Strategic Improvement of Quality of Global Sourcing in Unstable Environments

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Abstract

Global sourcing, regarded by many companies as an important measure to enhance competitive advantages particularly in today's "globalized economy", faces challenges related to the management of supply chains across large geographical distances between suppliers and markets. This paper examines a number of practical issues and suggests general strategies to attain the best quality of global sourcing based on methods consisting of mixed sourcing strategies, implementation of appropriate technology, and supplier selection and management. Two common but contrasting industries, the apparel industry and food industry, are first used to illustrate in detail various ways to achieve global sourcing practices despite different inherent products characteristics. A general guideline with general applicability is then developed, with emphasis on several particular aspects: First, any mixed sourcing strategy should be built on product and industry characteristics. Secondly, categorization of products according to the main uncertainty that exists in the supply chain is a desirable way to reduce or avoid problems associated with global sourcing. Thirdly, global sourcing is value-adding only if it could enlarge the competitive advantages of products. Finally, these three aspects are inter-related and should always be considered in totality for evaluation and implementation.

Keywords: global sourcing; mixed sourcing; supply chain management; quality management, apparel industry; food industry.

Introduction

Global sourcing implies either offshore production, or purchasing components or finished goods worldwide (Kotabe and Murray, 1990). The most recognized preliminary motivation for global sourcing is the reduction of unit production cost. Better product quality and availability of resources are also perceived to be important rationale behind global sourcing (Holweg, *et al*, 2011).

Despite the possible advantages of global sourcing, it complicates the management of supply chain due to the lack of buyer-supplier proximity. Moreover, supply and demand uncertainties bring in more challenges for the management of global supply chain. Consequently, long lead time and large inventory levels have been regarded as the most two prominent problems faced by companies (Golini and Kalchschmidt, 2011; Holweg *et al*, 2011).

In view of the above, the study reported in this paper aims to bring up approaches that, in their efforts to improve quality of their decisions and operations, global sourcing companies can take to overcome the difficulties and improve the chances of maximizing the potential benefits of global sourcing.

Background of study

Since the characteristics of products vary across different industries, risks and uncertainties arisen from global sourcing may be different, as well as the response strategies. Hence two different industries are used for illustrations. Comparisons and evaluation of optimization methods will then be brought up and, based on examples, suggestions with respect to application of methods in general are subsequently discussed.

Global Sourcing

A number of research studies have been carried out in the past to assess the impacts of global sourcing. A brief review of global sourcing is given here, including the common rationale as well as the benefits and challenges associated with it.

Global Sourcing Rationale

It has been acknowledged by most researchers that unit cost reduction is the primal motivation for global sourcing (Nassimbeni, 2006). Furthermore, access to better quality of goods and availability of sources in foreign markets are also regarded as important justifications for global sourcing (Holweg *et al.*, 2011).

Challenges of Global Sourcing

Despite the perceived benefits of global sourcing, challenges faced by companies engaged in global sourcing should not be overlooked. Long lead time and large inventory level are the most two significant problems faced by companies engaging in global sourcing (Jin, 2004). Furthermore, secondary effects of global sourcing could occur, such as increasing overall costs and decreasing service levels if those challenges are not satisfactorily managed.

Long Lead Time

There are many reasons for long lead times. Geographical distances often complicate supply chain management and exaggerate the impacts of uncertainties at either the demand or supply end. Compared with domestic sourcing, the lead time of global sourcing is usually much longer (Jin, 2005). Furthermore, custom clearance issues, as well as possible social or economic instability, may also prolong the expected lead time. Additionally, the lack of manufacturing technology and skills in a developing country would extend the production cycle time, thereby increasing the lead time. (Cho and Kang, 2000).

Large Inventory Level

The large inventory level is partially a result of long lead time. A larger safety stock level tends to be kept to prevent the uncertainty arising from lead time, which in turn raises inventory costs. Additionally, for those products with high uncertainty of demand, excess inventory is kept due to inaccurate or uncertain demand forecasts (Ho, 1992). From time to time, miscommunication between supplier and retailers could also result in unnecessary inventory.

Likely outcome

In short, long lead time and large inventory level are the most recognized disadvantages of global sourcing and are encountered by virtually all global sourcing companies in different industries. Long lead time is likely to decrease customer service level in terms of on-time delivery rate and fulfilment of customer demands. Large inventory is clearly undesirable for products with short shelf life. Those secondary effects are undesirable for any type of companies.

In general, the overall cost may eventually increase due to additional dynamic and hidden costs. Holweg, *et al* (2011) separated costs into three categories: Static, Dynamic and Hidden. Static cost includes all costs that are manageable and predictable such as production cost and logistics cost. Dynamic cost is additional cost incurred by demand or supply uncertainties. Hidden cost is the one related to macro-environment elements such as inflation of labour wage. Therefore, before launching into global sourcing for the sake of cost reduction, companies would better assess whether the expected savings from static costs could justify additional dynamic and hidden costs incurred by global sourcing.

Responses

Long geographic distance between suppliers and market is the key reason for long lead time and large inventory levels. In addition, inherent demand and supply uncertainties existing in different industries further aggravate these problems. Some approaches that can be taken to overcome such challenges are as follows.

Mixed Sourcing Strategy

A company could implement a flexible mixed sourcing strategy; in other words, carefully decide on the proportion of global sourcing and domestic sourcing to make them complementary, given different product and industry characteristics and perceived competitive advantages.

The mixed sourcing strategy allows a company to seek a balance between global sourcing and domestic sourcing. Ideally, with a well formulated strategy, the potential benefits of global sourcing can be maximized without compromising agility or flexibility (Jin, 2004)

Implementation of technology

Information Technology or IT has been well recognized as an essential tool for the efficient management of supply chains since it functions as bridge between upstream and downstream (Jin & Kang, 2013), thereby facilitate communication between different parties along a supply chain. In fact Chandra and Kumar (2001) argued that IT is the key element for fast reactions. Generally speaking, IT allows supply chains to achieve agility (Gunasekaran and Ngai, 2004), also to reduce uncertainty, lead time and inventory level (Levary, 2001; Srinivasan, *et al*, 1994) and to facilitate information sharing among networked members.

Other technologies such as those of manufacturing are perceived to be beneficial in terms of shortened production cycle time, product quality enhancement and labour cost reduction. However, the utilization and the need for advanced manufacturing technology differ in different industries. Generally, savings from labour cost would constitute the key driver for most of global sourcing companies. The high costs associated with introducing advanced technology may reduce the attraction for global sourcing to a certain extent. Therefore a company's sourcing strategy is indeed closely related to the extent of utilization of technology.

Supplier Selection and Management

The selection of supplier is of great importance to global sourcing firms as it is directly linked to the level of supply uncertainty. Based on previous research findings, linear programming is most commonly used in practice, with appropriate cost minimization as the objective function (Chan and Chan, 2010). Nevertheless such methods can only deal with quantifiable criteria and would fail to take the various encountered qualitative criteria into consideration (Ghodsypour and O'Brien, 1998). Chan and Chan (2010) proposed the Analytical Hierarchy Process (AHP) as an effective way to evaluate suppliers as it is capable of handling a multitude of criteria simultaneously, with

determination of the priority for each criterion as well. In this way the AHP provides a way to balance the various criteria and chose a rational alternative.

Illustration I: Global sourcing in Apparel Industry
Characteristics of Apparel Industry
The apparel industry is a buyer-driven industry with high demand uncertainty and variety. The most common approach adopted is lean retailing, which requires fast, small replenishment in order to satisfy quick changes of customer demand (Jin, 2004). Agility is the crucial factor in the world of lean retailing. This is particularly essential in the apparel industry due to the short shelf life of fashionable items (Chan and Chan, 2010).

It is noted that the stock keeping unit or SKU is the most detailed description of colour, fabric, size, style and so on (Jin, 2004). It is estimated that the average number of SKUs in a US apparel company is around 15000 (Abernathy *et al*, 1999). In addition, the apparel industry is labour-intensive. The intricate nature of sewing and cutting requires more labour involvement and the level of automation is low (Jin, 2004). Thus most of apparel companies prefer to outsource its manufacturing phase to developing countries with the intention of saving costs through cheap labour.

Uncertainties and Challenges of global sourcing in apparel industry
It is difficult to forecast demand due to the large variety of apparel items and fast and often unpredictable changes of fashion trends. Inaccurate demand forecasts compound the impacts of long lead time and large inventory, resulting in increased chances of product stock-out or overstocking, as a lengthened supply chain decreases its flexibility.

For companies producing high fashion goods, the cost of lost sales due to long lead time could be far beyond the savings from production cost, especially for luxury goods with high margin profits. Also, it is undesirable to keep a large inventory of fashionable items since once the season passes, the remaining inventory may be difficult to be sold without a large discount or markdown.

Apart from cost reduction, brand and quality are usually perceived to be competitive advantages of apparel companies and some customers are more willing to pay for apparel items with high-quality and sound brand name instead of cheaper price (Cho and Kang, 2001). When outsourcing the entire production phase to overseas, the quality of product could be in doubt especially in a situation where the company aims to save costs by manufacturing in developing countries where skills and infrastructure are inevitabl lacking.

Optimizing strategy
Mixed Sourcing
Jin (2004) stated that apparel companies need to balance domestic sourcing and global sourcing to achieve supply chain agility and cost reduction simultaneously. Fisher (1997) suggested that products could be grouped into Functional Products and Innovative Products according to different demand patterns which could be obtained by calculating coefficient of variation (CV) based on the product's weekly demand (Abernathy *et al*, 1999). It has been agreed by researchers that items with CV falling between 0.4 and 0.6 are the most predictable (Abernathy, *et al.*, 1999). Generally speaking, functional products are characterized by predictable demand trends and small demand variety with more than two years shelf life. In contrast, innovative products are those with unpredictable demand, high product variety and short shelf life.

Fisher's proposal could be utilized to balance domestic and global sourcing in the apparel industry since the most recognized benefit of global sourcing is production cost reduction, but the lead time for domestic sourcing firms is only half of that for global sourcing firms (Jin, 2005). Moreover, the performance of domestic sourcing firms is much better in terms of on-time delivery and quick response to fast changing fashion markets (Cho and Kang, 2000). Therefore it would be beneficial for apparel companies to source innovative products domestically and outsource functional parts to foreign suppliers. More specifically, innovate products in the context of apparel industry may be referred to high-fashion goods whereas functional parts are basic items. In the company ZARA, items with style variation are sourced from firms in nearer countries such as Morocco and Bulgaria to maintain agility, while basic items such as socks are sourced from China, Sri Lanka and India (Tokatli, 2007). At World Company, a Japanese apparel manufacturer, basic styles are produced in low-cost Chinese plants while high-fashion styles are sourced domestically (Fisher, 1997).

On top of outsourcing the entire production phase to foreign countries, the proportion of global sourcing and domestic sourcing could be based on the contribution of labour work to each phase (Jin, 2004). For example, as assembly and press-iron are the most labour intensive phases, it is rational to reallocate these phases to developing countries with lower labour cost (Bolisani and Scarso, 1996). Since the design of apparel items is directly links to factors such as sales volume, intellectual property and company reputation, in-house design is often encouraged. For example, Benetton only outsources assembly parts to manufacturers from Latin America, Turkey and Tunisia, with the rest production finished in-house so as to maintain agility, product quality and brand reputation (Bolisani and Scarso, 1996).

Implementation of Technology
High demand uncertainty, fast trends, management of numerous stocking units (SKU) within a season, and the practice of lean retailing require the most advanced IT to coordinate activities along the supply chain (Jin and Kang, 2013). The application of IT was found to introduce flexibility into a supply chain in terms of quicker response to meet rapid changes in the market (Stylios, 1996).

As apparel manufacturers have to predict demand and replenish products based on accurate information of actual sales, the adoption of barcode scanning appears to be one of the most cost-effective ways to achieve it. Barcode is also an indispensable hardware required for the implementation of Point-Of-Sale (POS) system, which enhances the accuracy of demand forecasting.

Electronic data interchange (EDI) replaces the paper transactions and provides faster transmission of large amounts of information with far greater accuracy (see, for example, Abernathy, et *al.*, 1999). Greater and faster information transmission between retailers and manufactures could shorten the lead time and cut the inventory level by reducing human errors. Unfortunately, EDI has not been as popular as barcodes; for example only 6.6% of apparel firms in South Korea used it for communication with partners (Chun and Hur, 2002).

Radio Frequency Identification (RFID) is another technology becoming increasingly popular for supply chain management owing to its ability to identify and track information throughout a supply chain. The use of RFID could effectively share precise product information among suppliers, manufacturers, distributors and retailers, which in return may cut ordering lead time, inventory cost, as well as reduce stock-outs thanks to enhanced inventory visibility (Zhu, *et al.*, 2012). US apparel companies such as GAP, Calvin Klein and American Apparel have adopted RFID in smart shelves at the POS level to improve supply chain operation performance (Zhu, *et al.*, 2012). Also,

Gaudin (2008) stated that consumer demand trends and probabilistic demand pattern could be generated by the use of RFID at POS level. This is extremely valuable to apparel companies, as sourcing strategy, order quantity and order frequency are dependent on demand forecasting given the buyer-driven feature of apparel industry. Furthermore, large inventory and lead time holding by global sourcing companies are partially due to inaccurate demand forecasting. These two problems could be alleviated as a result of proper usage of RFID at the POS level; however, the main concern for the use of RFID is its high installation cost.

The integration of information technologies into supply chain is not only aimed to facilitate information sharing and enhance accuracy of demand forecasting, but also support other executive operations.

MRP, MRPII, ERP are common systems adopted by apparel companies to initiate a production plan, schedule shipments or replenishments, and monitor inventory levels. However, they require users to specify clearly the lead time of each component and its production cycle time. It is difficult for apparel companies to achieve this due to increased logistics uncertainty in the global sourcing (Cho and Kang, 2000). Hence information technologies are expected to provide more accurate inputs so as to ensure the efficacy of those planning systems.

Supplier Selection and Management

With reference to previous studies on selection criteria of suppliers, cost was the top concern for global sourcing apparel firms in selecting suppliers (Birou and Fawcett, 1993; Bozarth, *et al.*, 1998; Monczka and Trent, 1991). For different categories of products, test of hypothesis (*t*-test) results by Jin and Farr (2010) showed that cost was the top priority while selecting suppliers for basic items; this was followed by lead time and quality. By comparison, lead time was the most vital for sourcing fashion items, with subsequent criteria being cost and quality. It implies therefore that the selection criteria of suppliers should also be different depending on the classification or category of each item (Jin and Farr, 2010).

While selecting the sourcing country, factors such as labour availability, proximity to market and cultural similarity shall be taken into consideration by the top management commitment (Jin and Farr, 2010). Since reliability and capability of foreign suppliers are directly linked to the delivery time, product quality and customer service (Vedel and Ellegaard, 2013), the selection process has to be carried out carefully, and the multiple-step approach of analytical hierarchy process (AHP) can be used here.

Integration of optimization methods

To manage the global supply chain effectively, the three methods above must be considered as a whole and be integrated since they are inter-related.

First, the supplier selection criteria would vary with characteristics and competitive advantages identified at the stage of product categorization in the mixed sourcing strategy. Thus it should be attached to and supports the mixed sourcing strategy.

Secondly, any demand characteristic, the criteria for product categorization in mixed sourcing strategy, is based on information generated and gathered by information technologies at the retailers. Therefore the implementation of mixed sourcing strategy is impossible without fast and accurate information sharing.

Lastly, the application of advanced technology also enhances the firm's control of suppliers in areas of inventory management and product quality, facilitating the transmission of information along the supply chain.

Illustration II: Global Sourcing in Food Industry
Characteristics of Food Industry
Customer's demand for the availability of fresh food throughout the year promotes the practice of global sourcing in the food industry (Chaudhuri, *et al.*, 2014). At the same time, as the quality and price of food differ considerably at various locations, global sourcing is regarded as a way to enhance the competitive competitiveness of the food company.

Unlike the apparel industry, the global sourcing trend in food industry is largely motivated by the availability of resources in foreign markets besides the attractiveness of cost levels. On top of the availability of resources and lower price, food quality is receiving increasingly attention after revelations of food safety problems from time to time.

Lastly, the price and quality of final food products are largely determined by the cost and quality of required raw material, given that the bulk of global sourcing practices in the food industry is raw material purchasing.

Uncertainties and challenges of global sourcing in food industry
The most important and prominent characteristics of food is perishability. Owing to the short shelf life of some foods like fruits and vegetables, long lead time and large inventory level would inevitably impact the freshness and quantity of food sourced from global suppliers (Chaudhuri, *et al.*, 2014). Obsolete food is also regarded as food waste, and approximately 40 to 50 percent of all root crops, fruits, and vegetables are wasted annually (Gustavsson, *et al.*, 2011). Therefore the storage and inventory management of perishable food are vital in the prevention of food waste.

Apart from food waste, the high-profile food safety issue should not be neglected. For example, spices in India had been found to contain prohibited food colorants and excessive pesticide residues (Chen, *et al.*, 2013). If food is sourced or produced from countries with less stringent sanitation and safety standards, the risk of product contamination can be expected to be higher (Whipple, Voss and Closs, 2009). Such unfavorable events would be detrimental to a company's reputation and brand equity, and the consequent cost of recovery is usually enormous (Whipple, *et al*, 2009).

Another challenge is agility of the supply chain. Food is categorized as fast consumer goods that require fast replenishments. However, the yield of agri-food is closely related to environmental condition. The occurrence of natural disaster would greatly reduce the food yield and consequently increase the likelihood of product stock-out. Even the processor or retailer could keep extra inventory to avoid the risk of stock out, besides the increased inventory cost, perishability of food would only allow them to only keep a certain amount of inventory which sometimes would still fail to fulfil customer demands.

Thus most of the uncertainties are from the supply side, and supply quality, quantity and lead time are identified as top concerns of a food company (Chaudhuri *et al*, 2014). It is therefore essential to select suppliers and build relationships of mutual benefit with them to minimize such supply uncertainties.

Optimizing strategy
Mixed Sourcing
Unlike apparel items, demand patterns for food products regardless of functional or innovative goods are quite stable in terms of sales data, which obscures the boundary between functional and innovative products. Moreover, since price and quality of final food products are greatly determined by the use of raw material, global sourcing of raw material in the food industry is more commonly practiced.

The categorization of food as raw material could follow a two-step mode. Firstly the company should look at the availability of raw material in the domestic market; if it is totally devoid of the required raw material, global sourcing will be the only way to gain access to it. However, if the local market has plenty of resources, a balance needs to be achieved between domestic and global sourcing.

Uncertainties of supply quality could be the way to categorize raw material. High uncertainty of supply quality refers to raw materials with short shelf life, those that exhibit high contamination risk and dependent on environment condition, for instance seafood and milk (Chaudhuri *et al*, 2014). For those kinds of raw materials, it would be better to source domestically since long lead time of global sourcing makes it hard to guarantee the quality without the installation of temperature control technologies, which in turn increases the uncertainty of supply quantity due to the high likelihood of deterioration. In such a situation, keeping a large inventory is perceived to be an undesirable approach to buffering against supply uncertainty, as the average shelf life is short and there the possibility of inducing more food waste. In contrast, raw material with low uncertainty of supply quality such as wheat and rice could be purchased from overseas for the reason of better quality and lower price.

This mixed sourcing plan built on the uncertainty of raw material quality is of particular interest in food industry since perishability is the most prominent characteristic of food. On top of the ability of the plan to reduce the negative impacts of global sourcing, the plan could help a company to enhance its competitive edge. The raw material with high uncertainty of supply quality is usually processed into food products with higher nutrition value to satisfy customers' demand for healthier eating (Jackson, 2010). Raw material with low quality uncertainty such as wheat are mainly made into products that are intended to meet customer's daily demand exemplified by bread and oil, which contains lower nutritional value and are not differentiable in terms of quality or taste but price. Hence, global sourcing of basic raw material could help the company to provide basic food products with lower price than competitors while domestic sourcing of more advanced raw material is able to ensure the high quality and in-time supply of food products.

The implementation of technology

The implementation of information technology along the food supply chain is imperative especially in in terms of the function to monitor food quality and quantity. A study of US food industry indicated that more than $30 billion was wasted annually due to the lack of coordination among the supply chains (Fisher, 1997). The use of barcode scanning and EDI are still important in food industry for reasons of demand forecasting and faster transmission of information. The application of RFID in food industry has received increasingly attention in the recent years and several studies indicated that the enhanced inventory visibility and product traceability along the food supply chain could greatly reduce food waste and ensure supply quantity (Zhu, *et al*, 2012).

Other than the use of technology for information sharing, technologies adopted to ensure food quality along with transportation is of particular interest in food industry due to perishability issues. Food packaging is a useful way to protect food from contamination or spoilage. Innovative packaging such as modified atmosphere and oxygen scavengers are capable of preventing spoilage and prolonging the shelf life of food. Therefore, those kinds of food packaging technologies are vital especially in the transmission of food with high uncertainty of supply quality from overseas. Except for food packaging, refrigerated container, trucks and warehouse are regarded as indispensable for the transportation of perishable food from overseas with long geography distance..

In summary, there are two types of technologies suggested to be used in the management of global food supply chain. The purpose of the application of information technologies is similar to the situation in the apparel industry, which is to realize information sharing along the supply chain and accurate demand forecasting. Food packaging and temperature control technologies are more specific in food industry since they are mainly used to maintain food quality and extend the shelf life.

Supplier selection and management

Supplier selection still follows a multi-step strategy by adopting AHP analysis, from the selection of sourcing countries to suppliers. The additional criteria added to the selection of sourcing country should be the environmental condition since food such as milk, fruits and vegetables are vulnerable to contamination from external environment; the percentage assigned to environmental condition should be higher than others as it is closely related to food security, quality and quantity. For the selection of suppliers, depending on the type of raw material sourced, selection criteria and corresponding global weight assigned to each criterion could vary; details of such considerations would vary from case to case.

In addition to using AHP to select suppliers, it is necessary for a company to build a comprehensive supplier network so as to reduce supply uncertainties in terms of quality, quantity and lead time. The dynamic allocation of order quantities to dispersed suppliers could spread supply risks and help the company gain access to raw material with high quality but lower price (Jain *et al*, 2014), and mutual beneficial relationships need to be built with suppliers so as to forge sustainable and strategic partnerships.

Except having contracts with suppliers and keeping a portfolio for each suppler, continuous audit against the company's specification is essential as the supply of raw material directly affects the quality of the final product. The implementation of Statistical Process Control (SPC) including sampling tests, quality control charts at processor levels for quality and quantity evaluation could play an important role from the point of view of supplier management and assessment (Dalgic *et al*, 2011)

Integration of Optimized Approaches

The proposal of sourcing raw material with high uncertainty of supply quality domestically, and sourcing those with low supply uncertainty overseas, aims to balance domestic and global sourcing modes and simultaneously help a company gain competitive advantages. However, the use of technologies during transportation could sometimes be used to reduce quality uncertainty. For example, if the company has a well-established information system and has invested in new food packaging and transportation technologies, global sourcing could take a larger percentage. However, the company has to carefully calculate whether the cost for investing in technologies could be compensated by savings or benefits arisen from global sourcing. In other words, cost-effective analysis including AHP should be performed if it has sufficient data together with time for its analysis.

Generalization

Two types of industry have been used in this paper to illustrate the uncertainties facing businesses and possible methods for securing benefits from global sourcing. This part would firstly draw a comparison of these two industries, followed by some generalized conclusion.

Comparison of Apparel Industry and Food Industry

Table 1 displays a comparison of apparel industry and food industry. These two industries are distinct in several aspects.

Although both industries are active in global sourcing, apparel companies mainly focus on offshore production or global procurement of finished goods whereas

the majority of food companies source raw material from foreign markets for further processing.

The reasons behind these differences are firstly due to the automation level at the manufacturing phase. The manufacturing procedures for apparel items are very labour intensive while the processing phase of a typical food product is highly automated. Therefore, offshore production in developing countries with cheap labour could save considerable costs for apparel companies. However, raw material plays an important role in the determination of quality and value of final product in food industry. Furthermore, quality and price of food raw material could differ substantially from place to place but these differences are not significant in the apparel industry.

Another reason is the different amounts of value-added in a supply chain. For apparel items, the value of the final product is mostly determined by design, sewing, clipping, with raw material accounting only a small percentage. In contrast, the most value-added portion for food product is its raw material. In other words, since global sourcing could be adopted as a way for a company to enhance its perceived competitiveness, companies should fully exploit the advantages of global sourcing to improve their most value-adding chain.

Although both industries face long lead time and large inventory problems arising from global sourcing, the main uncertainties identified in the supply chains are different. It is difficult to predict accurate demands of fashionable items owing to the demands' large variety, subjectivity as well as fast-changing fashion trends. Fast replenishment of in trend items is essential to maintaining customer service and satisfaction level. In food industry, variations of supply quality and quantity are sources of uncertainties. In addition, due to seasonality, supply lead time could vary considerably. On the other hand, the demand pattern for food is more stable.

With respect to overall optimization, in addition to the implementation of information technologies, technologies used for temperature control, for example, during transmission are of particular concern in food industry due to perishability. Moreover, since food is closely related to consumer health, food recalls will not only cause large amounts of loss but also damaged reputation. Safety related factors such as environment conditions must be monitored or investigated carefully, and the management of supplier in food industry is usually more demanding.

For an apparel company, the mixed sourcing strategy aims to balance domestic and global sourcing with the purpose of minimizing costs while maintaining supply chain agility as well as quality of innovative goods. To some extent this is also the objective sought by a food company. However, the most significant difference is the categorization of items. Apparel items are classified according to demand patterns, but food is categorized by uncertainty of supply quality: both categorization criteria are rooted in the type of uncertainty faced by each industry.

Table 1. *Comparison of apparel industry and food industry*

	Apparel Industry	**Food Industry**
Product Characteristics	Large variety and Seasonality	Perishability, Environment dependent and Seasonality
Manufacture/Processing Characteristics	Labour intensive	High level of automation
Value-Added chain	Production phase	Procurement of raw material

Main Uncertainties	Demand uncertainty Difficult to forecast demand	Supply Uncertainty – Supply quality, Supply quantity and Supply lead time
Global sourcing area	Service/Offshore Production/Finished goods	Raw material
Competitive advantages	Design, Brand, Price, Quality, Fast replenishment of products in season	Quality/Safety, price, flavor, fast replenishment
Mixed sourcing strategy	Based on demand pattern – Fisher theory	Based on uncertainty of supply
Implementation of Technology	Information Technology	Information Technology Food packaging Temperature control during transportation
Supplier selection and management	Depending on category of products.	Depending on category of products, but safety(quality) should always be the priority
Location of global sourcing companies/local market	Developed Countries	Both developing and developed countries

General principles

Industry characteristics include the level of labour involvement at the production phase, inherent characteristics of product and the value-added chain for the final product. A company can decide whether to globally source services or raw material. Generally, if the production phase is labour-intensive, a company would be more interested in global sourcing since it could lower the production cost to a large extent. In contrast, if the level of automation is high, the value of raw material would dominate the value of final product in which case global sourcing of raw material could appear more attractive. Some companies from high technology industries could be interested in global sourcing of both raw material and service as they contribute evenly to the final value of the products.

It may be argued, however, that global sourcing is a double-edged sword. Apart from benefits associated with it, long lead time and large inventory level are incurred due to enlarged demand or supply uncertainties and, consequently, challenges could arise from these two problems in various ways in different industries and for different products.

Thus, to maximize potential benefits of global sourcing, categorization of sourcing items according to main uncertainty is an effective way to reduce or avoid drawbacks caused by global sourcing. After that, the determination of sourcing allocation depends on perceived competitive advantages of products from different categories.

The types of technologies used in different industries vary except for information technology, which is mandatory for all industries. The use of other technologies should depend on the industry type and product characteristic, as well as its capability in solving drawbacks of global sourcing. For supplier selection, it should always be consistent with mixed sourcing strategy with weights assigned to different criteria according to competitive advantages perceived by the company. In any case, the mixed sourcing strategy, implementation of technology and supplier selection and

management should always be performed and evaluated as a whole since they are complementary considerations.

Conclusions

This study provides a framework of approaches that could potentially optimize the supply chain of global sourcing companies in the face of uncertainties.

Within this framework, the mixed sourcing strategy could assist managers to properly plan the proportion of domestic and global sourcing through product categorization, thereby maximizing profits when a balance between global and domestic souring is achieved. The implementation of technologies facilitates information sharing and reduces uncertainties encountered in the global supply chain. Supplier selection and management would enable a company to select suppliers based on specific requirements and keep a close eye on supplier performance.

Although none of these methods are new separately, all the optimization methods in this study are suggested in a manner to best serve the interests of companies according to product and industry characteristics. This is a point brought up via the analyses of two different industries, leading to the general guideline.

The study has certain limitations. For example, optimization methods are mentioned qualitatively. In fact elaborate analytics would be necessary to maximize the benefits of global sourcing, especially for the implementation of technologies based on rigorous cost-effectiveness analysis. Moreover, the uncertainties discussed in this report are limited to only supply and demand; in the context of global sourcing, uncertainties from macro-environments such as those of political, social or financial nature are could also be of considerable consequence. For example, inflation of labour cost, trade policy and exchange rate are external uncertainties that add difficulties to the management of global supply chain. Thus more comprehensive studies with elaborate mathematical models are possible for more specific cases in specific circumstances.

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