BENCHMARKING THE SUPPLY CHAIN PERFORMANCE:

THE FOOD AND BEVERAGE INDUSTRY

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BENCHMARKING THE SUPPLY CHAIN PERFORMANCE: THE FOOD AND BEVERAGE INDUSTRY

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Benchmarking the Supply Chain Performance:
The Food and Beverage Industry

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Thesis Abstract

Esin Özdemir, "Benchmarking the Supply Chain Performance: The Food and Beverage Industry"

Supply chain management is gaining importance in today's business world along with increasing globalization and the developments in technology. Companies shift their competition from organizational level to supply chain level to be able to sustain their competitiveness in today's globalized international trade environment.

Within this context, the study aims to develop a systematic approach to evaluate and benchmark supply chain performances of companies and implements it on Turkish food and beverage industry. Utilizing optimization tools, the analysis develops national and international benchmarks at company and sectoral levels. The study proceeds with discussing improvement opportunities in company supply chain performances as well as their international trade operations with an emphasis on export performances. Both the approach developed and the results of the implementation are expected to shed light on similar sectoral studies especially in Turkey. It might also aid practitioners such as managers, investors in their decision making process.

Tez Özeti

Esin Özdemir, "Tedarik Zinciri Performans Kıyaslamaları: Yiyecek ve İçecek Endüstrisi

Gittikçe artan globalleşme ve teknolojik gelişmeler ile birlikte, tedarik zinciri yönetimi günümüz iş dünyasında önem kazanmaktadır. Günümüz global uluslararası ticaret ortamında, rekabet edilebilirliklerini koruyabilmek için, şirketler aralarındaki yarışı organizasyonel seviyeden tedarik zinciri seviyesine kaydırmaktadırlar.

Bu bağlamda, bu çalışma, şirketlerin tedarik zinciri performanslarını karşılaştıracak bir sistematik yaklaşım geliştirmeyi amaçlamış ve bu yaklaşımı Türkiye yiyecek ve içecek sektörüne uygulamıştır. Optimizasyon yöntemlerinden yararlanarak bu çalışma, şirket ve sektör bazında ulusal ve uluslarası karşılaştırma analizleri geliştirmiştir. Çalışma, şirket performanslarında ihracata önem vererek, şirketlerin uluslararası ticaret operasyonlarında gelişme olanaklarını tartışarak devam etmiştir. Hem geliştirilen yaklaşımın hem de sektörel uygulamanın sonuçlarının özellikle Türkiye'deki benzer sektörel çalışmalara ışık tutması tahmin edilmiştir. Ayrıca bu çalışma, yönetci ve yatırımcılara karar verme aşamasında yardımcı olmayı amaçlamıştır.

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To my family

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CHAPTER I

INTRODUCTION

No time in the history, efficiency of supply chain systems has been as important as it is in today's business world (Ross, 1998, p.2). In the past, companies were focusing on marketing, sales and finance operations since they were considered to be more important and critical functions in business management. Along with the liberalization of trade, markets globalize and become fierce, supply chain management (SCM) has become an important necessity to stay competitive and profitable. The lack of importance given to supply chain operations and to the other members of the supply chain such as suppliers and customers are realized along with the spread of operations, suppliers and customers all over the world and along with international trade's globalization.

As trade regimes change with the removal of government incentives and restrictions on trade, global trade environment has become more competitive and free. International trade has globalized more with the increase in the number of countries that engage in trade activities. Companies from one part of the world have began to operate in another part of the world. Therefore, companies need core competences such as agricultural production of Turkey for food and beverage companies, to be able to compete in global markets. Moreover, in order to speed up the operations and transactions in between and to be able to compete in global markets, they need efficient supply chains as a competitive advantage.

Along with the developments in technology and globalization which is speeded up with the liberalization of trade regimes, product life cycles shorten,

market uncertainty increases and competition becomes fiercer than ever before. Companies are forced to compete on time and quality basis. In order to manage their global operations effectively, to be able to respond to rapid changes in the market more quickly, to increase their product and service quality and to accelerate the speed of their operations, companies realize the necessity to build efficient relationships with their suppliers and customers. Thus, they realize the necessity of effectively managed supply chains. Along with this realization, their competition has shifted from organizational level to supply chain level (Li, S. Ragu-Nathan, B. Ragu-Nathan and Rao, 2006). Therefore; this thesis analyzes supply chain performances of companies to improve inefficiencies of the companies. Moreover, it adds export to the supply chain performance measures to introduce it no longer as a minor contribution but as a crucial criterion for survival in international trade environment.

Basically, SCM is an operations management activity to increase the overall value generated. This value generation objective of SCM might be achieved through various management strategies such as decreasing inventory levels by increasing the flow of materials and information through the supply chain and optimizing the functions of members in the supply chain and their relations with each other. By focusing on these, the aim of SCM is to decrease the costs of operations while increasing productivity of the chain.

SCM aims to find the most efficient way of managing the supply chain to provide competitive and cost efficient products or services. In search for new ways to sustain or to improve the efficiency level, performance evaluation of the entire supply chain is highly important. However, this is a challenging and difficult task since it has to involve the coordination of all supply chain members present in the supply chain beginning from raw material suppliers and ending with the end-

customers. Among these members, all customers of the supply chain such as wholesalers, markets, groceries, all suppliers such as chemical companies, farmers, steel and package providers, all production facilities and all third party providers such as transportation companies are present. The challenge and difficulty of coordinating all of these members of the supply chain is mentioned also by Ross (1998). To explain the impossibility and difficulty of this task, Ross (1998) states that even successful corporations such as Sears and General Motors do not have a system to coordinate and evaluate their entire supply chain.

Instead of analyzing the whole chain, literature contains several studies evaluating performances of parts of supply chains such as suppliers, distribution channels and manufacturing departments or studies evaluating only internal supply chains of companies. Similarly, this thesis evaluates the performance of internal supply chain with an emphasis on the manufacturer.

Internal supply chain or supply chain at company level begins with tier 1 suppliers and ends with tier 1 customers of the company. These customers and suppliers of a company may spread all around the world to make even the supply chain at company level a complex network. Today, a lot of companies are performing their operations in different parts of the world. Some of them have suppliers in China and customers in the USA or in Europe, some of them produce at home and sell their products all over the world. As Handfield and Nichols (1999) mention, today it is not uncommon that multiple links of an organization's internal supply chain span around the world.

Along with the spread of companies and their operations all over the world, performance evaluations and benchmarking practices have emerged as other critical issues of companies to improve themselves and sustain their competitiveness in

global markets. Benchmarking is a tool to compare an organization with others to see where the organization is with respect to its competitors and best peer companies. In their article Bogan and Callahan (2001) mention a Zen-like management riddle which is about a fish's wetness. A fish cannot understand that it is wet until it comes out of water since it has not seen an environment other than water before. Organizations may be associated to fishes which do not know any other environment. Benchmarking helps organizations realize different conditions, operation strategies and innovative ideas. This realization can lead organizations to superior performances.

Apart from organizations themselves, performance evaluations and benchmarking are important to stakeholders and investors in the sense that they relate to efficiency. Efficient firms imply that existing resources are allocated and utilized efficiently as well as operational and financial functions. Since stakeholders and investors want to gain as much as possible from their investments, performances of the firms they invest in are critically important for them.

One of the most common and reliable tools for performance benchmarking is data envelopment analysis (DEA). DEA is a multifactor nonparametric productivity analysis technique. It measures the relative efficiencies of decision making units (DMU) present in the data set and places them in the efficient frontier developed according to their input-output levels. The inputs and outputs of a DMU can be both qualitative and quantitative. There is no need to specify a mathematical or logical relationship between them. DEA specifies relatively inefficient DMU's and defines a reference set for each DMU from relatively efficient DMU's in order to highlight the improvement opportunities for the system.

Based on the above discussions, the primary objective of this thesis is to develop an applicable and realistic approach in order to evaluate and benchmark internal supply chain performances at company level by determining the relevant input-output variables and to measure the effects of the selected variables by the sensitivity analyses performed. The systematic approach developed will be implemented on a promising industry in Turkey which is the food and beverage industry. The Turkish food and beverage industry will then be compared with that in the USA, which is the global industry leader. This international benchmarking practice purposes to search for improvement opportunities for Turkish companies in international arena.

The food and beverage industry is selected for this study since the sector is highly competitive and efficient management strategies in the supply chain is highly critical to be successful and profitable. Shelf availability and product quality, which can be improved via effective supply chain management, are very crucial factors for survival of companies. From the economic viewpoint, this sector is selected since it is a promising sector which may support the sustainable development of the Turkish economy via growth in international trade of Turkey. Although Turkey has a competitive advantage in agricultural production, Turkish companies do not utilize this advantage in the global arena. Share of foods and beverages in total annual export has been increasing since 1985 (Turk Sanayicileri ve Isadamlari Dernegi [TUSIAD], 2007), but still has a potential to make a jump. By efficient supply chain management techniques the sector can increase its productivity, export volume and presence in the global arena. USA based companies are selected as international benchmarks for Turkish companies because the USA is the leader of the sector in the global arena. It is the export leader of the food and beverage industry in the world

(TUSIAD, 2007). Moreover, USA based companies generate 42,5% of total food and beverage sales around the world and 34 rank top 100 food and beverage companies in the world (TUSIAD, 2007).

The remainder of the thesis is summarized as follows. In the first chapters, the focus is given to SCM and benchmarking, their brief descriptions by the concepts covered in this thesis and the related literature. Following, is an outline of a number of parametric and non-parametric benchmarking tools cited in the literature. Presenting the advantages and disadvantages of commonly used benchmarking tools, selection of data envelopment analysis (DEA) is justified. In the methodology part of the thesis, DEA is discussed in detail. Application areas of DEA are outlined and input-output variables that are selected from literature are interpreted in detail. In the implementation part, reasons for selecting food and beverage industry for this study is discussed in detail. The importance of the food and beverage industry for Turkish economy and exports is explained and the selection of US food and beverage industry as an international benchmark is discussed. Sensitivity analysis is performed by varying the pre-defined metrics in various combinations. Finally, DEA is applied to Turkish food and beverage companies, US food and beverage companies and Turkish and US food and beverage companies together to assess the performances of companies relative to the companies in their domestic markets and then to companies in international markets.

To organize the above mentioned summary of this thesis, outline of the study is presented as follows:

Chapter II discusses supply chain management and the related concepts covered in this thesis. Chapter III outlines supply chain analysis and benchmarking along with the supply chain performance measures cited in literature. The next

chapter discusses the analytics of benchmarking by presenting the parametric and non-parametric methods cited in literature along with their advantages and disadvantages. Chapter V reviews data envelopment analysis, its related mathematics and its uses in literature. Chapter VI presents the implementation of the methodology on the Turkish food and beverage industry, presents results along with their discussions. The thesis ends with the conclusions, managerial implications of the results obtained and directions for future research.

CHAPTER II

SUPPLY CHAIN MANAGEMENT

Supply chain management is increasing its popularity in business since its importance in competitiveness of a company was realized. Initially, the focus of business was on manufacturing. Focusing on manufacturing, while trying to find the best way for production, was the major aim of companies. However, the developments in technology increased the complexity of manufacturing and industrial processes. It was necessary to search for new ways in management strategies. Then, Frederick W. Taylor and his colleagues introduced 'systems approach' which can be said to be the basics of supply chain management (Heizer and Render, 2004).

As the complexity of industrial processes increases and as the efficiency of these processes becomes important, the necessity to develop a conceptual basis to overcome the complexity becomes necessary. The systems approach emerged when the need for common measures in order to manage and organize the complex systems were realized. Rather than optimizing each sub-system according to its own operations and goals, systems approach aims to optimize the whole system by considering the interactions of sub-systems with each other. Along with increasing competition, systems approach is then extended to cover the marketing and finance functions to optimize operations systems. However, this extension has not been enough. Liberalization of trade regimes, globalization, developments in technology and fierce competition in global markets unfold the truth that it is not enough to only optimize the operations systems but it is also necessary to optimize the relationships

with suppliers and customers to remain competitive. As a result, the lack of significance given to supply chain management and supply chain operations such as planning, purchasing, and distribution was realized.

With the developments in technology and decrease in transportation costs, companies have found more opportunities to spread their operations globally. There has been a shift in operations facilities to places where raw material, labor and production costs are low. Simultaneously, globalization and search for new markets have gained pace in order to diversify and increase the customer portfolio.

Trade liberalization refers to the removal of government incentives and restrictions from trade between nations. Liberalization of trade regimes of countries accelerates the speed of globalization. In earlier times, countries had closed economies in order to protect their domestic productions and GDPs. The collapse of economies and devaluations in 1970s and 1980s speeded up the liberalization process. Firstly, countries especially the developing ones implemented export oriented regimes and import restrictions simultaneously. Some engaged in trade blocs such as NAFTA, OPEC and EU to expand their markets and gave incentives such as decreases in import restrictions, to those that also engage in the same organizations. Finally, along with the foundation of GATT and WTO, quota restrictions which limited imports diminished in a broader extent for a larger number of countries. Bilateral trade between countries has increased. Global trade environment has become more free and competitive. Along with the expansion of trade blocs, international trade has become more global. As a consequence, companies have needed a core competence, like agricultural production in Turkey, as well as operational competence to be able to compete in global markets.

The globalization of supply and demand has forced companies to search for new and effective ways to coordinate their operations, flow of goods and information. In order to achieve this purpose of effective coordination, building closer relationships with suppliers and customers have become necessary. Parallel to this, developments in technology have forced companies to also compete on time and quality basis. Producing non-defective products and delivering them fast are no longer regarded as a competitive advantage but as a requirement to remain in the market. Customers demand on-time deliveries of the exact amount of products along with specified measures and the utmost quality. To fulfill these demands, coordination with suppliers and customers is required.

Another consequence of rapid changes in technology and globalization of markets is the increase in market uncertainty along with the shortening of product life cycles and fluctuations in supply prices. The increasing uncertainty of the marketplace requires high flexibility in production which can be achieved via closer relationships with customers and suppliers.

Based on the above discussions, it can be concluded that along with the liberalization in trade regimes, globalization and rapid developments in technology, companies have realized the importance of building strong mutual relationships with their customers and suppliers to be successful in the marketplace. As a result, they have given priority to supply chain management to increase the efficiency of their operations more and more in order to conduct international commerce as smoothly as possible and today they are competing in the market through their supply chains (Li et al., 2006).

Before discussing supply chain management (SCM) and efficiency under SCM concept in more detail, a clear definition of supply chain may be useful. Jones

and Riley (1985) (as cited in Croom, Romano and Giannakis, 2000) define supply chain as an integrative approach to deal with the planning and controlling of the flow of materials from suppliers to end-users.

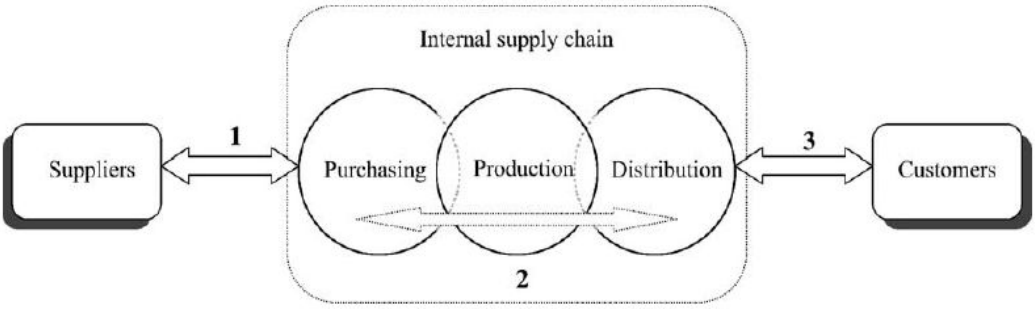

Figure 1. An illustration of a company's supply chain (Chen and Paulraj, 2004)

A supply chain consists of all parties involved directly or indirectly in fulfilling customers' demands (Chopra and Meindl, 2007, p.3). A typical supply chain is composed of three major levels which are supply, transformation and demand as illustrated in Figure 1. Each of the levels can also contain these three levels within themselves and may consist of several facilities such as manufacturing centers, warehouses, customer service centers, distribution centers, and retail outlets between which materials and information flow back and forth. SCM manages this two-way flow of materials and information between and among supply chain members which serve to fulfill the demands of customers and maximizes the total supply chain performance and profitability (Chopra and Meindl, 2007, p.3; Chen and Paulraj, 2007).

Within each facility of a particular supply chain, operations such as marketing, purchasing, finance, manufacturing and distribution occur. Each of these facilities or functions may have their own goals which may be complementing or

conflicting each other. Sub-optimization of these self focused goals may lead to the inefficiency of the whole chain. SCM was introduced in 1980s to overcome these drawbacks. The objective of SCM is to achieve strategic fit between these self focused goals by unifying them and thus increase the supply chain performance as well as competitiveness.

Competitive strategy of the company and functional strategies of each element and function in the supply chain must fit together in order to constitute a coordinated overall strategy and to achieve strategic fit. A company's competitive strategy determines, relative to its competitors, the set of customer needs that it seeks to satisfy through its products and services (Chopra and Meindl, 2007, p.22). Whereas, a supply chain strategy determines the nature of procurement of raw materials, transportation of materials in and out of the company, manufacture of the product or operation to provide the service, and distribution 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 (Chopra and Meindl, 2007, p.23).

Based on the above definitions, SCM can be regarded as strategy management. A company needs to define its strategy and design its supply chain according to its pre-determined strategy while trying to achieve a strategic fit between the elements and functions of its supply chain. There is no one correct supply chain strategy but there is a correct strategy for each supply chain.

A supply chain strategy can range from being totally responsive to being totally efficient. A responsive supply chain can respond to wide ranges of quantities demanded, meet short lead times, handle a wide variety of products, build highly innovative products, meet a high service level and handle supply uncertainty (Chopra

and Meindl, 2007, p.30). The more a supply chain has these abilities, the more responsive it is. On the other hand, being responsive incurs cost. For example, to build highly innovative products, intense focus has to be devoted on research and development which requires a huge amount of investment. On the other hand, efficiency is the opposite of being costly in producing and delivering products to the customers. Each additional strategic choice to increase responsiveness comes at a cost that lowers efficiency (Chopra and Meindl, 2007. p.30). For its supply chain, a company can choose between being responsive and being efficient according to its competitive priority. It then designs its supply chain in a way that matches its determined strategy. But today's fierce competitive environment forces companies to be responsive as well as efficient. In a given responsiveness level, customers choose the least expensive product. This requires a responsive supply chain to be as efficient as possible to remain in the market. For a given cost level, customers search for high responsiveness level such as high level of quality and customer service which require an efficient supply chain to be also responsive. Unifying all these requirements, today, companies have to provide the perfect balance of responsiveness and efficiency in their supply chain designs to be successful in the market.

For this design purpose of being responsive as well as efficient, a company has to consider how its supply chain drivers, which are facilities, transportation, inventory, information, sourcing and pricing, should be used in order to achieve strategic fit and maximize value generated by the supply chain.

Facilities are the physical properties of a supply chain. Production sites and storage sites are the two major facilities. For example, a responsive supply chain design would have many warehousing and/or production facilities located close to customers which in turn decrease efficiency. Whereas, an efficient supply chain

would have less warehousing and/or production facilities which in turn reduces responsiveness.

Inventory includes all raw materials, semi-finished and finished goods within a supply chain. Holding large amounts of inventory would increase responsiveness as well as costs which decrease efficiency. Whereas, reducing inventory would increase efficiency at the expense of responsiveness.

Transportation helps the movement of inventory from one point to another in the supply chain. The mode and route of transportation have an important effect on supply chain strategy. Choosing to deliver by plane makes the supply chain highly responsive but less efficient. On the other hand, choosing to deliver by ground transportation makes the supply chain efficient but less responsive.

Information may be the most effective driver of a supply chain since it affects all of the other drivers. Information is the data and analysis about all members of the supply chain. By accurate and timely information, a supply chain can increase its responsiveness as well as its efficiency. With correct and on-time customer demand data, a company can produce the anticipated amount of goods and services and deliver them to costumers on-time which will increase responsibility. In addition to this it will increase efficiency since producing the required amount of goods decreases inventory.

Sourcing is to decide which functions will be performed in-house and which will be outsourced. If sourcing can be analyzed effectively, it can increase both responsiveness and efficiency of a supply chain. For example, working with a reliable transportation company decreases costs by decreasing assets like trucks or planes the company should have and by providing truck load transportation options

in its distribution centers. Also, this reliable company increases responsiveness since it has expertise in its job and has warehouses in a lot of locations.

Pricing is the factor that affects the behavior of customers, and thus the value generated and the supply chain performance. It can be formed strategically according to customer needs. A goods provider can offer low prices for customers who value efficiency in cost of increased lead times whereas it can offer high prices for customers who value responsiveness.

In order to increase the smoothness of commerce between the members of supply chain and the value generated by the supply chain these above mentioned drivers should be designed in a way which provides higher levels of responsiveness and efficiency. All of these drivers affect each other and it is highly important to design them in a way that they complete each other to achieve strategic fit, since; this design leads all members of supply chain to success. To measure the effectiveness of the selected design and to be able to see the defects of the design, performance of the supply chain has to be measured and benchmarked regularly (Lapide, 2000). Benchmarking enables a company to see its place in the market and to realize improvement opportunities. By benchmarking the supply chain performance of a company with those of competitors, a company can find the best fit of operations and design for its strategy, improve its operations and sustain its competitiveness in the market.

Performance benchmarking answers the question regarding a company's efficiency in comparison to its competitors by identifying the most efficient companies and putting the remaining companies in rank referring the efficient ones (Goncharuck, 2008). Literature contains various studies regarding supply chain performance measurement benchmarking and its effects on company's success.

Reiner and Hofmann (2006) prove that efficient supply chains lead to high financial performance, and show improvement areas for the benchmarked supply chains. Tan, Kannan and Handfield (1998) (as cited in Basnet et al., 2003) show a significant correlation between certain SCM practices and performances of the firms. Narasimhan, Kim and Tan (2006) show that SCM can have a dramatic effect on profitability when it is viewed strategically and managed effectively. D'avonzo, Lewinski and Van-Wassenhove (2003) find a strong connection between superior supply chain performance and financial success which drives shareholder value. In addition, they show that companies that score high levels of supply chain performances also have high market capitalization rates which are significantly above the industry average growth rate. Ellram and Liu (2002) state that SCM also affects firm performance negatively. The negative effects on SCM about how much shareholder value can be lost through poor SCM also indicate how much can be gained through effective SCM. The study of Singhal and Hendricks (2002), show how supply chain glitches can have a significant negative effect on shareholder value regardless of company size, what industry the company is in, or how good or bad the company's growth prospects are.

The example of Motorola demonstrates how an ineffectively managed supply chain fluctuates stock prices (Kelly, 1995). In 1992 and 1993 Christmas seasons, Motorola could not meet the customer demand forcing Baby Bells one of its wholesalers to turn away business. In 1994, keeping this in mind Motorola built high levels of stock in inventory to get prepared for Christmas season but did not inform its distributors. Meanwhile, Motorola's distributors overordered before Christmas also to prepare for the Christmas season and did not inform Motorola. Along with such overzealous ordering from wholesalers, Motorola reported record fourth-quarter

earnings which highly increased their stock price. However, once Wall Street realized that the dealers were swamped with inventory and this hurt new orders, Motorola's stock tumbled almost 10 percent (Kelly, 1992).

All these studies and examples imply that an efficiently managed supply chain can be a crucial factor in a company’s financial strength and success in the market.

CHAPTER III

SUPPLY CHAIN ANALYSIS AND BENCHMARKING

Benchmarking

Productivity is one of the major requirements for continuous growth and wealth of nations and companies. To sustain long term growth and financial durability in the global competitive environment, industrial enterprises must unceasingly measure and improve their performances (Sudit, 1995). Targets for performance improvement in an industrial enterprise can be found via various tools, one of which is benchmarking.

Benchmarking enables the decision maker to determine improvement opportunities. The concept of benchmarking was originally rooted in Japanese industry. However, Xerox made this tool popular in 1980s by using benchmarking successfully against its Japanese competitors (Shetty, 1993). The Company discovered and developed new strategies to regain market share from its international competitors by this tool. After Xerox, various successful American companies such as Ford, Eastman Kodak, GTE, General Motors, Motorola, AT&T, Du Pont, Corning and NYNEX performed benchmarking successfully in their global operations (Shetty, 1993). Results of these successful practices clearly demonstrate that benchmarking leads to higher profitability. Furthermore, these practices enable benchmarking to grow and diffuse through competitive international business circles (Wong W. P. and Wong K. Y. 2008). In 2001, benchmarking was reported as one of the five most popular tools usually used by managers. More than 75 percent of

managers worldwide confirmed that they use benchmarking in their companies (Rigby, 2001).

Still, benchmarking does not have a singularly accepted definition (Binder et al, 2006). Heib and Daneva (1995) (as cited in Sarkis, 2001) point to 42 definitions of benchmarking in literature. In the dictionary it is defined as "a standard against which something can be measured or assessed" (Encarta online dictionary, 2008). By combining the definitions of Wong and Wong (2008) and Rigby (2001), benchmarking, as a management tool, can be viewed as the systematic process of comparing internal products and services with those of competitors and best in-class companies as well as searching for the best practices, innovative ideas and efficiencies that lead to continuous improvement.

Benchmarking is often seen as imitation. Drew (1997) states that some scholars define benchmarking as a perfect legal way of copying. However, instead of regarding benchmarking as a "stand-alone process" which only gives the chance to imitate, one must see it as "a front-end tool" which leads to significant change (Stewart, 1995). Benchmarking helps to find new improvement opportunities, opens ways for innovation and increases the quality of products and organizations. As stated by Thompson and Cox (1997) (as cited in Dattakumar and Jagadeesh, 2003) rather than imitation, benchmarking helps in innovation. By analyzing operations of best in-class companies and competitors, companies can innovate by finding new ways of doing business; improving themselves and setting new performance standards for their operations. As a matter of fact, innovation itself increases productivity and efficiency of supply chains (Kincade et al., 2001) in a number of ways such as decreasing costs of operations (Hatch and Mowery, 1998) and accelerating speed and response of operations (Sullivian and Kang, 1999). Moreover,

Wong and Wong (2008) state that literature cites various benefits of benchmarking all with the concept of value creation and improvement.

The methodology of benchmarking can be explained by several similar cycles such as PDCA (plan, do, check, act) cycle (Pulat, 1994) which is also known as the Deming cycle (as cited in Bhutta and Faizul, 1999) and by the benchmarking wheel (Andersen et al., 1999). Benchmarking wheel is demonstrated in Figure 2.

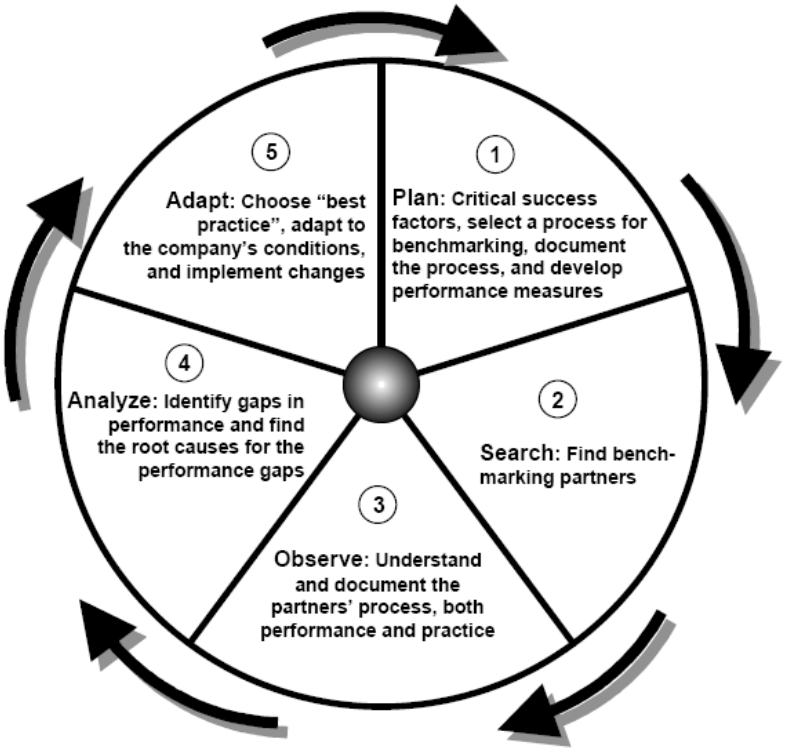

Figure 2. The benchmarking wheel (Andersen et al, 1999).

This improvement cycle consists of five continuous phases. In the "plan" phase, processes to benchmark, benchmarking study and performance measures are selected. In the "search" phase, benchmarking partners are selected. In the "observe" phase, benchmarking partners' processes are characterized using metrics and performances. In the "analyze" phase, findings of the study are compared and

reasons for performance gaps are found. Finally, in the "adapt" phase, the best practice companies are chosen and their operations are adapted to improve or sustain performance.

As of June 2002, literature cites more than 350 publications contributing to the literature of benchmarking (Dattakumar and Jagadeesh, 2003). Results of these studies show significant benefits of benchmarking such as higher profitability (Wong and Wong, 2008), EPS (Earnings per share) growth and better financial results (Rigby, 2001).

Benchmarking literature on the supply chain can be grouped into two: practical and theoretical. Performance measures, concept and trends are the elements covered in the theoretical aspect of benchmarking literature in the supply chain. On the other hand, the modeling framework and empirical case studies are covered by the practical aspect of benchmarking literature in the supply chain. In the literature, researchers are mostly interested in the theoretical aspects which constitute 60 % of the present publications in supply chain benchmarking (Wong and Wong, 2008).

This study focuses on the theoretical aspects of supply chain benchmarking especially on performance measures and methodology development following the call of Yasin (2002) for innovative methodologies for benchmarking practices in supply chain management.

Performance Measures in Supply Chain Benchmarking

Supply chain benchmarking differs from general benchmarking. When financial performance evaluation is considered, one can find similar and few performance metrics in literature whereas for supply chain performance evaluation there exists

different measures for different industries and conditions (Wong and Wong, 2008). This is because of the variety in operations and strategies of organizations in different sectors, economies etc. This variety in operations and conditions makes the selection of supply chain performance measures challenging. The selected measures are highly critical since decisions of managers depend on the outcomes of these measures.

Although supply chain management is a relatively new concept in business literature, focus of researches in the area have changed a lot and became complex gradually. Cost based performance measures are the main concern of early literature. Beamon (1999), who makes a literature review of supply chain performance measures in his study, presents Cohen and Lee (1988), Cohen and Moon (1990), Lee and Feitzinger (1995) and Pyke and Cohen (1993) as some of the authors that used cost based performance measures in their supply chain models. Cost based measures may include costs of goods sold, inventory costs and operating costs. But the models consisting of only these measures lack flexibility or customer requirements. Along with the lack of the measures that effect customers and suppliers, evaluations may miss the underlying factors that affect performance of the whole system. As the SCM area matures, the importance and need for qualitative measures as well as other quantitative measures are realized and measures such as quality (Chan, 2003), customer satisfaction (Gunasekaran et al, 2001) and risk management (Johnson and Randolph, 1995 as cited in Beamon, 1999) come into the picture.

Beamon (1999) groups performance measures of supply chain three which are resource, output and flexibility. After Beamon, Chan (2003) identifies seven supply chain performance measures. In his study, he categorizes them into two quantitative (cost and resource utilization) and qualitative (quality, flexibility,

visibility, trust, and innovativeness) measures. Gunasekaran et al. (2001) classifies supply chain metrics proposed in literature into three to evaluate strategic, tactical and operational level performance in supply chains. However, qualitative measures are not suitable to benchmark supply chain performances of different companies since most of the qualitative measures are evaluated subjectively based on perceptions of managers or on the employee of concern. There is no standardization in evaluations of these measurements since cultures of companies and perceptions of people differ. Qualitative measures may change the outcome of benchmarking analysis and mislead decision makers under these circumstances. Moreover, in these proposed supply chain models and performance metrics, a single supply chain or company is of main concern besides the qualitative measures specified. Most of the metrics defined are company confidential and models are for periodic performance measurement of a company's supply chain not to benchmark and position companies in a competitive environment.

After the early studies in literature, Pittiglio, Rabin, Todd and McGrath, known as PRTM, introduced the first universal supply chain performance measures which are a comprehensive set of fact based performance measures to be used to define a world class supply chain of plan, source, make and deliver activities accurately. These measures cover the four areas which are delivery performance, flexibility and responsiveness, logistics costs and assets management. These operational areas are historically proven to be the keys for excellent revenue growth and stock appreciation (Stewart, 1995).

Delivery performance is the driver of customer satisfaction. It shows the excellence of a supply chain in delivering goods and services to customers on the demanded date to the right location in correct specifications. Excellence in delivery

performance can be measured by delivery performance rate which is the rate of transactions that are made to customers in the correct shape and quantity on the demanded date. If this rate is high so is customer satisfaction. If customer satisfaction is high, so is revenue. Flexibility and responsiveness is the ability of the supply chain to react to changes in the market place. To be able to react to changes in the market efficiently increases customer satisfaction and brings success to organizations. Cycle time across the entire supply chain, which includes days to communicate with supply chain members and days to source, produce and then deliver to customers, gives the supply chain response time (Stewart, 1995). Flexibility is the speed of organizations to meet an unplanned sustainable demand change in time. For example, a company that can increase its production according to a sustainable 20% percent demand increase in 2 weeks whereas others can do it in 2 months is flexible. Logistics costs include transaction and infrastructure costs. Relatively high logistics costs point to inefficiency in supply chain design or management. The final operational key is asset management. Supply chain assets include accounts receivable, inventories, and selected plant, property and equipment. Cash to cash cycle time which describes the average days required to turn a dollar invested in raw material into a dollar taken from a customer is a metric to measure asset management efficiency (Stewart, 1995).

Supply Chain Council extended the PRTM's concept and developed the Supply Chain Operations Reference (SCOR) model which is now becoming an industrial standard (Huan et al., 2004). Like PRTM, the SCOR model, which is illustrated in Figure 3, is based on plan, source, make and deliver framework.

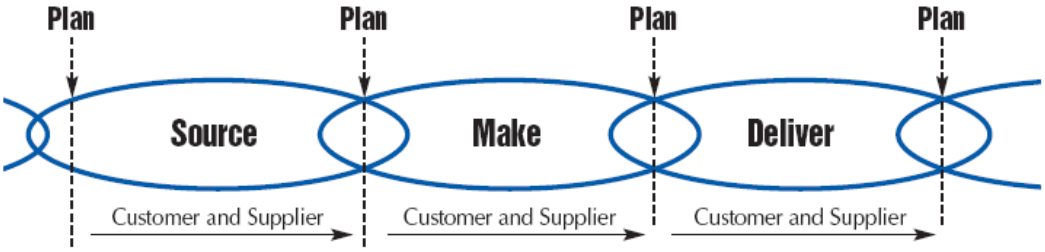

Figure 3. SCOR Model chain of source, make and deliver (SCOR, 2008).

SCOR is a standard model that is designed to fit all industries. Since it is a cross-industry framework, companies have the opportunity to benchmark themselves with the best peer companies in their sector or in other sectors to find new ways for management to further improvement and progress.

The SCOR Model defines variables that cover 1) all customer interactions from order entry through paid invoice, 2) all product and service transactions between all the supply chain members and 3) all market interactions from forecasting to fulfillment of order (SCOR, 2008). The defined variables are from the five dimensions of SCOR which are 1) reliability i.e. perfect order fulfillment, 2) cost i.e. supply chain management costs and cost of goods sold, 3) assets i.e. cash to cycle time, return on supply chain fixed assets and return on working capital, 4) responsiveness i.e. order fulfillment cycle time and 5) agility i.e. upside supply chain flexibility and downside supply chain adaptability (SCOR, 2008).

The advantages of the SCOR Model are that it takes into account all the supply chain process and gives a balanced approach to evaluate performance of supply chain in multiple dimensions. On the other hand SCOR does not attempt to include every business process or activity such as sales and marketing, research and development or customer support when describing supply chain performance. Secondly, SCOR assumes but does not explicitly address training, quality,

information technology and administration (SCOR, 2008). Although it has some drawbacks, the SCOR Model's usefulness is proven (Wong and Wong, 2008) and Geary and Zonnenberg (2000) (as cited in Wong & Wong, 2008) mention that companies using the SCOR model in benchmarking gains considerable financial and operational advantages.

There exist various studies in literature based on the SCOR model. In their study, Reiner and Hofmann (2006) benchmark 65 European and American companies from different industries. They determine their input and output variables by dependency analysis from the measures of the SCOR model. For their DEA model, they specify the number of full time employees in production and manufacturing, total inventory costs, supply chain costs, ship from locations (tier 1 suppliers), ship to locations (tier 1 customers), number of warehouse locations as input variables and revenue and delivery performance rate as output variables. Then, they conduct sensitivity analysis by varying input variables with the same set of output variables. They find that when added to the input variables, the number of warehouses increases efficiency of supply chains. This means that nearly all companies realize the benefits of warehouse pooling and decrease their warehouse numbers as much as possible to increase their efficiencies. They also find that efficient supply chains lead to high financial performance.

Wong and Wong (2007) also use SCOR metrics and the DEA model in their research to benchmark companies. They use revenue and on time delivery rate as output variables whereas supply chain costs, cycle time and manufacturing capacity as input variables. They find that the opportunity cost (profit loss) calculated by the model serves as a good reference to managers to make efficient decisions on resource allocations.

Lai et al. (2004) also benefit from SCOR metrics to evaluate supply chain performances of transportation firms in air and sea transport, freight forwarding, and third-party logistics services from both cost and service perspectives. Their results show that all the three sectors are mature, attaining a certain degree of sophistication in their supply chain performances. On the other hand, there are significant differences in supply chain performance levels between firms in the three sectors. They differ in their perceived service effectiveness towards shippers and consignees and in their operations efficiency in performing the services.

Li et al. (2005) develop a measurement instrument to assess the performance of the overall supply chain which consists of six dimensions which are strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices, and postponement. Then, they use the SCOR Model to objectively validate their proposed measurement instrument. This validation using the SCOR Model shows the reliability of SCOR metrics and model in supply chain literature.

Apart from studies that depend on the SCOR model, frameworks are also proposed regarding integrated supply chains which is the main concern of supply chain management today (Gunasekeran et al., 2004, Angerhofer and Angelide, 2006, Agarwal et al., 2006, Molnar et al, 2007). The importance of performance evaluation of all members in a supply chain towards a common goal of customer satisfaction is mentioned by a significant number of authors (Wong and Wong, 2007, Liang et al., 2006, Qu et al., 2006, Beamon, 1999, Gunasekaran et al., 2001) However most of the proposed performance evaluation models regarding integrated supply chains are hypothetical and inapplicable since managing overall supply chain efficiency is a difficult and challenging task. Ross (1998) also states that even leading companies

like Sears or General Motors do not have such data sets and measurement systems to measure and control their entire supply chains.

Moreover, most of the proposed methodologies in the literature contain confidential data which also makes their applicability challenging since most of the companies are not willing to share out data. To solve the difficulty in obtaining company confidential data, Shah and Singh (2001) develop supply chain performance measures which can be computed through publicly available data. In their proposed model they evaluate the efficiencies of companies by considering solely one financial ratio which is supply chain inefficiency ratio. However, their model's usefulness is not proven. Ulus et al. (2006) present a benchmarking study of industrial transportation companies which are traded in the NYSE by using solely publicly available data to conduct a financial performance analysis. They found significant performance differences among the sub-sectors of the industrial transportation industry.

All of these point out the opportunity for further research in supply chain performance measures as well as benchmarking.

CHAPTER IV

ANALYTICS OF SUPPLY CHAIN BENCHMARKING

Measuring and benchmarking supply chain performances of companies have been gaining more importance along with increasing globalization, technological improvements and importance of international trade. While most of the literature agrees with this fact, there is not much consensus on which performance measurement tool to use. In literature there are two types of measurement techniques that are commonly used for benchmarking evaluations; parametric and non-parametric.

Parametric models require assumptions which can be unrealistic and require functions to be specified by the user. They are statistically powerful models. But, the pre-defined functions may make the model and results unrealistic if they are incorrect. On the other hand, if the assumptions are correct these models might produce more accurate estimates than non-parametric models.

Gap analysis, such as spider or radar diagram and Z chart, is one of the non-parametric methods used in performance benchmarking. This method enables assessing the gap between present output of an organization and the optimized output that can be achieved with an efficient allocation of present inputs. These tools and their results are easy to understand but they are not user friendly mainly because all the considered elements have to be considered as a whole and logical relationships have to be developed between them.

Ratio analysis provides the efficiency score by computing the ratio of output to input. The computation process is easy, but each operation has a different

efficiency score. This analysis does not explain how the multiple inputs affect multiple outputs simultaneously. To reach a conclusion, the user has to either assign weights to calculate overall efficiency or draw a complete picture of efficiencies by determining each ratio's effect on others.

Regression analysis is also a parametric method used for performance benchmarking. It is a statistical technique for modeling and analysis of numerical data. It can be used to model and predict casual relationships between the variables, heavily depending on assumptions. As a drawback, this method gives average values in determining best practice operations which makes it hard to match the given average value with a real company to benchmark.

Nonparametric models differ from parametric models in that they do not require a pre-defined relationship between the analyzed variables. The parameters used in non-parametric models are not fixed and defined by the model itself. This easiness in usage of these models makes them have a widened application area than parametric models. They may be applied to the situations where less is known about the variables and their effects. Furthermore, these models rely on fewer assumptions than the parametric models and this makes them more robust. Analytic hierarchy process (AHP), balanced score card (BSC) and data envelopment analysis (DEA) are common non-parametric methods used for performance analysis.

AHP was developed by Thomas L. Saaty in 1980s. Saaty and Vargas (2001) define AHP as a basic approach for decision making which is designed to cope with both the rational and the intuitive to select the best from a number of alternatives evaluated with respect to several criteria. With this method, one constructs hierarchies, then makes judgments or performs measurements on pairs of elements with respect to a controlling element to drive ratio scales that are then synthesized

within the structure to select the best alternative (Saaty, 2001). Its most important feature is its ability to solve multi-criteria complex problems and to use both quantitative and qualitative data in decision making process. However, the method contains some drawbacks such as inconsistency, due to the subjectivity of managerial inputs, and the rank-reversal problem decrease its usefulness (Wong and Wong, 2008). In summary, if a new unit, i.e. company, is added to the previously considered data set, AHP does not change the ranks of older units, but it only adds the new unit in between and keeps the rank above and below units the same.

Balanced scorecard (BSC) presents a complete framework for implementing business strategy. Kaplan and Norton (1996) define BSC as a tool that translates an organizations' mission and strategy into a comprehensive set of performance measures that provide the framework for a strategic measurement and management system. In BSC, performance measures are divided into four as customers, internal processes, innovation and finance. The advantage of BSC is its ability to track financial results of companies while simultaneously monitoring progress in building the capabilities and acquiring the intangible assets they need for future growth (Kaplan and Norton, 1996). But as a disadvantage, this methodology does not provide a mathematical or logical relationship between measures to ease the comparison between companies. Furthermore, BSC may not report the inefficient use of resources.

Data envelopment Analysis (DEA) is another non-parametric tool that is commonly used for performance benchmarking as is in this thesis. DEA is a multifactor nonparametric productivity analysis technique which has been proven to be a powerful tool for benchmarking analysis (Reiner and Hofmann, 2006). The main advantage of DEA is its ability to evaluate and control system performance

without using detailed information. DEA can evaluate performance by considering multiple inputs and outputs simultaneously and there is no need to identify the relationship or function between these input-output measures. The methodology also estimates the contribution of each variable to the outcome which can be used for further management decisions. Both qualitative and quantitative data can be used to assess performance with no need to convert them on a common scale (i.e. cost, time). From the outputs of this tool, reasonable judgment can be made about resource usage levels of decision making units (DMU) as well as the inefficiently used resources and their sources of inefficiency.

Besides all of these advantages, there are also some limitations to using this tool. Application of DEA requires all the specified input and output to be available and measurable for each DMU that is determined for efficiency evaluation. Comparable DMUs can be hospitals, schools, non-profit organizations, companies or supply chains as the case in this thesis. As a second limitation, the ratio of the number of inputs and outputs to the number of DMUs should not exceed a certain limit which is 1:2 (Rickards, 2003). As this ratio increases, DMUs differentiate more in the outcome and the number of efficient DMUs increases. Another limitation is that DMUs which are similar in their operations are compared using this tool. DEA can compare the efficiencies of DMUs which use the same kind of resources to obtain the same kind of outputs. For example all hospitals to be compared would have nurses, doctors and assets like clinical equipments and buildings to produce revenue. However, these limitations that are mentioned do not endanger DEA's proven usefulness for performance benchmarking and its superiority in comparison to other methods in estimating efficiency (Cielen et al., 2004, Sherman, 1992, Banker et al., 1988)

Wong and Wong (2008) also explain why to use DEA for supply chain performance benchmarking, by giving evidence, literature support and suitability reasons. They highlight that in literature many researchers (Maskell, 1991, Sheridan, 1993, DeToro, 1995) support the idea that simplicity and ease-of-use have to be considered for measurement systems. They also state that a tool is useful for performance analysis, when it is able to address the whole problem, provide desired information at the time when decisions are made and inexpensive relative to the value of its information. Furthermore, they mention that the performance benchmarking tool must be reliable and its output results must be realistic enough to be helpful in making decisions. By basing their decision on the above criteria, which they form with a literature review, they conclude that DEA manages to fulfill all the requirements specified. Moreover, they underline DEA's features of robustness, standardization, transparency and flexibility to mold with other analytical methods for researchers who study the extensions of DEA models in evaluating performances.

With the features and basic characteristics of DEA discussed above, DEA is justified to be used as a benchmarking tool for supply chain performance measurement in this study.

CHAPTER V

METHODOLOGY

The methodology of this thesis is based on the Benchmarking Wheel (Andersen et al, 1999) which is discussed in chapter three. The Benchmarking Wheel developed by Andersen et al. considers micro level benchmarking process from the viewpoint of a company. In this thesis, the phases of this benchmarking wheel are interpreted at macro level benchmarking to evaluate and benchmark all the companies in an industry.

In the plan phase, supply chain performance is selected as a critical success factor for benchmarking. Input and output measures are selected. The variables are refined by sensitivity analyses.

In the search phase, the food and beverage industry is selected for national and international benchmarking analysis.

In the observe phase, by utilizing DEA, the efficiencies of all supply chains are observed. Best practice supply chains are defined.

In the analyze phase, by utilizing DEA, gaps in performances of inefficient DMUs are defined and causes of their inefficiencies are determined. In the adapt phase of the benchmarking wheel, target units are selected for each inefficient DMU for further improvement. Suggestions are made for adaptations.

Data Envelopment Analysis

Data envelopment analysis (DEA) is a non-parametric method to evaluate the relative efficiencies of DMUs by considering the relation of multiple inputs and outputs at a time. Farrell (1957) first introduces the basis of DEA, which is efficient frontier analysis, to show how to measure productive efficiency. The need for developing better methods and models for evaluating productivity motivates Farrell to propose an activity analysis approach to solve the problem of combining multiple inputs into any satisfactory conclusion. In their study, they intend to make their measures applicable to any productive organization and they extend the productivity concept to a more generalized concept which is efficiency (Cooper et al., 2004). Later Charnes, Cooper, and Rhodes (1978) develop the initial model of DEA to analyze efficiency of an organization while estimating the best practice organizations. They describe DEA as a mathematical programming model applied to observational data which provides a new way of obtaining empirical estimates of relations - such as the production functions and/or efficient production possibility surfaces. Moreover, they formalize the concept of relative efficiency, since the possible efficiency level of any entity will not be known (Cooper et al., 2004).

Based on Cooper et al. (2004)'s definition, full efficiency (100%) is attained by any DMU if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs. Whereas, in terms of relative efficiency, a DMU is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs (Cooper et al., 2004). Based on these definitions, DEA does not define

absolute efficiency levels; so efficiency of any DMU either defined as efficient or inefficient can be improved. After the initial DEA model, a lot of contribution is still being made to the literature of DEA to extend the model. One of the most used and well known model is the basic one that was developed by Banker, Charnes, and Cooper (1984). Assumptions and mathematics of this model and the initial model of DEA developed by Charnes et al. (1978) will be presented in detail in the following sections.

Besides the contributions made to extend the model, DEA is used in empirical analysis to assess performance in a variety of conditions for a variety of organizations such as schools (Kirjavainen and Loikkanen 1998), hospitals (Banker et al., 1986), bank branches (Berger et al.,1997), airline companies (Schefczyk, 1993), countries (Lovell et al., 1995), telecommunication companies (Lien and Peng, 2001) and distribution companies (Goncharuk, 2008). DEA is also used to assess performances of a variety of non-organizational entities like CNC machines (Sun, 2002) and supply chains (Reiner and Hofmann, 2006) as in this thesis. Below, a number of studies from literature on the use of DEA is presented.

Utilizing DEA, Seiford and Zhu (1999) examine the performance of the top 55 U.S. commercial banks via a two-stage production process that separates profitability and marketability. They uncover substantial performance inefficiency in both dimensions. Relatively large banks are found to exhibit better performance on profitability, whereas smaller banks are found to perform better with respect to marketability.

Junoy (2000) presents a performance analysis for acute care hospitals by applying DEA and a regression model, in a two-stage approach. He finds that effective or potential competition apparently matters even in a highly regulated

hospital market. His conclusion is more important when many local markets have very few competitors and allocative efficiency is independent of technical efficiency.

Sharma et al. (1999) evaluate the technical, allocative and economic efficiencies of swine producers in Hawaii using DEA and a parametric approach. Both of the approaches they use reveal considerable inefficiencies in swine production in Hawaii. Moreover, they find that contrary to popular belief, the results of DEA are more robust than those of the parametric approach.

Serrano-Cinca et al. (2005) use DEA in order to assess efficiency in dot com firms. They prove that a methodology based on multivariate analysis is successful at showing the strengths and weaknesses of individual dot com firms. It is shown that there is a relationship between the sub-sectors, and the way in which efficiency is obtained.

DEA is a technique relatively rarely employed in operations management research (Boer, 2003). Literature cites only a few studies where DEA is used for supply chain performance analysis. These relatively few DEA applications about supply chain benchmarking generally focus on supplier-customer relationships (Reiner and Hofmann, 2006). Supplier evaluation via DEA is a core topic studied by authors such as Garfamy, (2006), Liu et al., (2000) and Forker and Mendez, (2001). Another commonly addressed area in supply chain benchmarking via DEA is efficiency evaluation of manufacturing processes (Talluri and Sarkis, 2002). Distribution systems and third party logistic firms (Zhou et al., 2008, Min and Joo, 2006) are other core application areas of DEA.

There are also some applications of DEA considering the overall supply chain performance at company level which is also the intention of this study. Reiner and Hofmann (2006), Wong and Wong (2007), Goncharuk (2008) are the authors of

some of these studies which are relatively few in number compared to other application areas of DEA.

There are not so many researches utilizing DEA in supply chain management area in Turkey. Regarding SCM performance evaluation and benchmarking, researches in Turkey mostly concentrate on supplier evaluation (Cebi and Bayraktar, 2003, Sevkli et al. 2007), certain SCM practices and their effects (Ulusoy, 2003, Lenny Koh et al. 2007, Bayazit, 2003) and supply chain scenario analysis (Karaali, 2001) There are also researches on supply chain performance evaluation (Capar, 2002).

Lenny Koh et al. (2007) investigate the effects of SCM practices on performances of small and medium sized enterprises (SME) that are the manufacturers of fabricated metal products and general purpose machinery in Turkey. They conduct their analyses through questionnaires and test their framework by using partial least squares method. In their study, they group SCM practices in two as outsourcing and multi-suppliers and strategic collaboration and lean practices. They find that both groups of SCM practices have direct positive and significant impact on operational performance of SMEs.

Cebi and Bayraktar (2003) propose an integrated model which includes both tangible and intangible factors in supplier selection decision making process. They develop an AHP model and grouped the metrics they defined into four main criteria such as logistics, technological, business and relationship factors. They implement their framework in a food company that produces dry mixed food and drink products in order to select suppliers and suggest that it is better to work with limited strategic suppliers in order to maintain collaborative relationships and also cope with global competition in its supply chain.

Another supplier selection approach is developed by Sevkli et al (2007) to benchmark the performances of the suppliers of Beko, which is a well-known company in home appliances sector in Turkey, by utilizing a hybrid approach which is formed by embedding the DEA in AHP methodology. As supplier selection criteria, Sevkli et al. (2007) define six main criteria, which are namely performance assessment, human resources, quality system, manufacturing, business and information technology. They define metrics for each criterion such as employee number for human resources and on-time delivery for performance assessment. Then, they rank the criteria according to their importance in supplier selection and find that the most important criteria is business criteria which can be assessed by location and reputation. In contrast the least important criteria is found to be information technology.

Capar (2002) aims to develop a performance measurement framework and implements his framework on the automotive industry. The proposed framework consists of customer satisfaction, financial, and collaboration perspectives. The collaboration perspective proposed is mainly focused on relationship, information sharing and integration level, and commitment among supply chain members. Unfortunately the presented study is not able to evaluate the company's overall supply chain performance with the developed model due to data unavailability.

The DEA Model

DEA is a non-parametric linear model. It assesses relative efficiencies of similar DMUs in a given set by building a relationship between multiple inputs and outputs that are defined. The term decision making unit (DMU) is developed by Cooper et al.

(2004) to refer to any entity that is to be evaluated and compared in terms of its abilities to convert inputs into outputs.

By calculating the efficiency of each DMU simultaneously, DEA forms a production possibility frontier (PPF) from the most efficient DMUs. To define this PPF by DEA, some assumptions need to be made. First of all, DEA connects the points of relative DMUs with each other by interpolation to form PPF. The new lines and points on the PPF are also relatively efficient. Secondly, inefficient production is possible. Lastly, the PPF constructed is the smallest set that meets the foregoing assumptions and that contains all input –output correlations observed at the units being assessed (Thanassoulis, 2001).

To be able to explain the concept of PPF and the DEA mechanism, an illustrative graph that is based on Thanassoulis (2001), is shown in Figure 4. To ease the representation of the graph, single input and single output model is used in illustration. The envelopment concept in the name of DEA can be connected to the shape of the graph it plots. DEA measures the efficiency of DMUs with reference to the constructed PPF which envelops all input and output levels observed at DMUs (Thanassoulis, 2001).

DMUs that form the PPF (A, B, C, and D) are considered to be the efficient ones of the set and DMUs that are enveloped by the PPF (E and F) are considered to be the inefficient ones. DMUs that are on the PPF are given the efficiency ratio of 100% (E=1). These DMUs are the ones that use and allocate their resources most effectively to achieve the highest level of products and services in the data set. The enveloped inefficient DMUs are given an efficiency ratio less than 100% (E<1). These efficiency score of these inefficient DMUs are calculated by using the PPF as a reference. For example in the input orientation, which is to minimize inputs for a

given output level, the efficiency of DMU E is calculated by drawing a horizontal line from E to the vertical axis of the graph. This line enables one to find the minimum input level (I) for for the given output level (O) by the optimal point (E_1) on PPF. The efficiency of DMU E equals the fraction of OE_1/OE (Thanassoulis, 2001).

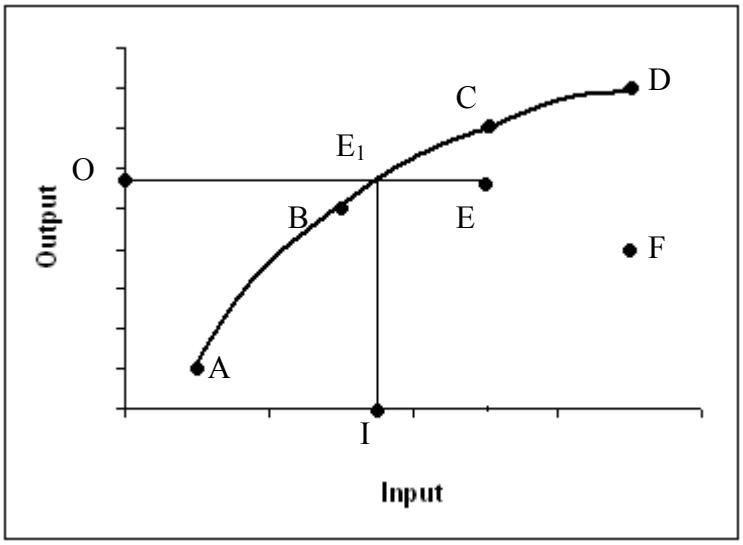

Figure 4. An illustration of an assessment by DEA (Thanassoulis, 2001)

DEA is used not only to evaluate the efficiency scores of each DMU and then to rank them, but also to realize improvement opportunities. For this purpose, DEA specifies one or more benchmark or target DMUs for each inefficient DMU and calculates input excesses and output shortages according to these benchmark DMUs. The target DMUs are specified by their closeness to the reference point of the inefficient DMU on the PPF. For example for DMU E, the minimum input or reference point is E_1. This point is between the efficient DMUs of B and C. So, the target DMUs of E can be B and C.

The DEA model works the same way when multiple inputs and outputs are involved in an assessment. The only difference of single input and single output graph from multi input multi output graph is that linear programming methods are needed to construct the PPF and to calculate the slack variables of inefficient DMUs (Thanassoulis, 2001).

To understand DEA in its mathematical concept, the basic models of Charnes et al. (1978) are discussed in the following sections.

The CCR Model

The CCR model of DEA used in this study was developed by Charnes, Cooper and Rhodes in 1978. The model assumes constant returns to scale principle while estimating the relative efficiency score of each DMU, ranking them according to their performances and providing managerial insights. Constant returns to scale can basically be explained by the fact that the scale of operations of a DMU has no impact on its efficiency level. According to Charnes et al. (1978), the efficiency of any DMU is calculated as the maximum of a ratio of weighted outputs to weighted inputs subject to the limitation of the similar ratios for every DMU be less than or equal to one. This explanation is formulated as

$$\max h_0(u,v) = \frac{\sum_r u_r y_{ro}}{\sum_i v_i x_{io}}$$

subject to:

$$\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \le 1\,; \quad j = 1,....,n,$$

$$u_r, v_i \geq 0 \text{ for all i and r.}$$

where:

h_0: the efficiency value that maximizes the ratio of DMU_o.

v_i: weight for input i

u_r: weight for output r

x_{io}: value for input x of DMU_o

y_{ro}: value for output y of DMU_o

n: the number of DMUs

Where the v_i and u_r are the decision variables indicating the weights for each related input or output. The x_{io} and y_{ro} are the observed input and output variables for the rated unit o.

The above non-linear model can be converted to a linear one where the weights are indicated as (μ,v).

$$\max z = \sum_{r=1}^{s} \mu_r y_{ro}$$

subject to

$$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0$$

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$\mu_r, v_i \geq 0$$

In order to obtain the relative efficiency score of each DMU, this linear model is run for each DMU and the optimal efficiency score is calculated for each one by

determining the optimal weights of μ and v. The two models presented above are the primal models of output orientation where the aim is to maximize the level of output for a given level of input.

Besides output maximization, the DEA model can also be oriented for input minimization where the aim is to minimize the amount of resources used for the given output level.

$$\min h_0(u,v) = \frac{\sum_i v_i x_{io}}{\sum_r u_r y_{ro}}$$

subject to:

$$\frac{\sum_i v_i x_{io}}{\sum_r u_r y_{ro}} \le 1\,; \quad j = 1,....,n,$$

$$u_r, v_i \ge \varepsilon > 0 \text{ for all i and r.}$$

Transformation of input oriented model to linear model is presented below,

$$\min q = \sum_{i=1}^{m} v_i x_{io}$$

subject to

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \ge 0$$

$$\sum_{r=1}^{s} \mu_r y_{ro} = 1$$

$$\mu_r, v_i \ge \varepsilon \qquad \forall\, r,i$$

The basic assumption of CCR that is the scale of efficiencies does not affect the productivity of operations is not always appropriate in real life context (Thanassoulis, 2001). Basing their study on this constant return to scale problem, Banker, Charnes and Cooper developed the BCC Model in 1984. This model assumes variable returns to scale (VRS) principle while estimating the relative efficiency scores of DMUs. VRS can basically be explained by the fact that economies of scale do exist and scale of production or services can affect efficiency.

This thesis utilizes the CCR model of DEA with the objective of output maximization under the assumption of constant returns to scale (CRS). Since; if a DMU is efficient under CRS, it would certainly be efficient under VRS. But, if a DMU is efficient under VRS, there is no guarantee that it would be efficient under CRS. Thus, when it is determined that DMU is efficient under CRS, the efficiency of DMU can be claimed for sure (Duzakin and Duzakin, 2007). Another preference made when conducting the analysis is choosing output maximization objective instead of input minimization objective. This preference depends on the fact that suggestions about input reductions might be inappropriate in some cases. So, suggesting improvements in outputs seems wiser. Moreover, both these objectives yield the same result insofar as technical and mix efficiency are concerned (Cooper et al., 2000).

Input and Output Measures

Implementing DEA for efficiency assessment requires the selection of appropriate inputs and outputs for efficiency analysis. To reach relevant results, a reasonable number of meaningful measures has to be selected.

In this thesis, the food and beverage industry is selected for performance assessment. Detailed explanation of this selection will be presented in section VI. There exists a considerable amount of differences between the sub-sectors of the food and beverage industry. To eliminate the effects of these differences on the outcome of DEA, SCOR metrics are chosen as a starting point. SCOR is a cross-industry framework to evaluate and improve supply chain management in a company. The need for independent and common criteria to measure supply chain performance in all industry fields initiates the development of this model (Stewart, 1995) which depends on four processes namely; plan, source, make and deliver. With the variables defined in this model, the current state of a company can be assessed and compared to benchmarked companies. In this thesis, some of the SCOR variables, which are related to the source, make and deliver processes of supply chain, are used along with the variables related to managing and improving the relations with suppliers and customers of the company. In this respect, the measures selected represent the processes of companies beginning from tier 1 suppliers and ending with tier 1 customers all these measures are tabulated in Table 1.

Table 1. All Input and Output Measures Used in this Study

Inputs	Outputs
SCM costs	Revenue
Total inventory	On-time delivery rate
Number of full time employees	Capacity utilization
Number of ship to locations	Profit
Number of ship from locations	Export
Number of warehouses	
Number of production locations	

For a comprehensive evaluation of a company's supply chain; number of full-time employees, total inventory, supply chain management costs, the number of

warehouse locations, the number of tier 1 customers (ship to locations), the number of tier 1 suppliers (ship from locations), the number of production locations, revenue and on-time delivery are seen crucial in evaluating supply chain performance. These measures are selected from SCOR metrics and from related literature in supply chain benchmarking. Regarding their effects on SCM operational performance, capacity utilization, profit and export are also added to the pre-mentioned metrics in the final stage of performance evaluation.

Total inventory, which constitutes the major supply chain cost, is specified as an input for the study. In the literature, inventory is used both as an input (Reiner and Hofmann, 2006) and as an output (Ross and Droge, 2004) for supply chain performance evaluation. This dual usage emerges from the fact that inventory can be a resource that has to be minimized as well as an output which indicates supply chain efficiency. Since DEA is a methodology that either minimizes input or maximizes output to evaluate efficiency, it is more meaningful to use inventory as input. Otherwise trying to maximize inventory would be an undesirable case for supply chain efficiency. Inventory within the input variables is recognized as a resource by the DEA model which aims to maximize output with the minimum level of inputs. There may be a limitation of using this variable which is seasonality. The inventory may vary during the year because of seasonality. Since the data is used from balance sheets, the results may vary.

Supply chain management cost is related with the costs of operations within the supply chain. Minimization of this cost along with maximization in outputs increases efficiency. This thesis prefers and sticks to the method of Shah and Singh (2001) to calculate this cost. Shah and Singh (2001) define SCM cost as the sum of distribution costs and inventory holding costs. Inventory holding cost is the multiple

of total inventory and inventory carrying cost rate. Inventory carrying cost rate includes the cost of capital of a firm in addition to the other costs such as obsolescence, deterioration, warehousing, insurance, stock loses. As in Shah and Singh (2001), cost of capital of a firm is used as its inventory carrying cost. Cost of capital constitutes a major part of inventory carrying cost and it can be estimated from financial statements. However, financial statements and operations of Turkish companies are not so transparent. In order to represent the cost of capital for the Turkish food and beverage industry, average cost of capital of food and beverage companies is taken from the study of Ege and Bayraktaroglu (2008). For international benchmarking, the average cost of capital data of US companies are retrieved from the website of New York University. Unfortunately, distribution cost data is also unavailable publicly. Instead of distribution costs, marketing and selling costs are used since distribution costs is a percentage in this expenditure. Usefulness and validity of using this variable instead of distribution costs is verified by professionals of the sector via phone interviews. These interviews are made by three logistics managers in food and beverage industry.

Number of full time employees is a resource for a company and for a supply chain. Efficient use of employees decreases costs and increases productivity of the system. In literature, the total number of full time employees is generally used for distribution firms (Goncharuk, 2008) in which employees are one of the major costs and major resources. Nearly all employees in these firms are a part of the main operation which is distribution. For manufacturing firms, number of full-time employees in manufacturing is generally used to assess supply chain performance of the companies (Reiner and Hofmann, 2006). In this thesis, the number of full time

employees is used due to data availability problems for supply chain performance evaluation with some concerns about its effects on the results.

To analyze sensitivity of evaluation to the use of the number of full time employees instead of the number of full-time employees in manufacturing, the number of production locations is selected. Reiner and Hofmann (2006) find a high correlation between the number of full time employees in manufacturing and the number of production locations. Keeping in mind this high correlation, the number of production locations is considered to be an appropriate proxy for the number of employees in manufacturing. So, to measure the sensitivity of the model to using the total number of full time employees instead of the number of full time employees in the manufacturing department, the number of production locations is used.

The number of warehouse locations, number of tier 1 customers (ship to locations) and number of tier 1 suppliers (ship from locations) are considered inputs to the model. These three variables are selected from SCOR metrics. All are also used together in the study of Reiner and Hofmann (2006) to benchmark supply chain performances of companies in DEA context. These variables are important elements of supply chain management that effect design and efficiency of supply chain and logistics costs as well as supply chain efficiency and responsiveness. As the number of suppliers and customers increase, complexity of the chain increase and managing the chain effectively gets harder. The traffic of warehouses increase and managers are forced to decide on their strategies either to increase warehouse number or to add some distribution centers to the chain or to work with a few reliable suppliers and customers to decrease their number and hence the traffic and costs. These supply chain strategies of managers affect supply chain efficiency and responsiveness. Increase or decrease in warehouse or distribution center numbers affects

responsiveness and efficiency of the supply chain. In summary, these variables are very effective elements of supply chain design. Furthermore, along with the number of tier 1 suppliers and customers, warehouses are inputs of the system that significantly affects on-time delivery rate which is one of the most common measures of supply chain performance.

On-time delivery rate and revenue are two common measures in literature to evaluate supply chain performance (Tan, 2002, Hausmann, 2003, Wong and Wong, 2007, Reiner and Hofmann, 2006, Beamon, 1999, Gunasekaran, Patel and Tirtiroglu, 2001, Goncharuk, 2008, Friedman and Stern, 1998, SCOR, 2008). On-time delivery rate is a service quality measure that is related to customer satisfaction and supply chain reliability (Ross, 1998, p.261). It is a significant indicator of supply chain efficiency. This measure links the operations of a company to its customers. It gives the performance rate of a supply chain in delivering goods to customers on the demanded time at the right place, in the correct package, shape and quantity. Like other activities, on-time delivery relies on the quality of information exchanged between supply chain members (Gunasekaran et al., 2001) and the coordination among them. It may represent all the delays in the sourcing, manufacturing and transportation processes (Chan, 2003), thus the delays in all supply chain processes which emerge from un-coordination among the supply chain members.

Revenue indicates how well the company performed its operations and controlled its supply chain. If a company generates a significant amount of revenue, then it means that the company is successful in the market-place. Success in the market means high customer satisfaction and on-time delivery of defect free, quality products and services all of which are the outcomes of effectively managed supply chains.

At a later stage, capacity utilization, export and profit, are added to above mentioned variables regarding their significant effects on SC operational performance. These three variables also show how well companies benefit from their resources and operations. Based on the literature review performed, adding export and profit to the supply chain performance variables is a contribution to literature; since, they are not used for SC performance evaluation in the DEA context before. There are only a few studies (Duzakin and Duzakin, 2007) that measure the performance of manufacturing firms in the DEA context.

Capacity utilization is a performance metric used to evaluate production performance. In literature, capacity utilization is used to evaluate supplier performance (Muralidharan et al., 2002) and in DEA context it is used to measure manufacturing management performance (Sheu and Peng, 2003). Motivation to use this metric in overall supply chain performance evaluation at company level comes from the fact that production capacity is an indicator of supply chain responsiveness since it is highly correlated with flexibility, lead-time and deliverability (Gunasekaran et al., 2003). Moreover, utilization of this resource reflects the capabilities of a company in resource management (Chan and Qui, 2003).

Profit is added to the variables to analyze whether the firms are utilizing their generated revenues. Considering only revenue to assess performance may lead to misleading conclusions in performance evaluations (Duzakin and Duzakin, 2007). Generating extensive revenues does not mean making profits. For example, a company that makes significant revenues might lack in managing its operations effectively. In that case, costs of goods sold would increase and profit would decrease. If only revenue is considered to assess supply chain performance of this company, it can misleadingly be assigned a high efficiency level which misleads the

analyzer. As a result, considering both profit and revenue in performance measures would help to assess a supply chain better.

Profit is stated and used as a supply chain performance measure in literature before but as far as one knows not in DEA context to measure supply chain performance. Beamon (1999) states profit as a cost based global competitive performance measure in his literature review of supply chain performance measures. In addition, Li and O'Brien (1999) use profit as a performance measure along with lead time, delivery promptness and inventory costs when proposing a hierarchical approach to supply chain modeling.

Export is a strategy that affects operations of companies and design of supply chains. In their article Breitman and Lucas (1987) describe a model developed at General Motors. The model gives the optimal supply chain solution by considering the companies' business environments and strategies one of which is export. Gutierrez and Kouvelis (1995) develop a model and an algorithm for supply chain design in order to solve the problem of fluctuations in currencies that emerge from export and import activities. The model selects the most appropriate suppliers for the global supply chain network by minimizing the fixed and variable costs such as transportation cost, import and export taxes.

Companies may decide to solely focus on domestic customers or may choose to export to expand their customer portfolios, learn from global competitors, catch up with rapid global trends and increase their revenues. However, this decision of companies has to be supported by a good performance in domestic operations, since companies that are efficient in their operations tend to export (Helpman et al (2004); Bernard et al., (2003) and Melitz (2003)). Considering this fact, it can be said that, export is an indicator of good operations performance and so it is an indicator of

effectively managed supply chains. In his article about globalization, Blanchard (2008) gives place to an interview with Bradley Feuling who is the CEO of a Shanghai-based supply chain consulting firm. Feuling states that an importer or an outsourcing company pays attention to the efficiency of an exporter company since buying a product means buying the supply chain. If a company's supply chain performance level is high, then its products and services will be better quality, will be delivered on-time and will be at a lower cost relative to its competitors, and customer satisfaction will be higher. Then, it will have the chance to export more and be successful in the global arena. Belisle (2001) also mentions in his article that export of a company is only as strong as the weakest link in the supply chain of that company. To increase its exports, a company should focus on its supply chain and manage it as efficient as possible.

In the global arena, customers are very picky in choosing their suppliers. To remain competitive and become a significant supplier in the export market, Piercy et al. (1998) list some specifications, all of which are improved by an effective supply chain management, which needs to be considered. These are; cost per unit production, cost of goods sold, selling price to end-user abroad, product quality, product accessibility, delivery speed and reliability. Supporting this listing, Zou and Stan (1998) find that low cost can have significant impact on export performance and Ling-Yee and Ogunmokun (2001) state that exporting companies should pay more attention to the development of SCM skills which is a key issue for success.

Keeping in mind the above facts of export which is considerably related with operations and supply chain efficiency, a brief discussion is presented below about international trade, export and company and country prosperity.

Export is one of the first stages of the internationalization process which is followed by joint ventures and green field investments. It is also considered the most common tool for international expansion (Leonidou et al., 1996). Most of the developed countries have already succeeded in the export stage of the internationalization process. According to WTO data, only G-7 countries constituted 36.61% of world total exports in 2007. In addition to their export activities, companies in these countries now make green field investments in promising markets or enter in joint ventures in more risky markets to decrease their costs and to penetrate the market in these countries better. Export is especially important for the companies in developing markets and hence for the economies of developing markets. Leonidou et al. (1996) present the benefits of export from both country and company perspectives. From the viewpoint of countries, export can enable their national economies to enrich their foreign exchange reserves, provide employment, create backward and forward linkages, and, ultimately, lead to a higher standard of living. From the view point of companies, exporting can give them a competitive advantage, improve their financial position, increase capacity utilization, and raise technological standards.

From the viewpoint of companies in developing markets, export is crucial for economic growth. Along with the entry of companies of developed countries in developing markets either via export or investments, market shares of domestic companies fall (Bernard et al. 2006), producers in domestic markets face falling profits (Kletzer, 2001) and workers in these industries lose jobs or face downward wages (Kletzer, 2001). Consumers in developing markets are more likely to buy foreign country products. Most of the time, this consumption pattern can be explained by the high quality perception of customers for products originated from

developed countries, Japan, the USA and western Europe (Kaynak and Kara, 2002). This behavior of consumers in developing countries causes decreases in market shares and revenues of domestic companies. To be able to grow, increase productivity and make more revenue, export along with a strengthening in domestic operations is a crucial choice for these companies. According to Feder (1982), export has a direct impact in the growth of companies and exporting sectors in a variety of ways. Feder states that exports increase capacity utilization; lead companies enjoy economies of scale by the increases in production levels and ease the spread of know-how from global markets. He also states that foreign competition develops management skills in these companies and export has a positive impact on the rest of the economy as well.

From the view point of countries, export is also vital for the economic development especially for developing countries. Literature cites a significant number of articles about export and economic growth. Although the specific remarks differ somewhat, almost all empirical work seems to have concluded that exports are probably good for economic growth (Ram, 1987). Kavoussi (1984) examines the relationship between export expansion and economic growth in a sample of seventy-three developing countries, using data for the period 1960–1978. In his study, he shows that in both groups of low- and middle-income countries, export expansion is associated with better economic performance and that an important cause of this association is the favorable impact of exports on total factor productivity. Ram (1987) presents the predominantly positive effect of export on economic growth by reporting individual-country estimates of two growth models for the eighty eight least developed countries (LDCs) on the basis of time-series data for 1960-1982.

The increase in foreign companies entering developing markets via export and/or investments decreases the strength and market share of domestic companies which decreases their production scales and revenues. Along with this decrease in domestic value generation, the increase in imports broadens trade deficit. All these have negative effects on the growth of the total economy. Especially, developing countries have to give importance to sustainable export activities to obtain economic development. However, this importance given to export has to be for value-added products and services.

The neo-classical school suggests that export makes major contributions to economic growth in developing countries such as increasing specialization and expanding the efficiency-raising benefits of comparative advantage, offering greater economies of scale due to an enlargement of the effective market size, affording greater capacity utilization and inducing more rapid technological change. On the other hand, neo-Marxist school states the opposite of this thought and even believes that export worsens economies of less developed countries that engage in trade with more developed countries (Ram, 1987). This statement of the Marxist school is acceptable for developing or less developed countries that are exporting commodities or low-value added products or services. History is full of stories of developed countries and their colonies. But today, it can be regarded as a real fact that export enables growth of developing countries as in the example of Asian Tigers.

However, it still has to be kept in mind that export of value-added products enables growth of economies. Value added products are crucial for expanding employment and income opportunities beyond the farm gate (Aksoy and Beghin, 2005). If production scales of companies increase via export activities, these opportunities expand. The economic well being of citizens gets better with the

employment opportunities in these exporting firms. Moreover, increase in exports balances imports of the countries and so decreases the trade deficit. All of these outcomes of export enable countries to grow in economic aspects.

In summary, it can be said that export is a significant strategy and maybe a significant opportunity for developing countries and companies in those countries. As a result, export is a significant performance measure of operations and supply chains of companies, especially like those in Turkey. Supporting this idea, Sutuntivorakoon (2006) investigates important issues in SCM in order to increase success in exporting business in a developing country which is Thailand. In his case study, he analyzes a company's supply chain to find the defects in their management and give suggestions to improve supply chain performance which in turn will increase export of the company. Friedman and Stern (1998) use export in their study to measure manufacturing efficiency in the DEA context while trying to improve the DEA methodology by combining it with other performance measurement tools.

Based on above discussions, in this thesis, supply chain performances of companies are assessed via DEA by running the model for different combinations of above mentioned variables. All of these combinations, their implementations, results and discussions are presented in the next section.

CHAPTER VI

EMPRICAL ANALYSIS FOR THE TURKISH FOOD AND BEVERAGE INDUSTRY

The Food and Beverage Industry

The food and beverage industry is selected for analysis in this study. The food and beverage industry experiences a high level of competition; therefore, effective management strategies in company supply chains are highly critical in being competitive in this field. Firms have to be efficient in their operations by cutting edge strategies. They have to find new management ways to increase their market shares to be successful in the market since production techniques are highly standardized in this field. This statement is proven by the research of Miller and Roth (1994). In their study, they show that consumer packaged food manufacturers' competition is based on infrastructural changes in manufacturing operations which will cut costs and improve quality. This cost cutting can be achieved through efficient use of resources and efficient management of supply chains.

Another motivation to select this industry field is its importance for the Turkish economy. The food and beverage sector is among the first industries established in Turkey which has a competitive advantage in agricultural production (Istanbul Ticaret Odası [ITO], 2006). But today, Turkey does not benefit from this competitive advantage in the global arena (TUSIAD, 2007). Resources are used inefficiently and production of value added products as well as their exports are low. Researches on this area (TUSIAD, 2007, ITO, 2006) suggest effective management

strategies to overcome the existing problems between suppliers and manufacturers, to increase capacity utilization and to decrease production costs. A detailed explanation of the food and beverage industry in Turkey along with the problems of the sector is explained in the following section.

Performance Analysis of the Food and Beverage Industry in Turkey

Food and Beverage Industry in Turkey

Food and beverage industry in Turkey has a competitive advantage in the global arena because of the availability of a high variety of agricultural products and labor force (ITO, 2006). However, this advantage of Turkish companies cannot be turned into success in global markets basically due to the companies' inefficient use of resources and wrong strategies. In studies of both ITO (2006) and TUSIAD (2007), the food and beverage industry is specified as a strategic sector of Turkey that can become a significant player in the global arena as well as a significant exporter industry that increase international trade of Turkey.

An overview about the food and beverage industry in Turkey is presented based on the study of TUSIAD (2007). The food and beverage industry is one of the first industries established in Turkey. After the foundation of the Turkish Republic, industrialization of Turkey began with this sector. Sugar, flour and beer processing plants were the first modern food processing companies founded. Developments in the sector began in the second half of the 1970s. After export gained support and importance in the 1980s, private investments in the sector increased tremendously. In 2005, the share of the food and beverage industry in GDP was 4.8% with an

opportunity to increase since the share of agricultural products in GDP at the same year was reported to be 11.3% (TUSIAD, 2007). This huge difference in GDP shares of raw agricultural products and processed foods can be attributed to the statements present in the study of ITO (2006). These statements demonstrate the misfits in company strategies as well as inefficiencies of companies and consumption behavior of Turkish customers.

One of the major problems in the Turkish food processing industry is low capacity utilization (ITO, 2006). Most of the plants are highly equipped with modern equipments. However, due to seasonality, improper strategies in production and lack of coordination in supply chain, capacity utilization remains relatively low and so, production costs remain relatively high when compared to international firms in the global arena. Based on the Turkish Statistical Institute (Turkstat) data, in 2007, the average industry capacity utilization rate in Turkey was 82% whereas it was 72% for the Turkish food and beverage industry. On the other hand, according to Federal Reserve data, capacity utilization of food and beverage industry in USA was 80% in 2007. To be able to compete with global firms, Turkish companies have to increase their capacity utilizations and decrease their production costs. Especially cost reduction is one of the major goals of food and beverage industry in Turkey and can be achieved through efficient supply chain management.

Turkish customers prefer to consume home cooked meals rather than frozen or canned meals. They usually buy fresh food from bazaars or groceries. This preference of Turkish customers may be connected to several reasons such as economic reasons that fresh food is relatively cheap when compared to canned food and eating habits that they are used to cook at home. Therefore, in Turkey, the canned and frozen food market is not developed when compared to other G-20

countries. Although this consumption pattern of Turkish customers has begun to change, Turkish companies have to focus towards export both to utilize their excess capacities and to utilize the competitive advantage of the country in agricultural production.

When export levels of Turkish food and beverage industry are analyzed, it is seen that a major part of exports consists of relatively lower value-added products which can be defined as unprocessed agricultural products like hazelnut or basic products like sugar. Top exporters in the food and beverage industry are tabulated in Table 2 according to years and their field of activity.

Table 2. Biggest Exporters among ISO 500 Companies (TUSIAD, 2007)

Company	Year	Rank	Export (1000$)	Field of activity
Turk Seker	1993	7	147693	sugar production
Turk Seker	1994	6	166398	sugar production
Baskan Gida	1998	207	154139	hazelnut processing
Turk Seker	1999	6	153245	sugar production
Baskan Gida	1999	157	118795	hazelnut processing
Baskan Gida	2000	121	170327	hazelnut processing
Turk Seker	2000	7	124077	sugar production
Turk Seker	2001	4	224002	sugar production
Baskan Gida	2001	105	190091	hazelnut processing
Oltan Gida	2001	63	121525	hazelnut processing
Oltan Gida	2002	99	107958	hazelnut processing
Oltan Gida	2003	95	164687	hazelnut processing
O. Akca T. Urunleri San. A.S.	2003	150	105240	legumes, dried and fresh fruit

Source: ISO 500 data

Processed high value added products constitute only a minor part of exports of Turkey in food and beverages (TUSIAD, 2007). The relatively lower value added agricultural products constitute a significant value in exports of Turkey. Table 2 shows that still in recent years, Turk Seker that exports sugar ranked fourth among ISO 500 companies. This high level of export in commodities indicates the

competitive advantage of Turkey in agricultural production in the global arena. The global markets need Turkish agricultural products as inputs to their production operations in the related area. This need of global markets should be met by processed products instead of lower value added in order to increase export revenues and create job opportunities.

According to Turkish Statistical Institute data, food, beverage and live animal export of Turkey constituted 8% of total exports in 2007 and as TUSIAD's study implies low value added products constitute a significant part of this 8%. As tabulated in Table 3, exports of Turkey as well as its imports have increased since 1999 and the increase in exports could not cover the trade deficit of Turkey which also has increased since 1999 at an average rate of 30% a year.

Table 3. Export, Import and Trade Deficit of Turkey: 1999-2008

Year	Export (billion $)	Import (billion $)	Trade Deficit (billion $)
1999	26.6	40.7	-14.1
2000	27.7	54.5	-26.8
2001	31.3	41.4	-10.1
2002	36.1	51.5	-15.5
2003	47.3	69.3	-22.1
2004	63.2	97.5	-34.4
2005	73.5	116.8	-43.3
2006	85.5	139.6	-54.1
2007	107.3	170.1	-62.8
2008	132.0	202.0	-70.0

Source: Turkstat

Gradually and continuously growing trade deficit may be harmful such as by decreasing GDP and employment rate of the country. Imports if not are used as raw materials may replace the production of country, domestic production volume decrease and GDP reduces. For the well being of Turkey, Turkish companies should give more importance to export, especially export of the higher value added,

processed products to balance the trade deficit. Balancing the trade deficit eventually provides capital for new investments for further industrialization of the country (Balyemez, 2008) which inturn creates new job opportunities and provides well being of country. The amount of agricultural and live animal exports indicates the need of foreign markets for Turkish agricultural products and live animals in order to use them as raw materials in their productions. Instead of exporting basic agricultural products, Turkish companies should process them at home and then sell them in global markets. However, to be able to market their goods in global markets, Turkish companies need to improve their operations and ensure smoothness of international commerce.

Based on the above discussion, it might be concluded that the processed food industry has a high potential to be one of the major exporter industries in Turkey which will in turn increase international trade volume of Turkey and create growth opportunities for the Turkish economy. However, this high potential can only be utilized by effective management strategies. To be able to overcome the existing problems of the industry, companies should give importance to supply chain management which can decrease cost of production, improve supplier-customer relations and create high level of customer satisfaction.

In this part of the thesis, firstly, supply chains of Turkish food and beverage companies are analyzed to see the relative efficiencies of companies in domestic market. The study of Salomon and Shaver (2005) is a motivation to conduct this analysis. In their study, they analyze the domestic companies in Spain and find that export and domestic sales are complements and the strength in the domestic market drives export sales. To be able to enter foreign markets and increase their exports, first of all companies have to learn from their domestic competitors and strengthen

their positions in their domestic markets. An analysis of supply chains of companies in the domestic market give companies the opportunity to see its place in the domestic market and to learn from domestic competitors. Learning and implementing the operations of the outperforming domestic competitors may increase competitiveness of the inefficiently managed companies and export revenues of the industry.

Data

Most of the supply chain performance analyses conducted for food and beverage companies in this study rely on publicly available data. In Turkey, companies are generally not so transparent in their operations and do not share their data publicly. Most of them are not institutionalized and most of the data required for analysis is not available or is not standardized. The lack of standardization decreases data compatibility between different firms; since, to be able to obtain reliable results, observed data has to be standardized and reliable. To prevent most of the data availability problems and to strengthen the results with the reliability of the data, stock market companies are selected.

Financial data of companies that are traded in stock markets have to be public. This publicly presented data conforms to specifications and is reliable. In this thesis, food and beverage companies are limited to those that are traded in the ISE (Istanbul Stock Exchange). A total of 24 food and beverage companies are traded in the ISE. One of the companies is omitted due to its additional operations in textile sector. Data is collected via internet from ISE and companies' websites. For a number of analyses, some additional data is collected via e-mail and telephone

interviews with managers such as supply chain, logistics or production managers. 14 companies out of 23 responded to the questionnaire which resulted in a response rate of 61%.

Collected data is used to analyze the supply chain efficiencies of food and beverage companies, which are numbered such as TR1, TR 2, TR 3 and TR 4 due to confidentiality reasons, by testing various combinations of pre-selected measures of supply chain performance. These measures are basically selected from supply chain benchmarking and financial benchmarking literature and are combined in various ways to obtain a comprehensive and robust efficiency scoring. The following sections of the thesis proceed with results and discussions of the sensitivity analyses performed with these different combinations of pre-selected measures. Some analyses will measure supply chain performance by using only publicly available data. This will create awareness for the food and beverage industry as well as other industries and ISE as to what analyses can be made with ISE available data. The developed approach will be used for benchmarking analysis of Turkish food and beverage companies according to their 2007 performances. Finally, Turkish food and beverage companies will be benchmarked with the companies of a global food and beverage industry leader country.

Results

Supply chain efficiency of Turkish food and beverage companies in 2007 are analyzed in this thesis to expose the companies to improvement opportunities and to strengthen their positions in the domestic market. The analyses are conducted with

different combinations of the pre-determined variables, which are indicators of supply chain efficiency, via sensitivity analysis.

Sensitivity analysis helps to decrease the number of variables in the proposed input and output set. It is important to keep a number of variables relatively low in comparison to the number of DMUs. As the number of input and output variables increases, the DMU efficiency scores differentiate less and this might give misleading results. As a result, if data set is limited as in this thesis, the input and output variables may need to be decreased to obtain meaningful results. To conduct sensitivity analysis and to test the effects of various variable combinations on performance of supply chains, combination of publicly available and confidential company data are used for the first four runs. The first run is the most comprehensive data set claimed to have all crucial variables that may determine performance of a supply chain. However, data availability problems due to confidential data limit the number of companies that are analyzed. To overcome this problem and to be able to make further analysis possible in international markets, the variable set is rearranged to consist of only publicly available data. Then the study proceeds with combinations that consist only of publicly available data.

The analyses are conducted utilizing the CCR model of DEA with the objective of output maximization under the assumption of constant returns to scale. Each model is run using computer facilities and the related DEA software, DEA Solver Pro 5. When conducting the analysis, the objective is set as output maximization instead of input minimization. This preference depends on the fact that suggestions such as reducing the number of employees, which is one of the inputs, would not be very appropriate due to employee unions and welfare policies.

Therefore, suggesting improvements in outputs would be wiser in terms of social and economic policies in Turkey (Duzakin and Duzakin, 2007).

Due to confidentiality reasons as explained in the previous section, supply chain efficiencies of 14 companies are assessed in the first four combinations. Since only 14 companies out of 23 traded in ISE share their 2007 data to be used in this thesis, DEA analysis are performed with these companies. This is the major limitation of these following four runs.

In the first combination; total number of full-time employees, total inventory, number of warehouse locations, number of ship to locations, number of ship from locations and internal supply chain management costs are used as inputs, revenue and on-time delivery rate are used as the output variables. All these variables are considered to be in a set, because they define and affect a supply chain system comprehensively. Therefore, these inputs and outputs are the ones that need to be in the model, ideally. All of these variables are considered in this run; however, results need a careful explanation since there are a high number of variables relative to the number of DMUs.

Running the specified model demonstrates that 86% of the companies in the data set are efficient. This high number of efficient DMUs might be obtained due to the decrease in discriminative power of the model. There exists a total of 8 input and output variables in comparison to 14 DMUs where the ratio of number of variables to DMUs is 4/7. This relatively high ratio distorts the differentiation power of the model. With the availability of a larger data set, the number of relatively efficient DMUs is expected to decrease and more meaningful and reliable results is expected to be obtained.

The variable set of the first run can be regarded as a comprehensive supply chain performance measurement set. The variables specified link internal supply chain i.e. SCM costs, inventory and employee number to external supply chain i.e. on-time delivery rate and evaluate the performance of the entire supply chain of a company. This input-output set combines and analyzes efficiencies of all three levels of the supply chain model of SCOR, which are source, make and deliver. In addition to this, this set also contains the variables that indicate the design of the supply chain. The number of warehouses and ship to and ship from locations are among the major elements of a supply chain design. Having these variables in data set enables the decision maker to assess the efficiency of supply chain design. In case of inefficiency, design of supply chains may be developed by benchmarking the best practice competitors. Although the results may not be highly reliable due to data availability problems, meaningful results are expected to be obtained by this variable set, provided that the number of DMU's is appropriate.

In the second combination, total number of employees, total inventory, and internal supply chain management costs are used as inputs and revenue and on-time delivery rate are used as outputs. The number of warehouse locations, the number of ship to locations and number of ship from locations are taken out from the performance measurement set in order to decrease the number of inputs and outputs and to prevent the misleading of data due to the structural differences between the sub-sectors of the Turkish food and beverage industry.

As mentioned earlier, the ratio of the total number of inputs and outputs to the number of DMUs should not exceed the generally accepted limit of 1:2 (Rickards, 2003). This is required not to distort the discriminatory power of the model and to reach meaningful results. Taking out three variables from the variable set improves

the variable number to DMU number ratio to a value below 1/2. Number of warehouse locations, number of ship to locations and number of ship from locations are selected to be the discarded variables due to the structural differences between the sub-sectors of the Turkish food and beverage industry. This difference between the sub-sectors results in significant divergence in the number of ship to and ship from and warehouse locations which necessarily result in significant differences in supply chain designs. The structural differences among the sectors result in a high variance within the data set. The number of tier 1 suppliers range from 4 to 1200 and the number of tier 1 customers from 15 to 2000. Canned and frozen food companies in Turkey work with individual farmers which increase their supplier number whereas chocolate and biscuit companies work with a relatively few number of suppliers. On the other hand, chocolate and biscuit or beverage companies deliver their goods to a lot of customers and locations; whereas, canned and frozen food manufacturers generally work with relatively few wholesalers.

Another motivation to discard the variables, which are the number of warehouse, ship to and ship from locations, is the hypothesis that SCM costs also reflect the effects of these variables on supply chain performance to some extent. The numbers of warehouses, ship to and ship from locations are a part of logistics and SCM costs as well as being a part of supply chain design. Therefore, SCM costs are expected to include the costs of these three variables and increase and decrease according to the number of these variables to reflect their effects on supply chain performance to some extent.

The result of the second run, where the input variables are number of full-time employees, SCM costs, total inventory and output variables are revenue and on-time delivery rate, is tabulated in Table 4.

Table 4. Results of the Second Input-Output Combination

Rank	DMU	Score
1	TR 11	1
1	TR 9	1
1	TR 2	1
1	TR 3	1
1	TR 4	1
1	TR 8	1
1	TR 1	1
1	TR 7	1
9	TR 12	0.99
10	TR 13	0.85
11	TR 6	0.85
12	TR 10	0.78
13	TR 14	0.62
14	TR 5	0.37

According to the results of the second run, 57% of the sample is found to be efficient. The average efficiency of the sample is 0.89. The number of relatively inefficient units increased from 2 to 6 compared to the previous run. The average efficiency scores of food and beverage companies in the sample according to their sub-sectors which are beverages, canned and frozen foods and others (chocolate, biscuits dairy and poultry) are found to be 1, 0.78 and 0.96 respectively. TR 5 and TR 6 are found to be relatively inefficient in both of the first and second runs. In the first run, TR 5 is projected to decrease its warehouse number by DEA; whereas in the second run, projection is converted to a decrease in SCM costs. In the first run, inefficiency level of TR 6 is attributed to its excess ship to and ship from locations that cannot be effectively controlled with the company's assets whereas, in the second run, since these variables are taken out from the variables set, the inefficiency is based on the SCM costs.

The comparison of inefficiency roots of TR 5 and TR 6 in the first and second runs strengthens the hypothesis previously mentioned. DMU efficiencies are rather insensitive to the eliminated performance metrics of number of ship to, ship from and

warehouse locations in presence of SCM costs which is expected to reflect the effects of these three variables on supply chain performance. Although these three variables form the major part of the supply chain design and reflect the effects of design on supply chain performance, they are also a part of SCM costs. SCM costs may also reflect the effect of these three variables on supply chain performance to some extent and this statement is strengthened with the results of the second run.

In the next analysis, total inventory, SCM costs and the number of production locations are taken as the input variables whereas on time delivery rate and revenue as the output variables. As different from the second analysis, the number of full-time employees in input variables is replaced with the number of production locations.

In their study, Reiner and Hofmann (2006) make dependency analysis on SCOR metrics to find out which metrics to use in DEA model to benchmark supply chain performances of companies. They find that the number of production locations should be used as an input. However, they use the number of full-time employees in manufacturing, which is a common measure in supply chain performance literature, instead of the number of production locations. They state that the number of production locations is highly correlated with full-time employee number in manufacturing and replacement will give similar results in the analysis in DEA context.

Based on the study of Reiner and Hofmann (2006), the number of full-time employees is replaced by the number of production locations in this study. Using the number of production locations give similar results to using the number of full-time employees in manufacturing in the study of Reiner and Hofmann. Therefore, if using the number of full-time employees give similar results to using the number of

production locations, then it may support the hypothesis that the number of full-time employees of the whole company can be used as a proxy to the number of full-time employees in manufacturing in supply chain benchmarking analysis.

The result of the third run where the number of full-time employees is replaced by the number of production locations is tabulated in Table 5.

Table 5. Results of the Third Input-Output Combination

Rank	DMU	Score
1	TR 11	1
1	TR 1	1
1	TR 2	1
1	TR 10	1
1	TR 4	1
1	TR 9	1
1	TR 8	1
1	TR 7	1
9	TR 12	0.99
10	TR 3	0.73
11	TR 6	0.59
12	TR 13	0.45
13	TR 5	0.39
14	TR 14	0.38

When Table 5 is compared with Table 4, no significant change is observed between the two tables. For both of the performance variable combinations, number of relatively efficient and inefficient DMUs is the same and 57% of DMUs are defined to be relatively efficient. Nearly all DMUs which are defined as inefficient or efficient are the same in both of the tables. When the two tables are compared, it is seen that only two of the DMUs change place which are TR 10 and TR 3. TR 10 is defined as relatively inefficient in Table 3 and relatively efficient in Table 4 whereas, TR 3 is defined as relatively efficient in Table 3 and relatively inefficient in Table 5. For each inefficient DMU, DEA model specifies excess amounts in its inputs and insufficiencies in its outputs. Based on this, target input-output levels are defined for

each DMU to improve its efficiency. The two runs also resemble each other in terms of the amounts of excess resources and output shortages.

In both of the runs, inventory is specified as an excess resource of TR 14, SCM costs as an excess resource for TR 5 and TR 12 and on-time delivery rate as a shortage for TR 13. Having the same variables specified as the causes of inefficiency of the same DMUs might support the hypothesis of using the number of full time employees as a proxy of the number of full-time employees in manufacturing.

To conclude, the statement of using the total number of full time employees to assess supply chain performance instead of the number of production locations and hence the number of full time employees in manufacturing operations is supported by the results presented in Table 5.

The results of the three runs indicate the possibility that the practitioner can choose between the variable sets from fully comprehensive to comprehensive to some extent which can also shed light on the performance of the companies.

Table 6. Results of the Fourth Input-Output Combination

Rank	DMU	Score
1	TR 12	1
1	TR 11	1
1	TR 2	1
1	TR 3	1
1	TR 4	1
1	TR 9	1
1	TR 8	1
1	TR 7	1
9	TR 6	0.92
10	TR 10	0.78
11	TR 14	0.62
12	TR 1	0.53
13	TR 5	0.39

In the fourth run, total number of full-time employees, total inventory and SCM costs are used as input variables and capacity utilization, on time delivery rate and revenue as output variables. The difference of this run from the second run is only the variables of capacity utilization, which is added to the outputs mainly because it is an indicator that shows how efficiently the resources are managed and used. 13 companies can be evaluated with this input-output combination. TR 13 is taken out from the data set because of data confidentiality and availability problems. Resulting efficiency scores are presented in Table 6.

When Table 4 and Table 6 are compared, no significant difference is observed. The only difference between the two tables is the efficiency score of TR 1 which decrease from 1 to 0.53. Average efficiency of the sample decreased from 89% to 86% which is not a significant decrease. In both of the combinations, excess resources are the same for the same inefficient DMUs. For instance, TR 5 and TR 12 should decrease SCM costs, TR 10 should decrease its full time employees and SCM costs and TR 14 should decrease total inventory at hand. Despite the insignificant difference between the two runs, this result can not be generalized to the insensitivity of supply chain performance to capacity utilization rate due to data limitations.

DEA Benchmarks

To increase the reliability and generalization possibility of applications and to make industrial and international benchmarking possible, input and output measures are restricted to publicly available data for further analysis. Company confidential data is difficult to obtain and has no specifications that enable standardization of data among companies. To ensure data reliability and accessibility, the performance

variables set is restricted to consist of only publicly available data. This restriction will enable the applicability of the developed efficiency analysis approach to all companies that have data in public domain. This also provides international benchmarking opportunity for local and international companies. So, input and output measures are restricted to publicly available data by eliminating on-time delivery rate from the set of output variables. The selected performance measurement model is illustrated in Figure 5.

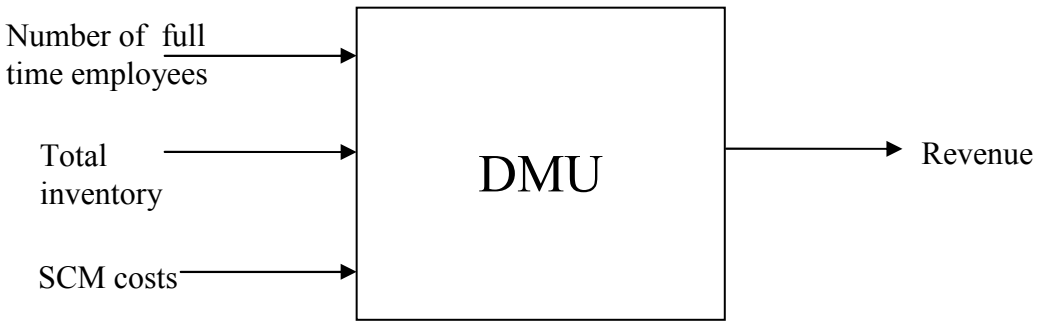

Figure 5. The basic model

The model completely consists of publicly available data. This significantly reduces data availability problems as well as reliability problems. Moreover, publicly available data of companies that are traded in stock markets have to be standardized as requirement. Therefore, using publicly available data also solves the standardization problems which may mislead results. For example, in collecting data from primary sources, one company can give its profit as before tax while another may give it as after tax. This difference may distort the validity and reliability of the result. Using publicly available data taken from stock markets provides data reliability. By limiting variables to those for which publicly available data exists, it

becomes possible to include all food and beverage companies in ISE which increase the number of DMUs from 14 to 23.

In the model run that consists of all publicly available inputs and outputs, supply chains of all 23 food and beverage companies that are traded in ISE are benchmarked. The result is tabulated in the final column of Table 7. The result of the basic model reveals that during 2007, four companies, TR 2, TR 7, TR 9 and TR 23 manage their supply chains efficiently in comparison to other companies in the data set. The average efficiency of the sample is 0.63 and twelve DMUs have efficiency scores below the sample's average.

In Table 7, the result of the basic approach discussed above is tabulated along with sensitivity analysis which is performed by adding export and profit to output variables. The table presents the results of seven different runs where the input variables are kept the same as defined in Figure 5 but the output variables are changed each time. Export and profit variables are also considered in performance variables due to their previously mentioned importance in supply chain performance evaluation. The input variables of the number of full-time employees, total inventory and SCM costs remain the same for all analyses conducted. Export (e) and profit (p) are added to the output variable of revenue (r) for sensitivity analysis purposes.

The analysis which is conducted by considering export, profit and revenue in outputs is named after the initials of the variables used in analysis as erp. Similarly, pe is the analysis where profit and export are used as outputs; pr is the analysis in which profit and revenue are used as outputs; er is the analysis in which export and revenue are used as outputs, e is the analysis in which only export is considered as an output; p is the analysis in which only profit is considered and r is the analysis of the basic model.

Table 7. Results of the Basic Model along with the Sensitivity Analysis

	Runs						
	first	second	third	fouth	fifth	sixth	seventh
DMU	erp	ep	pr	er	e	p	r
TR 1	1.00	1.00	0.61	1.00	1.00	0.61	0.53
TR 2	1.00	0.94	1.00	1.00	0.90	<0.01	1.00
TR 3	0.40	0.05	0.40	0.40	0.01	0.05	0.40
TR 4	1.00	1.00	0.19	1.00	1.00	<0.01	0.19
TR 5	0.31	0.31	0.28	0.28	0.08	0.28	0.26
TR 6	1.00	1.00	0.48	1.00	1.00	<0.01	0.48
TR 7	1.00	1.00	1.00	1.00	0.06	1.00	1.00
TR 8	1.00	1.00	1.00	0.76	0.39	1.00	0.70
TR 9	1.00	1.00	1.00	1.00	0.65	1.00	1.00
TR 10	1.00	0.84	0.76	1.00	0.70	0.57	0.76
TR 11	0.97	0.10	0.97	0.97	<0.01	0.10	0.97
TR 12	0.94	0.74	0.94	0.76	0.05	0.74	0.76
TR 13	0.85	0.23	0.85	0.85	0.22	<0.01	0.85
TR 14	0.77	0.56	0.61	0.77	0.51	0.18	0.61
TR 15	1.00	0.81	0.78	1.00	0.61	0.58	0.78
TR 16	0.74	0.21	0.74	0.74	0.21	<0.01	0.74
TR 17	0.66	0.64	0.26	0.61	0.61	0.02	0.26
TR 18	1.00	1.00	0.67	0.95	0.85	0.67	0.56
TR 19	0.69	0.69	0.28	0.63	0.63	0.00	0.28
TR 20	0.97	0.97	0.29	0.97	0.97	<0.01	0.29
TR 21	0.55	0.53	0.54	0.55	0.06	0.53	0.54
TR 22	0.90	0.90	0.43	0.90	0.90	0.16	0.43
TR 23	1.00	0.89	1.00	1.00	0.89	<0.01	1.00

Sensitivity analysis is performed by defining different combinations of output variables with no change in input variables in order to see the strength of firms to the varying variables. For example, a company can make high revenue but cannot utilize this revenue to make profits. To see how profit affects supply chain efficiency of companies of to assess the effects of export on supply chain efficiency, sensitivity analyses are performed.

When the results in Table 7 are compared, it is found that there is no DMU which is efficient in all combinations. This result may show that resources are not utilized totally efficiently. Supply chains of TR 7 and TR 9 are the closest to

efficiency in any combination. Their efficiency scores only decrease when only export (e) is considered in the output variables. This result can be explained by the management strategies of these two companies. These two companies are not export oriented. Export revenue constitutes 1% of TR 7's revenue and 7% of TR 9's revenue. With these low amounts of export revenues, it is not surprising that these two companies are rated relatively inefficient when only export is considered.

As another result of the analysis, Turkish companies are found to benefit from export. Although Turkish food and beverage companies are not utilizing a majority of their resources to generate export revenues, the results might imply that they use their export strategies wisely. Efficiency scores of all DMUs increase or at least remain the same when export is added to output measures of profit and revenue. The efficiency scores increase when export (e) is added to the analyses conducted by profit and revenue (pr), revenue only (r) and profit only (p). This means that supply chains of Turkish food and beverage companies generally benefit from export activities in terms of supply chain efficiency.

Profit is also found to be a significant variable in explaining supply chain and hence financial efficiencies of companies. For example, when profit is used along with revenue in output variables, the efficiency scores of five companies, TR 1, TR 5 TR 8, TR 12 and TR 18 increase and the efficiency scores of the rest of the companies (18 companies) remain the same in comparison to the efficiency scores of the run in which only revenue is used. Seven companies in the sample are making minus profits, and three companies, which make minus profits, already have an efficiency score of one in the result of the model which use only revenue. Adding profit to output variables cannot increase the efficiency scores of these seven companies.

When profit is used along with export and revenue in outputs, the efficiency scores of six companies increase in comparison to the run where export and revenue are used. The increases in supply chain efficiency may mean that these companies are utilizing their revenues to make profit.

DEA Benchmarks

DEA model calculations make it possible to assess each input and output variable's contribution to the DMU's efficiency score. The following section includes a discussion of the contributions of each variable for the various runs taken. First discussion is about the basic model where inputs are employee number, total inventory and SCM costs and outputs are revenue, export and profit. The related results are tabulated in Table 8.

Table 8. Contributions of the Variables to Efficiency Scores

DMU	Employee	Inventory	SCM	Revenue	Export	Profit
TR 1	0.62	0.38	0	0	1	0
TR 2	1	0	0	1	0	0
TR 3	2.47	0	0.06	1	0	0
TR 4	0	0.12	0.88	0.07	0.93	0
TR 5	0.58	1.72	0.98	0	0.15	0.85
TR 6	1	0	0	0.06	0.94	0
TR 7	0.75	0.25	0	1.00	0	0
TR 8	0	0.86	0.14	0.57	0.21	0.21
TR 9	0.70	0.30	0	1	0	0
TR 10	0.21	0.79	0	0.65	0.35	0
TR 11	0.96	0	0.07	1	0	0
TR 12	0	1.07	0	0.87	0	0.12
TR 13	1.13	0	0.05	1	0	0
TR 14	1.15	0	0.16	0.63	0.37	0
TR 15	0.56	0.44	0	0.76	0.24	0
TR 16	0.61	0.75	0	0.89	0.11	0
TR 17	0	1.05	0.47	0.25	0.75	0.005
TR 18	1	0	0	0	0.89	0.11

Table 8. continued.

DMU	Employee	Inventory	SCM	Revenue	Export	Profit
TR 19	0.97	0.13	0.35	0	1	0.001
TR 20	1.04	0	0	0	1	0
TR 21	1.37	0.48	0	1	0	0
TR 22	0.00	0.77	0.34	0	1	0
TR 23	0	0.06	0.94	0.39	0.61	0

The table demonstrates that some of the variables are not assigned any weight (zero weight) for some DMUs. For example seven companies such as TR 16, TR 2, TR 6, TR 13 and TR 23 made minus profits for 2007. On the other hand, companies with positive profits such as TR 1 and TR 15 are also assigned zero weights to profit variables. These companies are making huge revenues and their export volumes are significantly high whereas their profit margins are 12% and 8% respectively. The explanation might be that their profits remain relatively low in comparison to their total revenues or export revenues; therefore, DEA assigns zero weight to their profit variable to maximize the efficiency scores of these DMUs.

In the sample, profit variables of 17 companies are assigned zero weight by DEA. As a result, it can be concluded that Turkish food and beverage companies are not successful in utilizing their resources to make high profits compared to the revenues they generate. Another inefficiency of Turkish companies seems to be their SCM costs. SCM cost variable of 11 companies are assigned zero weight by DEA. This may indicate that SCM costs of Turkish food and beverage companies are higher than other operation costs such as inventory and employees and minimization of SCM costs is required. The minimum amount of zero weights is assigned to the variables of revenue and full time employee number. Revenue seems to be the outcome that compensates the inefficiencies in other outputs of the companies. As the variable with the least zero wieght assigned, full-time employee number seems to

be the most wisely utilized resource. This outcome is also supported when the value of weights assigned are compared. The highest values are given to the variable of number of full-time employees. When the zero weights assigned to the variables of inventory and export are considered, it may be said that with eight zero values in inventory, Turkish companies learn to benefit from inventory management strategies of supply chain such as inventory pooling. In addition, with seven zero values in export variables, the Turkish food and beverage companies seem to benefit also from their exporting activities to some extent.

Table 9. Slack Variables of DMUs Determined by DEA

	% Excess	% Excess	% Excess	% Shortage	% Shortage	% Shortage
DMU	Employee	Inventory	SCM	Revenue	Export	Profit
TR 3	0	40.12	0	152.92	999.90	999.90
TR 5	0	0	0	233.15	227.10	227.10
TR 11	0	73.34	0	2.82	999.90	700.63
TR 12	57.89	0	31.24	6.50	70.03	6.50
TR 13	0	40.47	0	18.05	56.63	999.90
TR 14	0	60.27	0	30.68	30.68	72.51
TR 16	0	0	48.57	35.55	35.55	999.90
TR 17	55.55	0	0	52.00	52.00	52.00
TR 19	0	0	0	110.15	45.36	45.36
TR 20	0	73.20	28.25	67.74	3.55	94.36
TR 21	0	0	0	83.06	83.06	87.57
TR 22	6.84	0	0	14.34	10.86	119.78

Similar conclusions about profit can also be reached by analyzing Table 9 which presents input excesses and output shortfalls of each inefficient DMU. It is observed that 23 DMUs have an average of 35.09% revenue shortage whereas 191.54% profit shortage. This result also support the idea that Turkish food and beverage companies can generate revenues but cannot utilize their resources to generate profits. Turkish food and beverage companies need to decrease costs to increase their profits and this can be achieved via more efficiently managed supply chains which can be achieved

by sufficient inventory keeping, utilization of resources, distribution network configuration and strategic partnerships with suppliers and customers.

Although previous findings suggest that Turkish food and beverage companies benefit from their exporting activities, findings of Table 9 may imply that Turkish food and beverage companies do not make enough export. On the average there is 113.69% shortage in export revenues of the 23 analyzed companies to become efficient. In order to be a successful exporter and to increase their efficiencies, Turkish food and beverage companies should give importance to international trade activities. Increase in their export activities will increase companies' capacity utilization, decrease costs which is rendered by idle capacity, and increase revenue and profit of the firms. This increase in efficiency will shift up the efficiency curve of Turkish companies and raise them to higher rank in global markets. This well being of companies will create job opportunities for citizens and lead economic growth of country.

Apart from output shortages presented, input excesses are also tabulated in Table 9. Since the model used in this study is output oriented, it firstly aims to determine output shortages and then input excesses. With respect to the averages of output shortages stated above, averages of input excesses found are relatively low. 23 DMUs analyzed have an average excess of 5.23% in number of employees, 0.47% in SCM costs and 12.5% in total inventory. These excesses in inputs affect performance of supply chains negatively (Duzakin and Duzakin, 2007). Costs of these inputs increase the costs of goods sold. This decreases the profits of companies. Value generation is the ultimate aim of supply chain management. When companies can not generate value through their operations due to their inefficient management strategies and high costs in operations, supply chain efficiency decreases.

International Benchmarking of the Turkish Food and Beverage Industry

National benchmarking analysis can be extended further to assess a company's competitiveness in global markets. Comparison with global players is regarded as necessary to realize new improvement opportunities in terms of strategy and operations so that will increase overall performance. As Goncharuk (2008) states, international industry benchmarking expands opportunities of increase in the overall performance of companies in an industry. In this context, US food and beverage companies which are traded in the NYSE (New York Stock Exchange) are selected as benchmarks for Turkish companies.

Food and Beverage Industry in USA

Motivation to select the USA lies behind the success of the US food and beverage companies in global markets. USA has been the world export leader of the world since 1996 with 34 US companies present in top 100 food and beverage companies in the world. Furthermore, US companies constitute 42.8% of total food and beverage sales revenue (TUSIAD, 2007).

The food and beverage industry in the world defines a oligopolistic market. However, the efficiency and successful management techniques of the globally successful companies can be an important benchmark for the industry in general.

Data

The input output model of the international benchmarking consists of publicly available data for purposes of availability, reliability and comparability. Consequently, food and beverage companies that are traded in the NYSE are selected to compose the US sample. Financial data of companies that are traded in stock markets has to be public and conform to predefined specifications; therefore, comparison between Turkish and US companies becomes possible.

A total of 56 food and beverage companies are traded in NYSE. 15 of these are omitted either due to their diversified operations in other industrial fields or due to their operations wholly outside of the USA or else due to their country of origin which is not the USA. Observed data are collected via Compustat database and from annual financial reports in company websites.

Results

For the first run, supply chain efficiencies of the selected US food and beverage companies are compared within themselves. Employee number, total inventory and SCM costs are used as input and revenue is used as output. The result is tabulated in Table 10. Average efficiency of the sample is 0.69. Relatively efficient DMUs constitute 19% of the sample. The ratio of inefficient DMUs which have an efficiency score below 0.50 is 22%.

Table 10. Benchmarking Results of the US Companies

Rank	DMU	Score	Rank	DMU	Score
1	US 1	1	22	US 22	0.61
1	US 2	1	23	US 23	0.61
1	US 3	1	24	US 24	0.61
1	US 4	1	25	US 25	0.60
1	US 5	1	26	US 26	0.60
1	US 6	1	27	US 27	0.58
1	US 7	1	28	US 28	0.58
1	US 8	1	29	US 29	0.55
9	US 9	1.00	30	US 30	0.54
10	US 10	0.98	31	US 31	0.52
11	US 11	0.95	32	US 32	0.51
12	US 12	0.87	33	US 33	0.49
13	US 13	0.85	34	US 34	0.49
14	US 14	0.75	35	US 35	0.47
15	US 15	0.75	36	US 36	0.42
16	US 16	0.75	37	US 37	0.41
17	US 17	0.73	38	US 38	0.38
18	US 18	0.72	39	US 39	0.33
19	US 19	0.72	40	US 40	0.29
20	US 20	0.66	41	US 41	0.26
21	US 21	0.63			

For international benchmarking purposes to see where Turkish companies stand in the international league and to expand learning and improvement opportunities, supply chains of all 23 Turkish and 41 US food and beverage companies are benchmarked with the developed model in which employee number, total inventory and SCM costs are inputs and revenue is output. The result is tabulated in Table 11.

There are some limitations of pooling Turkish companies with US companies. First of all, most of the US companies are global and are operating outside the Americas (USA, Canada and Mexico). This spread of operations increase the resources they use and hence the revenues they obtain. However, the result of comparison of these highly globalized companies to companies mostly concentrating their operations in a domestic scale can be discussable.

Table 11. Results of the International Benchmarking

Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score
1	US 1	1	23	TR 16	0.68	45	US 34	0.49
1	US 3	1	24	TR 2	0.67	46	US 35	0.47
1	US 4	1	25	TR 10	0.64	47	TR 1	0.45
1	US 5	1	26	TR 12	0.64	48	TR 6	0.43
1	US 6	1	27	US 21	0.63	49	US 36	0.42
1	US 7	1	28	TR 15	0.62	50	US 37	0.41
1	US 2	1	29	TR 8	0.62	51	US 38	0.38
1	TR 23	1	30	US 22	0.61	52	TR 22	0.37
1	TR 9	1	31	US 23	0.61	53	US 39	0.33
10	TR 7	1.00	32	US 24	0.61	54	TR 11	0.33
11	US 9	1.00	33	US 25	0.60	55	US 40	0.29
12	US 10	0.98	34	US 26	0.60	56	TR 14	0.27
13	US 11	0.95	35	US 27	0.58	57	TR 2	0.27
14	US 8	0.90	36	US 28	0.58	58	TR 17	0.25
15	US 13	0.85	37	US 29	0.55	59	TR 5	0.24
16	US 12	0.78	38	US 30	0.54	60	TR 18	0.24
17	US 14	0.75	39	TR 21	0.53	61	TR 19	0.24
18	US 15	0.75	40	TR 13	0.52	62	US 41	0.23
19	US 16	0.74	41	US 31	0.52	63	TR 4	0.19
20	US 17	0.73	42	US 32	0.51	64	TR 20	0.12
21	US 18	0.72	43	US 20	0.50			
22	US 19	0.72	44	US 33	0.49			

Secondly, in the USA most of the companies are traded in the stock market to take advantage of the opportunities and resources in the market. If a company is traded in a stock market it gains from the capital turnover in the exchange market. The US stock exchange market is the biggest market in the world by dollar value of the securities of companies traded. As of 2006, the combined capitalization of all domestic companies listed in only NYSE was US$15.4 trillion whereas it was US$ 4.60 trillion in Tokyo (NYSE, 2009). The requirements to be traded in the stock market can be fulfilled more easily for companies in the US when compared to those in the Turkish stock market. To be able to be successful in the exchange markets companies needs to attract the traders. In Turkey, a company has to have a known brand name as well as good performance to be traded, since capital resources are

limited and the market is small in comparison to those in the USA. As a result, companies in Turkey which are traded in the ISE are relatively efficient companies in the domestic market regarding their operations. On the other hand, companies traded in the NYSE or in any other stock market in USA pertain to a wide range of efficiencies.

The interpretation of the analysis conducted and presented in Table 7, Table 10 and Table 11 are summarized and demonstrated in Table 12 to make the comparison of these three tables visual and easier to follow.

Table 12. Comparison of the Results in Table 6, Table 10 and Table 11

	Table 7	Table 10	Table 11	Table 11 US only	Table 11 TR only
Average efficiency	0.69	0.62	0.61	0.69	0.49
Efficient DMUs	19%	17%	17%	19%	13%
DMUs over average efficiency	46%	52%	50%	56%	39%
DMUs under the score of 0.50	22%	35%	33%	22%	52%
Minimum relative efficiency	0.26	0.19	0.12	0.23	0.12

When Table 11 is analyzed, the average efficiency of the international sample is found to be 0.61. Relatively efficient units constitute 17% the sample. Eight of these relatively efficient DMUs are US food and beverage companies and three are Turkish food and beverage companies. Average efficiency of US companies in the sample is 0.69. This average is 0.49 for the Turkish companies in the sample. Efficiencies of 56% of the US companies are over the average efficiency of the sample which is 0.61. This percentage is 39% for Turkish companies. 52% of Turkish companies score under the efficiency value of 0.50 whereas this percentage is 22% for US companies. Minimum relative efficiency calculated is 0.12 for Turkish companies and 0.23 for US companies.

The presented result is not unexpected. The USA is the global market leader in food and beverage industry; therefore US food and beverage companies are expected to outperform Turkish food and beverage companies. 11 DMUs are specified as efficient and 73% are US companies. US food and beverage companies outperform with respect to Turkish food and beverage companies. However, keeping in mind that the USA is the global leader in the food and beverage sector, the results are as expected and they support the model.

When results in Table 11 are compared to the results in Table 7 and Table 10, no significant difference is obtained between the efficiency scores of US food and beverage companies but significant differences are observed between the efficiency scores of Turkish food and beverage companies. In Table 7, Turkish companies have an average efficiency score of 0.62 which decreases to 0.49 in Table 11 whereas US food and beverage companies' average supply chain efficiency score remain the same as 0.69 in both Table 11 and Table 10. These differences can be explained by analyzing their reference sets assigned in the model output. DEA determines the benchmark or target DMUs for each inefficient DMU in order to give insight for improvement opportunities. These target DMUs are specified by their positions on the production possibility frontier. The closest DMUs to the maximum output level which can be achieved by the given inputs of the DMU, is determined to be the targets for that DMU. As a result, the efficiency score of a DMU and target DMUs are highly related to each other. When international and domestic benchmarking practices are compared, it is seen that US companies are assigned nearly the same targets and they have the same average efficiency of 0.69 both in Table 10 and in Table 11. On the other hand, target companies of Turkish companies are replaced with US companies in the international benchmarking practice. All Turkish

companies have at least one US benchmark company and a significant portion of them have TR 9 or TR 23 in their reference sets in addition to their US benchmarks. Having more efficient DMUs, which are US companies in this study, in the sample decreases the efficiency scores of Turkish companies. This statement is supported by the reference sets of Turkish companies. The average efficiency score of Turkish sample decreases from 0.62 to 0.49. Moreover, the minimum efficiency score of Turkish sample decreases from 0.19 to 0.12 in the international benchmarking run.

These results may imply that the Turkish food and beverage companies need to increase their supply chain efficiencies to be successful in their international trade activities. This comparison of the Turkish food and beverage companies with the global leader of the sector may give hints for managers to improve their supply chain networks and including their transportation ideas and inventory keeping techniques.

To sum up, although this study cannot be generalized to all industry fields, the selected methodology and the results of the implementations may aid future benchmarking analyses. It also draws attention to the possibility of supply chain benchmarking with only publicly available data.

CHAPTER VII

CONCLUSION

This thesis develops a systematic approach to measure and benchmark supply chain performance and implements it on Turkish food and beverage industry including national and international benchmarks. The presented study aims and realizes the following:

First of all, a methodology has been determined in order to measure and benchmark supply chain performances. The methodology also includes the related input-output variables of the selected model for benchmarking purposes and measuring the effects of the selected variables in the developed model by the sensitivity analyses performed. The thesis focuses on supply chain management because; global trade environment is more free and competitive today. International trade is more global than ever before. As a consequence, companies need a core competence to compete in global markets. Moreover, they need efficient supply chains to make the international commerce smoother and faster and hence to be more competitive in the global arena. All these force competition to take place at supply chain levels of companies.

The steps of the developed methodology are parallel to the benchmarking wheel of Andersen et al. (1999). In the plan phase of the methodology, DEA is selected as the benchmarking methodology along with the input and output supply chain performance measures. In the search phase, the industry and best practice companies of the sector, which are the Turkish food and beverage industry and determined. In the observe phase of the methodology, the criteria at which the best

practice companies are good is them inefficient are determined according to the efficient ones. In the analyze phase, gaps in the performances of inefficient DMUs are defined along with their causes. Finally, in the adapt phase, improvement suggestions are made for the inefficient companies by comparing them with their target national and international companies.

Secondly, this thesis implements the developed methodology on the Turkish food and beverage industry which is a promising industry that may have a positive influence on the Turkish economy. During the implementation phase, sensitivity analysis allows for testing the robustness of the results to different input output sets defined.

Thirdly, the benchmarking analysis is conducted by restricting the determined input-output variables to only publicly available data and so that the applicability of the developed tool could increase among practitioners in industry, shareholders in ISE and researchers in academic area. Moreover, by adding export to benchmark criteria, this thesis aims to show the link between supply chain management activities and international trade and to introduce export as a major criterion to be able to compete and survive in international trade environment.

Fourthly, an international analysis is conducted by benchmarking supply chains of the Turkish food and beverage companies with those in the USA which is accepted to be the global leader of the sector. This analysis provides managerial insights for Turkish companies to improve their supply chain performances in order to compete in global markets.

Finally, improvement opportunities for the Turkish food and beverage industry are discussed based on the findings.

In the implementation phase of the study, the systematic approach developed is used to evaluate the relative supply chain performances of food and beverage companies in Turkey. The relative performances of Turkish food and beverage companies are evaluated by using DEA methodology followed by a discussion of improvement opportunities for the sector. For this purpose, input and output variables that compose a comprehensive performance analysis set is compiled from the supply chain literature. The data comprising to these input output variables consists of both secondary and primary data. Presence of confidential data in the inputs and outputs of the model limits the number of companies benchmarked in regard of their supply chains stays. This comprehensive set could be applied to a limited number of companies in the Turkish food and beverages sector due to confidentiality and unavailability of data. Since the number of companies analyzed is limited and the ratio of the number of input and outputs to the number of DMUs is high, the computed relative supply chain efficiencies of the companies give a relatively high number of efficient companies.

Despite the limited data sample, the comprehensive input output variables set compiled in this study is a contribution. The variable set consists of employee number, total inventory, SCM costs, number of warehouses, number of ship to and ship from locations as inputs, on-time delivery rate and revenue as outputs. In addition to combining all three levels of supply chain which are source, make and deliver, also contains the variables that indicate the design of supply chain such as the number of warehouses, ship to and ship from locations. These variables determine the balance of supply chains in responsiveness-efficiency spectrum.

This variable set is expected to give more meaningful results that practitioners may benefit from, when applied to appropriate number of DMUs. So, the specified

input-output set gives opportunity to further research in supply chain management area.

Various sensitivity analyses conducted with these variables and the results obtained may aid practitioners in better decision making.

The analyses are also conducted with restricted number of variables that require only publicly available data. This facilitates applications for supply chain performance benchmarking at cross-industrial and international level. The variable set is extended to include profit and export as output variables. Export is found to increase supply chain efficiency scores of a high number of companies. Supporting the study of Greenaway, Sousa and Wakelin (2004), which presents that export is an indirect channel to increase productivity, this thesis reveals that export increases productivity of Turkish companies which may positively affect the overall Turkish economy.

For international benchmarking purposes which may create new improvement opportunities, the Turkish food and beverage industry is benchmarked with the US food and beverage industry who is the global leader. As expected, US companies are found to outperform Turkish companies to some extend. The results of the international benchmarking serves as a further improvement opportunity for the sector. Obtaining expected results strengthen the validity of the input-output variable set.

Another support for the validation of the variable set can be the reference set of inefficient DMUs. DMUs that are determined as relatively efficient are all found in the reference sets of inefficient DMUs. If a DMU is a part of many reference sets than it is a good performer and shows true efficient performance (Boussofiane et al., 1991), and efficient DMUs that are seldom found in reference sets of inefficient

DMUs are probably not true efficient performers (Ramanathan, 2003 as cited in Reiner and Hofmann, 2006). Since all of the relatively efficient DMUs are found in reference sets of many inefficient DMUs, these efficient DMUs are true efficient performers and this might further validates the results and hence the input output set developed.

To conclude, Turkey is a developing country which can achieve sustainable economic development through improvements in productivity and increase in export. The food and beverage sector in Turkey is a promising sector in terms of its export potential and Turkey's competitive advantage in global markets in agricultural production. Supply chain management is a critical issue that may enhance international trade opportunities and volumes. It is also a crucial factor in a company's operational and financial productivity and export performance. Literature consists of methodologies for supply chain performance evaluation which are hardly applicable due to company confidential data requirements. Keeping these facts in mind, this study aims to develop a supply chain benchmarking methodology that is also implemented on the Turkish food and beverage sector in order to improve performances of companies by uncovering the inefficiencies in their supply chains.

Finally, this study proposes a comprehensive input-output set to assess supply chain performances of food and beverage companies. Utilizing an input output variable set that consists of publicly available data to benchmark supply chain performance and implementing the approach on food and beverage companies, this thesis may open new analysis and improvement paths. As a second contribution, this study fills a gap by benchmarking the supply chain performances of Turkish food and beverage companies nationally and internationally. Moreover, this study uses export in addition to profit and revenue as an output variable to determine supply

chain performance in DEA context. Using export as a performance benchmark criterion shows managers, investors and researchers that international trade can be effective in benchmarking and improving performances of companies.

The following suggestions can be made for further studies.

The developed comprehensive input-output set can be applied to a large number of food and beverage companies in Turkey including the ones that are not traded in ISE, by collecting data via questionnaires. This would make it possible to generalize the findings for the industry with a high confidence level.

The developed supply chain methodology and the compiled measurement set can be applied to all the companies traded in ISE with the accompanying sensitivity analyses in order to evaluate supply chain efficiencies of different sectors in Turkey.

Finally, a longitudinal study can be conducted by utilizing Malmquist index DEA model with publicly available data. By performing a longitudinal study company as well as sector performances can be traced. This implementation would make it easier and more comprehensive to relate the changes in supply chain efficiencies to macro criteria such as international trade.

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