	55.79	106. Morocco	52.11	106. Cuba	50.23	106. Central African Republic	61.17
107. Mozambique	55.63	107. Syrian Arab Republic	52.11	107. Botswana	49.11	107. Cambodia	61.12
108. Nigeria	55.53	108. Algeria	51.51	108. Egypt, Arab Rep.	48.97	108. Cuba	61.06
109. Botswana	55.46	109. Ghana	51.23	109. Peru	48.11	109. Cyprus	60.72
110. Ghana	55.32	110. Gabon	50.82	110. Albania	47.94	110. Kuwait	60.25
111. Mongolia	55.27	111. Sri Lanka	50.40	111. Philippines	46.76	111. Saudi Arabia	58.58
112. Algeria	54.75	112. Cote d'Ivoire	50.12	112. Lesotho	46.52	112. Libya	58.41
113. Sri Lanka	54.46	113. Chad	49.09	113. Sri Lanka	46.47	113. Costa Rica	58.39
114. Senegal	54.05	114. Uganda	48.93	114. Senegal	45.98	114. Panama	58.03
115. Belarus	53.46	115. Bahamas, The	48.17	115. Syrian Arab Republic	45.01	115. Tanzania	57.84
116. Pakistan	53.32	116. Pakistan	47.55	116. Brazil	44.95	116. Syrian Arab Republic	57.43
117. New Caledonia	53.25	117. Zimbabwe	47.03	117. Mozambique	43.92	117. Nicaragua	56.52
118. Cote d'Ivoire	52.47	118. Guinea-Bissau	46.92	118. China	43.50	118. Sudan	55.91
119. French Polynesia	52.40	119. Cameroon	45.11	119. Bhutan	42.97	119. Latvia	55.91
120. Suriname	52.06	120. India	44.84	120. Ghana	42.78	120. Vietnam	53.89
121. Mauritania	51.55	121. Malawi	43.58	121. Vietnam	42.11	121. Moldova	53.69
122. India	51.36	122. Tanzania	43.21	122. Cote d'Ivoire	41.98	122. Iceland	53.67
123. Cambodia	51.30	123. Haiti	42.73	123. Zambia	41.85	123. Iraq	53.37
124. Syrian Arab Republic	50.58	124. Sierra Leone	42.64	124. Zimbabwe	40.78	124. Azerbaijan	52.82
125. Zimbabwe	50.42	125. Belarus	42.56	125. Eritrea	39.97	125. Singapore	51.91
126. Togo	50.23	126. Senegal	42.42	126. Algeria	39.85	126. United Arab Emirates	51.51
127. Vietnam	50.01	127. Madagascar	42.27	127. Bolivia	39.44	127. Malta	50.84
128. Cape Verde	49.93	128. Central African Republic	40.75	128. Kenya	38.10	128. Trinidad and Tobago	49.05
129. Kenya	49.59	129. Yemen, Rep.	40.57	129. Pakistan	37.98	129. Samoa	48.77
130. Macao, China	48.63	130. Kenya	40.24	130. Burkina Faso	37.52	130. Angola	48.62
131. Mali	47.96	131. Benin	38.63	131. Malawi	37.33	131. Mauritania	48.47
132. Cameroon	47.61	132. Burkina Faso	38.53	132. Congo, Rep.	36.60	132. Qatar	48.36
133. Lesotho	46.98	133. Burundi	37.59	133. Tajikistan	35.78	133. Kazakhstan	47.92
134. Burkina Faso	46.16	134. Ethiopia	37.28	134. Cameroon	35.25	134. Congo, Dem. Rep.	47.55
135. Uganda	45.82	135. Bangladesh	36.22	135. Mongolia	34.84	135. Vanuatu	47.37
136. Malawi	45.66	136. Nepal	34.72	136. Indonesia	34.44	136. Armenia	47.36
137. Congo, Rep.	45.23	137. Iran, Islamic Rep.	33.46	137. India	33.93	137. Guyana	47.18
138. Papua New Guinea	44.57	138. Niger	31.13	138. Benin	32.72	138. Georgia	46.08
139. Benin	44.34	139. Rwanda	29.96	139. Iran, Islamic Rep.	32.69	139. Haiti	45.18
140. Chad	43.78	140. Afghanistan	.	140. Togo	32.57	140. Papua New Guinea	45.08
141. Haiti	43.65	141. American Samoa	.	141. Guinea-Bissau	32.33	141. Afghanistan	44.85
142. Ethiopia	43.18	142. Andorra	.	142. Papua New Guinea	31.34	142. Timor-Leste	44.74
143. Madagascar	42.79	143. Antigua and Barbuda	.	143. Cambodia	30.75	143. Bahamas, The	44.71
144. Yemen, Rep.	41.82	144. Aruba	.	144. Yemen, Rep.	30.44	144. Bahrain	44.64
145. Iran, Islamic Rep.	41.49	145. Bermuda	.	145. Madagascar	28.92	145. Liberia	43.58
146. Guinea-Bissau	40.51	146. Bhutan	.	146. Sudan	28.74	146. Guinea-Bissau	43.57
147. Tanzania	40.36	147. Brunei Darussalam	.	147. Burundi	28.64	147. Belize	43.29
148. Sierra Leone	39.83	148. Cape Verde	.	148. Rwanda	28.48	148. Oman	43.10
149. Bangladesh	39.78	149. Cayman Islands	.	149. Nigeria	28.35	149. Uzbekistan	42.80
150. Nepal	39.65	150. Channel Islands	.	150. Uganda	27.82	150. Congo, Rep.	42.34
151. Sudan	38.86	151. Comoros	.	151. Tanzania	27.15	151. Tajikistan	42.33
152. Tajikistan	38.22	152. Congo, Dem. Rep.	.	152. Nepal	27.10	152. Barbados	41.95
153. Central African Republic	37.97	153. Cuba	.	153. Chad	26.44	153. Belarus	41.85
154. Rwanda	37.23	154. Djibouti	.	154. Ethiopia	25.99	154. Burundi	41.01
155. Niger	36.67	155. Dominica	.	155. Mali	23.22	155. Botswana	40.91
156. Burundi	34.91	156. Equatorial Guinea	.	156. Sierra Leone	22.85	156. St. Lucia	39.63

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