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Assessing consequences of low-cost sourcing in China

Anna Fredriksson and Patrik Jonsson
Chalmers University of Technology
Gothenburg, Sweden
E-mails: anna.fredriksson@chalmers.se; patrik.jonsson@chalmers.se

ABSTRACT

Purpose: The objective of the paper is to develop a framework for low-cost sourcing assessment and to explore the consequences of low-cost sourcing in China for a European manufacturer.

Design/methodology/approach: The low-cost sourcing framework generated from literature and the consequence analysis is based on a case study of a European company that has outsourced part of its casting processes to Chinese suppliers.

Findings: Characteristics of low-cost sourcing were based on a literature review divided into three categories: country characteristics, supply network structure and supply network relationships and the case study showed that these three categories of characteristics jointly created negative effects. A two-directional cause and effect relationship was proposed between the characteristics and the operational supply chain performances. The presented low-cost sourcing assessment framework should be a good starting point for low-cost sourcing assessment, including mapping a firm's total characteristics, and for analysing their performance impact.

Research limitations/implications: The conducted single case study is not enough for identifying, formulating and validating all existing relationships between the low-cost sourcing characteristics. The present study has identified the existence of the relationships but has not evaluated their levels of impact.

Practical implications: Managers should be aware of how suppliers in low-cost countries may affect the structures, relations and operational supply chain performances of the supply network. This paper presents a sourcing assessment framework enabling describing what dimensions of the sourcing characteristics would be affected by sourcing to a specific area of the world and what consequences and performance effects this would have.

Originality/value: Few prior studies have focused on companies with already established relationships with low-cost-country suppliers and how these companies should make the best out of these supply chains. This study takes a holistic perspective on low-cost sourcing and identifies several streams for further research.

Key words: low-cost sourcing, China, sourcing assessment, supply chain, performance effects

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INTRODUCTION

Outsourcing to China and other low-cost countries is common among European and North American companies today. Firms outsource to achieve positive effects in a number of areas. Desired benefits of outsourcing include enhanced effectiveness, increased flexibility, improved operating performances, reduced investments, market access and reduced costs (Greaver, 1999). Outsourcing to low-cost countries is often an attempt to gain large cost savings as a result of differences in wages and prices.

It is important not to assume that low-cost-country sourcing is simply low-labour-cost-country sourcing, since all associated costs of sourcing should be taken into account (Nelson and Sisk, 2005). Several companies have taken high-level decisions to source a minimum proportion of the total purchasing value in low-cost countries (Fredriksson and Medbo, 2006), which often means that the companies source to achieve budget goals. For these companies, the issue is not to carry out thorough make-or-buy and risk analyses in order to decide whether to outsource or not; rather it is to understand how to make the best out of low-cost-country supply chains. Nevertheless, outsourcing production to low-cost countries is likely to negatively affect one or more competitive priorities (Rudberg and Olhager, 2003).

Characteristics of low-cost-country supply chains such as long geographic distances, increased delivery times, and decreased delivery precision may increase costs in terms of expedited freight, unfulfilled demands, extra inventory and managerial time spent on “fire-fighting” (Levy, 1995). The long distances and delivery times reduce flexibility: to achieve the necessary flexibility, companies need to increase inventories or have a second source locally. Differences in culture, language, practices and time zones also diminish the effectiveness of business processes such as demand forecasting and material planning, increasing the transaction and governance cost of material supply (Levy, 1995; Mattsson, 2002; Meixell and Gargeya, 2005; Mol *et al.*, 2005; Brannemo, 2006). Consequently, characteristics of low-cost-country supply chains may affect the performance of logistics and thereby decrease the sought-after positive effects of outsourcing, such as cost savings.

Several studies describe what factors to consider before making outsourcing decisions (e.g. MacCarthy and Atthirawong, 2003), how to make outsourcing decisions (e.g. McIvor, 2000) and the risks of sourcing from low-cost countries (e.g. Cavinato, 2004). However, few studies focus on already established relationships between European or North American companies and low-cost-country suppliers and how these experiences can be utilized to improve sourcing from low-cost countries for followers. It is therefore of importance to develop sourcing assessment frameworks based on experiences made by companies already operating low-cost supply chains.

The objective of this paper is to develop a framework for low-cost sourcing assessment and to explore the consequences of low-cost sourcing in China for a European manufacturer. The analysis is based on a case study of a European company that has outsourced part of its casting processes to Chinese suppliers. Casting goods are quite standardised and mature items, physically non-sensitive to transport and have a low value. However, casting goods put some very specific requirements on the supply chain depending on their physical characteristics and how they are produced. Casting goods are in most cases volumous items and normally transported by sea. Quality defects are sometimes only discovered after processing and the scrap rates are often quite high compared to other items. A casting supply chain should therefore be a relevant study object here. The focus is on the effect on the so called operational

supply chain performance variables in the case and the prerequisites for them rather than on costs.

The paper begins with a literature review that generates a framework of the characteristics of low-cost sourcing, structured as sourcing country characteristics, supply network structure characteristics and supply network relationships characteristics. This is followed by a description of the data collection method and a case description. The paper ends with an analysis and presentation of a practical framework for low-cost sourcing assessment.

A SOURCING ASSESSMENT FRAMEWORK

Sourcing decisions aim at establishing and managing supply networks by evaluating characteristics, factors or criteria like supplier quality consciousness, cost potential, reliability of delivery, innovativeness and geographical location (Momme, 2002). Different authors make use of different terms for these characteristics, factors, considerations and criteria: Schniederjans and Zuckweiler (2004) call them outsourcing risk issues, Momme and Hvolby (2002) call them operational and tactic considerations and MacCarthy and Attirawong (2003) call them factors. In this paper, the term "sourcing characteristics" is used to denote these characteristics, factors, considerations, risks and criteria by which decision makers evaluate the effects of sourcing decisions.

There are several sourcing characteristics present in the literature and several attempts to categorize them. Fill and Visser (2000) introduce two groups of characteristics: *strategic and structural aspects associated with an organization's decision to reconfigure* and *costs*. Graf and Mudambi (2005) classify characteristics into *firm-specific* and *situation-specific*. Levy (1995) summarizes sourcing characteristics into *location-specific factors* and *relational factors*. Location-specific factors determine the optimal location for each activity in the supply chain considered in isolation from the rest of the supply chain. Relational factors address the relationship between the activity being sourced and other activities within the value chain. According to Fraering and Pasad (1999), sourcing decisions and logistics strategies are affected by *product, organization* and *country factors*. Even though several categories of sourcing characteristics exist, the descriptions of them lack detail.

Sourcing decisions affects the supply network configuration and the coordination of supply network is contingent upon the configuration (Rudberg and Olhager, 2003). Both the configuration and the coordination affects how flow and the storage of goods and information exchange should be managed in a supply network. Competitive advantage may be gained from both superior network structure configuration and superior network relations and co-ordination (Colotla *et al.*, 2003). The Fill and Visser (2000) category *strategic and structural factors associated with an organization's decision to reconfigure*; Graf and Mudambi (2005) *firm-specific and situation-specific factors*; Levy (1995) *relational factors*; and Fraering and Prasad (1999) *product and organization factors* are all connected to how the supply network is organised. However, there is a need to analyse supply network organisation by both its effect on the configuration and its effect on the coordination. Therefore, factors for analysing the organisation of supply networks are in this paper divided into two categories of characteristics: the supply network structure (Harrison and van Hoek, 2002) and the supply network relationships (Gadde and Håkansson, 2001)

To create stable and cost efficient supply chains, it is important to match the right product with the right supplier at the right location. Low-cost country implies certain characteristics of the supplier and its location and sourcing from these countries requires that companies are aware of these characteristics. Levy's (1995) location-specific factors, Fraering and Prasad's (1999) country factors and MacCarthy and Attirawong's (2003) supplier and location factors are all related to the location of the supplier. How the characteristics of the location of the supplier affects the supply network will here be analysed via one category of characteristics: the characteristics of low-cost countries (Handfield and McCormack, 2005),

Consequently, three categories of characteristics are identified: the supply network structure, the supply network relationships and characteristics of low-cost countries. The main dimensions of the characteristics are outlined in Table 1 and described in more detail in the next sections. There is also a section on performance measures of low cost sourcing.

Table 1: Summary of sourcing characteristics

Category of sourcing characteristics	**Sourcing characteristics dimension**
Supply network structures	Layering and tiering Plant roles
Supply network relationships	Business relationship Operative dependencies and transaction costs
Sourcing country characteristics	Infrastructure Culture Human capital Policies and regulations

Supply network structures

Outsourcing and sourcing decisions affect the structure of the supply network. Supply networks consist of suppliers, warehouses, distribution centres, raw materials, work-in-process inventory, finished products and so on (Simchi-Levi *et al.*, 2003). According to Harrison and van Hoek (2002), at least three elements are involved in the structuring of international supply networks: layering and tiering of nodes and links, the role of plants (nodes) and the reconfiguration processes of the network.

Layering and tiering

Layering and tiering are the structuring of information flows and the different coordination options of the physical operations, the links, and the localization of nodes (Harrison and van Hoek, 2002). The localization of assets affects the geographical distances between nodes, the length of the links, and also the available means of transport. Distance and means of transport affect lead times, and lead-time length affects a company's ability to respond to market and demand changes and increase response times (Markides and Berg, 1988; Levy, 1995) – this can therefore have a negative impact on flexibility. One way of achieving the necessary flexibility is to use larger safety buffers (Mattsson, 2002; Brannemo, 2006), or through extra costs for air freight and administration (Markides and Berg, 1988; Lowson, 2003). Long lead times may also increase costs in terms of expedited freight, unfulfilled demand, extra inventory, tied-up capital and managerial time spent on "fire-fighting" (Levy, 1995). Long distances also

increase the length of communication lines, decreasing the closeness of contact and making problem solving at an operational level difficult (Caddick and Bale, 1987).

Plant roles

Different plants have different roles within a network. According to Ferdows (1997), plant roles can be analysed by two questions: "What is the primary strategic reason for the factory's location?" and "What is the scope of its current activities?" Based on the answers to these questions, plants can be categorized into offshore, source, server, contributor, outpost or lead factory. Depending on category, plants should also be managed differently, especially with consideration of autonomy over key decisions (Maritan *et al.*, 2004). Plant roles are not set once and for all: superior manufacturers gain competitive advantage by upgrading the strategic role of their plants (Ferdows, 1997).

Supply network relationships

Outsourcing and sourcing decisions also changes the relations within a supply network. Supply network relationships are here divided into two factors; business relationship, and operative dependencies and transaction costs.

Business relationships

Several studies have explained the importance of interorganizational process integration based on strong cooperation, trust and commitment (e.g. Gadde and Håkansson, 2001), knowledge transfer, innovation capability, and simplification or elimination of activities (Rodriguez-Diaz and Espino-Rodriguez, 2006). Studies show that developing business relationships and integrating processes may be especially difficult with Chinese and other low-cost suppliers (Handfield and McCormack, 2005). China is a relationship-focused culture, which means that Chinese people expect to see their suppliers and partners in person much more than Europeans do (Song *et al.*, 2007). It takes time to build trust in a business relationship with a Chinese company, and there is a need to meet socially before talking business, which means negotiations take longer (Handfield and McCormack, 2005; Song *et al.*, 2007). Many Chinese suppliers lack knowledge of supply chain management, which can result in little planning and high inventory levels (Handfield and McCormack, 2005). One consequence of this is that many Chinese suppliers struggle to increase volumes quickly (Handfield and McCormack, 2005); another consequence may be less understanding for process integration and business relationship development.

Operative dependencies and transaction costs

Transactions between producing and consuming units may become more complex and costly if they are carried out between external plants and companies, rather than within the same plant and company. The transition to external suppliers may cause both administrative and material transactions to become more complex and extensive. This may include orders, order confirmations, delivery notifications, invoices, extra control activities, packing/unpacking activities and so on, which would not have been necessary with in-house production.

There are also operative dependency relationships between activities and material flows in procuring organizations and corresponding activities and material flows in the supplying organizations. A reason for strong dependency is that companies avoid different types of safety stocks and safety times in material and information flows. Global sourcing of small order quantities, with small buffers and no long-term frozen production schedules, increases transaction costs (Ettlie and Sethuraman, 2002). Studies show that an overall high-quality

infrastructure is important for decreasing sourcing-related transaction costs (Sakakibara *et al.*, 1997) and that quality management is a common problem, at least initially and possibly longer, in low-cost sourcing (Song *et al.*, 2007).

More customer-order-specific products also increase operative dependencies and transaction costs. An increasing significance of short delivery times makes it more difficult to decrease operative dependencies with lead-time buffers. Availability of complete, reliable and timely planning information in the supply chain is identified as important for successful global sourcing (Trent and Monczka, 2003) and should be especially important when there are strong operative dependencies and customer-order-driven production.

Global material flows with strong operative dependency relationships between the companies involved consequently result in high transaction costs. In order to decrease these costs, quality management, frozen schedules, information availability, and relations and process integration must be part of the relationship between the procuring and supplying company.

Sourcing country characteristics

Every country can be described by a set of characteristics. Prasad and Sounderpandian (2003) divide sourcing country characteristics into endowment factors such as infrastructure and access to skilled labour, cultural factors, arbitrage and leverage, and government incentives and regulations. Graf and Mudambi (2005) make another, though similar division of sourcing country characteristics into infrastructure, country risks, government policy and human capital. In this paper, sourcing country characteristics are described and analysed under the following four categories: infrastructure, culture, human capital, and policies and regulations. Arbitrage and leverage describe comparative advantages between countries, while country risks describe risk factors of one country compared to others. Country comparison is not the purpose of this study and is therefore excluded here.

Infrastructure

Companies inexperienced in working in less developed countries could have problems handling infrastructural deficiencies in transportations and telecommunications (Meixell and Gargeya, 2005; Brannemo, 2006). The transportation structure in China is at present below European levels: there are bottlenecks and congestion not only due to capacity constraints and equipment performance but also due to politics and a low level of logistics planning (Handfield and McCormack, 2005). Telecommunications and transportation infrastructure in China differs between regions and the more developed regions with functioning infrastructures also have higher labour costs (Song *et al.*, 2007). These more developed regions of China also have other problems: worsening pollution, overheated infrastructure and power bottlenecks (Handfield and McCormack, 2005). Less reliable communication infrastructure and more time-consuming transports increase lead times and decrease delivery dependability.

Culture

China is a relationship-focused culture compared to European cultures which are more individualistic in nature (Song *et al.*, 2007). Cultural differences between China and Europe are exacerbated by language difficulties hindering effective communication (Handfield and McCormack, 2005). Studies, for example, show that Asian people compared to Western people may say *yes* to show that they are listening, but this does not show whether they understand or are giving a positive answer, and they may also hesitate to say that they do not understand or give bad news such as problems or product quality defects (Song et al., 2007).

Business processes such as demand forecasting and material planning are dependent on effective communication; however, effective communication is obstructed by different cultures, languages, practices and time zones (Levy, 1995; Mattsson, 2002; Meixell and Gargeya, 2005; Mol *et al.*, 2005; Brannemo, 2006). Cultural differences can also result in innovation barriers and different understandings of tolerances and specifications of products (Smith, 1999; Nellore *et al.*, 2001)

Human capital

A lack of human capital and skilled labour may also have a negative impact on sourcing in low-cost countries (Graf and Mudambi, 2005). The Chinese workforce is very mobile – the majority of current factory workers are what are called the floating population, coming from rural areas to the cities to look for work (Handfield and McCormack, 2005). There is high employee turnover, which can be a problem for manufacturers that rely on trained and skilled workers, and in more developed regions of China there is a shortage of available labour (Handfield and McCormack, 2005). Training suppliers to produce a company's products takes time and can be costly, and their inexperience makes it less likely that parts meet specifications, affecting the cost of product quality (Markides and Berg, 1988). If product quality focus and knowledge is not embedded within a supplier's organizations, there is a greater risk of product quality failure. This means that when sourcing from low-cost countries there is a risk that product quality could become more variable**,** which may increase inventory levels (Caddick and Bale, 1987; Zsidisin *et al.*, 2000).

Policies and regulations

Intellectual property rights protection and legal systems in some low-cost countries, including China, are less mature than in Western countries (Song *et al.*, 2007). There are also cultural differences in the interpretation of contracts and how they should be used in society and in legal proceedings (Schniederjans and Zuckweiler, 2004; Handfield and McCormack, 2005). Countries with rapid social change increase the risk of participants nullifying or changing contracts (Schniederjans and Zuckweiler, 2004). There is also a risk of copying or suppliers using the companies' products or drawings when supplying another customer with goods, which decreases sourcing companies' willingness to share information (Handfield and McCormack, 2005; Song *et al.*, 2007). A low degree of cooperation and information sharing in supply chains may have a negative effect on lead times and product quality. Companies sourcing from China should also pay attention to humanitarian and environmental issues and to the working conditions at plants; this applies not just to first-tier suppliers, but also to second and third-tier suppliers (Handfield and McCormack, 2005). Several Western companies have learned the hard way to beware of these issues since they have been targeted by human rights groups or consumer activists (Handfield and McCormack, 2005).

Performance measures

Characteristics of sourcing may also counteract the sought-after positive effects of sourcing from low-cost countries and result in for example long lead times, high inventories, extra freight and administrative costs, reduced flexibility and planning ability, low product quality and reduced customer service (Markides and Berg, 1988; Mattsson, 2002; Lowson, 2003; Brannemo, 2006). These effects can be summarized into five variables measuring operational supply chain performance: product quality, speed, dependability, flexibility and cost (Slack *et al.*, 2001). Speed and dependability are issues of customer service, and costs include the cost of tied-up capital in inventories. This paper discusses the effect on operational supply chain

performance of the following four variables: product quality, customer service, flexibility and cost of tied-up capital. Therefore, these variables are here called operational supply chain performance variables.

METHODOLOGY

A single case study was conducted in order to gain deeper insight into the study phenomenon and to explore the consequences of the sourcing country characteristics, supply network structure and supply network relationships for a European manufacturer engaged in low-cost sourcing in China. The supply chain investigated comprises three parts: 1) a European Manufacturer (EM), 2) a Chinese Manufacturer (CM), and 3) Chinese suppliers of casting goods. EM and CM are owned by the same American corporation. The case was selected based on the opportunity it provided to study a low-cost casting goods supply chain from Chinese component manufacturers, through a Chinese intermediary company to a European overall equipment manufacturer.

The study uses qualitative and quantitative data to explore not only the consequences of the supply of casting goods from China from the EM perspective, but also how CM experiences the cooperation and the company's role as an intermediary between EM and the Chinese suppliers. The Chinese suppliers were studied from CM's perspective, with the data collections on the Chinese suppliers drawn from the CM employees. The fact that the Chinese suppliers are studied from CM's perspective gives only one view of the cooperation; however, the supplier data are analysed only from the perspective of how CM experiences its role as an intermediary.

The case data were gathered mainly through interviews, but also from documentation and transcripts from company records and the authors' on-site observations. Data collection took place during 2006 and 2007. For observation, interviews, collection of documents and transcribing, CM was visited once and EM several times.

Interviews were semi-structured and conducted at the production sites in Europe and China. Complementary questions were asked by phone and email, and a follow-up interview was conducted with the CEO of CM during a meeting in Europe. Interviewees were drawn from purchasing, logistics, production planning and quality control. Some interviews were conducted by one of the authors only, and the Chinese supplier was visited by only one of the authors. Notes were taken during the interviews by the author(s) present and compared after completion of the interviews.

The quantitative data are drawn from company records and transcripts when available or experience-based estimations. Company records and transcripts were collected either onsite by the authors in person or provided by the company by email. The quantitative data on the European side are drawn mostly from company records and transcripts and have been validated by an experience-based evaluation by the responsible managers. Some figures, such as transportation time, lead time and inventory levels, have been estimated by several of the interviewees and validated by their consensus of the estimations. The quantitative data regarding the Chinese side have first been estimated by the respective manager responsible and thereafter validated by the CEO of CM.

The interviews were used to outline the casting supply chain structure, both globally and locally, and how the companies experience the relationship and supply chain cooperation with one another. The aim was to gain a two-company perspective of the relationship and the experience of the actual supply network structure. The quantitative data were used to strengthen the descriptions of the supply chain structure from the interviews and to validate interview findings. Interview data were also validated by asking several persons at both companies the same questions; if differences were found in respondents' answers, these were taken up for discussion with a number of people, both in CM and EM. The data presented in this article reflect the views and interpretation of the interviewees.

THE CASTING SUPPLY CHAIN

In this section, the casting supply chain is first presented and thereafter the consequences of the sourcing characteristics on the studied supply chain. The discussion of consequences follows the structure of the sourcing assessment framework presented earlier.

The casting supply chain

The European Manufacturer (EM) manufacturers between 100,000 and 110,000 final products in 20,000 to 30,000 variants annually, with main markets in the USA and Europe. EM purchases about 300 casting items and produces about 1,000 items in its own foundry. At present about 50 casting items are sourced from China. EM manufactures about 240 tons per week and receives about 10-11 tons of castings from the Chinese Manufacturing (CM) per week. The EM demand has historically been even with only minor variation each year, though in the summer of 2005 there was a sudden increase in demand. This has resulted in an increased supply from China in order to handle capacity problems in the EM production**.**

CM was established about ten years ago, has about 200 employees and makes a similar but smaller assortment of products as EM. The sale of finished products in the Asia-Pacific market makes up 84% of its turnover; the remaining 16% is supply of components mainly to three European OEM manufacturers in the American Company. EM is the largest of the OEM customers.

EM has the capability and capacity to manufacture all parts of the final product within its own facilities. The EM production includes a foundry and five workshops, with machining, assembly and testing. The five workshops focus on different sizes and materials of the final product. Three are supplied with castings from China. Items arriving from China are pre-processed in China and, after goods reception and quality control at EM, delivered into the inventory of the workshop. Several items from China are used in more than one workshop, though each workshop at EM has a separate inventory. The estimated average lead times and inventory levels of EM are shown in Table 2.

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Table 2: Transport and EM production characteristics

Factor	**Case data**
Transport from China	6-8 weeks
Lead-time for foundry, machining and administration, EM	1-3 weeks
Inventory safety stock, EM	2-7 days' consumption
Inventory cycle stock, EM	2 weeks' consumption

In order to not miss deliveries to EM, CM makes casting components to a finished goods inventory and delivers to EM from this inventory. One or two containers are sent each week from CM to EM by ship; the shipping time is about seven weeks. The product quality of the items arriving from China has improved from poor to generally good; today the quality is about the same as items from European casting suppliers or from the local foundry. At present, quality control is carried out both before leaving China and on arrival at EM.

The CM plant has similar production resources to EM, except for the foundry and engine production processes. CM buys casting goods from Chinese suppliers. The main operations carried out by the suppliers are casting (foundry) and machining. There are about ten active suppliers of casting goods, but 80% of the volume is purchased from four major suppliers, located about four hours from CM.

It is difficult for CM to find suppliers that can perform multiple operations – as yet it has been unable to identify any supplier able to carry out all operations required. Although there are some suppliers with foundry and machining capabilities, CM must use special foundry suppliers and special machining subcontractors. Washing, quality control and packaging are always carried out by CM in its own plant at present.

The different capabilities of the suppliers and the number of operations a supplier can perform creates very different supply chains within China for CM. Figure 1 describes two typical supply chains of casting goods to CM. Supply chain (a) represents the characteristics of the "short" chain, where one supplier conducts both casting and machining. Supply chain (b) illustrates the "long" chain, where casting and machining are carried out by different suppliers and casting goods fail quality control and must be returned to machinery for rework and sometimes also to the foundry.

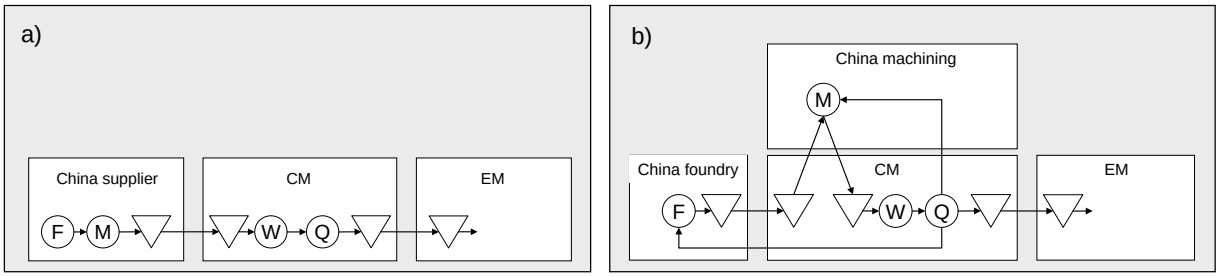

Figure 1: Short (a) and long (b) supply chains of casting goods to CM: F=foundry, M=machining, W=washing and Q=quality control. A triangle illustrates an inventory, a circle illustrates an operation and an arrow illustrates a material flow.

Estimated average lead times and product quality levels differ between the short and long supply chains (Figure 1), see Table 3.

Table 3: Supply from CM characteristics

Factor	Data short supply chain	Data long supply chain
Delivery times, Chinese foundry suppliers	N/A	2-7 weeks
Delivery times, Chinese machining	3-5 weeks (including foundry)	2-4 weeks
Inventory throughput time, CM	2-3 weeks	2-3 weeks
Washing and quality control lead time, CM	1-2 weeks	1-2 weeks
Total lead time China	6-10 weeks	7-16 weeks
Product quality level	93%	90-97%

Note: Figures in Table 3 are estimates by the CM CEO, purchasing manager, quality manager and logistics manager. Monitored actual figures used when available.

Low-cost sourcing consequences on the casting supply chain

Layering and tiering: The studied supply chain is a network of long distances, covering several time zones. The supplier structure in China also varies due to a lack of suppliers that can offer multiple operations. This creates considerable differences in lead times and product quality between the short and long supply chain in China. The long supply chain requires several suppliers to complete an item, and increasing lead times as a result of the longer supply chain. Due to the increased unreliability of the supply chain and product quality, it is also then necessary to increase inventory levels at CM to ensure the agreed service level to EM. In the short supply chain, these problems are reduced as there are fewer echelons in the supply chain and product quality is generally better. The long lead times in China and the shipping time to Europe of seven weeks increase the planning horizon for EM and make it necessary to base Chinese purchase orders on forecasts. EM must also manage all short-term demand changes by internal capacity. In addition, the long transport times increase work in process and the cost of tied-up capital. Because of the long delivery times by ship, it is sometimes necessary to use more costly air freight. The long lead times in China also create long ramp-up times when demand increases. It takes about two to three weeks before changed volumes are shipped from CM, making it difficult to plan and make changes of items and orders. The quality problems and long lead times make it necessary to maintain safety stocks at EM for items sourced from China.

The role of plants: CM was originally established to serve the Chinese and Asian markets and to open up for EM to source from China. To ensure product quality and to ensure or reduce lead times to EM from China, i.e. to increase overall delivery dependability, it has been necessary for CM to act as intermediary and handle quality control, communication, and to hold inventories. Using CM as an intermediary has made it possible for EM to obtain a low-cost supply of castings from China. It would have been very burdensome for EM to handle the product quality problems and communication from Europe with the Chinese suppliers. In the early days of CM, CM needed EM demand to fully utilize capacity; today, however, the deliveries to EM oblige CM to carry out operations when they lack space and time, creating order backlogs and increased delivery times for other customers – CM would like to use its

resources to focus on its own market supply. One positive effect of CM's presence in China is that it opens up the Chinese and Asian markets and supply market for the whole American Company, including EM.

Business relationships: Low product quality is a general problem among the current suppliers, especially the foundries, and there is a lack of knowledge transfer and communication about delivery and product quality requirements from CM to its suppliers. CM is also a relatively small customer to most suppliers, and this is one of the reasons why it cannot convince suppliers to adjust to its requirements. Another effect of its weak position towards suppliers is that suppliers often prioritize deliveries to other customers when there are delivery problems, in spite of delivery agreements with CM. Since it is difficult to find trustworthy and reliable suppliers in China, CM spends considerable effort finding new suppliers or developing relationships with the best active suppliers to further improve the best supply chains.

The EM–CM relationship is not trouble free. Within EM there is some resistance to sourcing from China, which has made employees less cooperative. This lack of cooperativeness has been evident in communications, among other things in a lack of explanation of drawings and instructions provided to CM. Some of the sourced components have also been too complex to produce at the right quality, which has further increased problems for CM. In addition, drawings and prototypes are not interpreted in exactly the same way, leading to extra administration, which also negatively affects the planning processes. The resistance to CM at EM is sometimes shown by employees almost looking for errors in the components arriving from China. Some of the problems experienced by EM with the supply from China, such as communication and cooperation, product quality and supplier reliability, have been improved. To further integrate the two organizations, the responsible purchaser at EM visits CM in China five to six times a year for about two to three weeks, and a European CEO has been hired for CM.

Operative dependencies and transaction costs: What is sent from CM to EM depends on weekly updated orders based on forecasts. The forecast is a 15-week rolling forecast, based on historical sales and a moving average calculation. Orders are placed eight weeks in advance of delivery. The unreliability of Chinese casting suppliers in terms of product quality, lead-time length and variability has in the past created shortages at CM, resulting in delivery problems to EM. To be able to deliver to EM at the appropriate level, CM has been forced to make a larger proportion of its assortment to stock and maintain high safety stocks in the finished goods inventory. CM must also quality control all components received from Chinese suppliers. Thus, quality problems, long lead times and deficiencies in delivery precision – and the need to maintain the appropriate delivery quantities and qualities to EM – decrease CM's ability to reduce tied-up capital and production costs.

The low reliability of the Chinese component manufacturers further increases the need to manage the volume and product mix flexibility in-house, not only at CM but also at EM. EM feels that it cannot trust the supply chain from China, and does not know when and what will be delivered until the ship leaves port from China. Because of the overall unreliability of supply, EM must manage flexibility in-house, which increases inventories at EM, too. It also compels EM to keep its in-house production planning open for short-term changes in priorities depending on what is sent from China. Some items sourced in China have been too complicated for CM to produce and this has resulted in product quality issues. Product quality has recently improved, however, with the result that EM is considering reducing the quality control of goods delivered from China.

Culture: Chinese workers have a tendency to change jobs frequently, which makes it hard to retain trained personnel. At CM employee turnover is about 10% per year. In addition, there have been a number of culture-related problems between CM and EM resulting from language difficulties and differences in thinking, especially between departments of the two companies that do not regularly meet. As a result of lack of common mindset, both sides consider the quality of communicated information to be low, leading to extra administration and a negative effect on the planning processes.

Human capital: CM experiences that it is difficult to find skilled personnel in China and difficult to keep them. Knowledge of supply chain management among CM personnel and CM's suppliers is not considered sufficiently high to optimize the supply chain as a whole rather than specific parts in isolation. CM argues that Chinese suppliers lack understanding about the consequences for other parts of the supply chain of defects in product quality and low delivery reliability. This creates problems of late deliveries and low product quality, and results in an environment already in China where deliveries and product quality cannot be trusted. Therefore, a great deal of effort is spent on trying to identify new and further develop relationships with the best-performing current suppliers. For EM, one of the positive aspects of sourcing from China is the low-cost workforce, which is reflected in product prices.

Policies and regulations: CM must deal with Chinese suppliers who do not adhere to what has been agreed. However, CM has little power over its suppliers, and suppliers sometimes prioritize other customers rather than agreements made with CM. The result is that Chinese suppliers cannot always be trusted, and dependability and service are considered low. One example is that if CM pushes deliveries, some suppliers will still deliver even if they do not have the necessary material and even if they know the quality is substandard. The suppliers sometimes do not accept that they are responsible for a product quality problem; instead they may claim that the problem occurred during transportation, handling or in the CM process during washing.

Infrastructure: Most foundries and machining subcontractors are located close to the CM plant, often within one day of transportation. Making infrastructure an issue not considered to result in any significant consequences. However, some suppliers are located in more rural areas where poor road quality can sometimes be a problem.

Summary: Table 4 summarizes the consequences related to each dimensions of the sourcing characteristics identified in the case and the perceived performance effects of these. According to Levy (1995) and Mattsson (2002), outsourcing creates supply network structures and relations that increase inventory levels and thereby the cost of tied-up capital. It is identified that the selection of a low-cost supplier results in a certain layering and tiering of the supply network structure affecting the performance measures product quality, flexibility and cost of tied up capital. The establishment of an intermediary in the supplier country or region affects the layering and tiering of the network since one further node is added to the network. This node depending on the plant role it is assigned can have positive effects and do so for EM regarding product quality and customer service. However, with more nodes in the network, the cost of tied up capital increase depending on more inventories in the case and flexibility decrease for CM as a consequence of this. CM also affects the supply network relationships by decreasing the operative dependency and transaction costs between EM and the Chinese suppliers and thereby decreases the cost of tied up capital and increase the customer service for EM, but the flexibility decrease and the cost of tied up capital increase for CM. The business relationship is improved between both EM and CM and between CM and the Chinese suppliers

with time, which have positive effects on customer service and product quality, which decreased initially. The analysis of the sourcing country characteristics show that culture, human capital, infrastructure, and policies and regulations have significant effects on the performance effects because they set the preconditions for both the supply network structure and the supply network relationships.

Table 4: Summary of consequences and performance effects per sourcing dimension

Sourcing characteristics dimension	**Consequences**	**Performance effects**
Layering and tiering	Long distance EM and CM Transport by sea Long planning horizon Long ramp-up times Inventory and quality control both at EM and CM Several suppliers in China	Increased cost of tied up capital Decreased flexibility Decreased product quality
Plant role	CM acts as intermediary between Chinese suppliers and EM EM needs CM to use Chinese supply CM would like to be more independent of EM	Increased customer service for EM Increased product quality EM Decreased flexibility for CM Increased cost for tied up capital Decreased customer service for CM's other customers
Business relationship	Communication misunderstandings Lack of knowledge transfer Lack of cooperation Low levels of trust	Decreased product quality Decreased customer service Increased cost of tied up capital
Operative dependencies and transaction costs	Long time from order to delivery Unreliable Chinese suppliers CM delivers to EM from inventory CM needs to quality check all items	Decreased flexibility Decreased customer service Increased cost of tied up capital
Culture	High employee turnover CM Differences in thinking Low quality of information exchange	Decreased product quality Decreased flexibility
Human capital	Hard to find skilled personnel in China Hard to find suppliers with supply chain management knowledge	Decreased product quality Increased cost of tied up capital
Policies and regulations	Hard to make Chinese suppliers keep their promises and take responsibility	Decreased customer service Decreased product quality Increased cost of tied up capital
Infrastructure	No significant effect	

DISCUSSION

This section uses the low-cost sourcing assessment framework to explore the experiences of the case company of sourcing casting goods from China. It is analysed how the sourcing characteristics are related to each other and the performance effects. This is followed by a presentation of how the low-cost sourcing assessment framework can be utilized.

The sourcing characteristics

The previous section shows that the dimensions of the sourcing characteristics can be used to assess the casting supply chain. This supports earlier studies done within the area of how to analyse sourcing decisions. Though, what separates this study from earlier studies is the combination of all eight dimensions. Earlier studies have either focused on the structure and the relationships of the supply network (e.g. Fill and Visser, 2000) or the characteristics of the sourcing country (e.g. MacCarthy and Attirawong, 2003); however they have not combined all three categories into one framework. This study indicates that all dimensions, except for infrastructure, generate some kind of consequence for the casting supply chain and should, thus, be considered in different types of low cost sourcing assessment.

According to Sakakibara *et al.* (1997), product quality has an effect on the transaction cost of sourcing. The case analysed showed that the sourcing characteristics are affected by the operational supply chain performance, especially by the product quality and cost of tied-up capital. It was identified that layering and tiering, operative dependencies, business relationship and plant role were affected by the product quality of the Chinese suppliers. Therefore, improving the product quality from the Chinese suppliers would increase the possibility of improving the layering and tiering of the supply network structure and the relations between the Chinese suppliers and CM and between CM and EM. The analysis could also identify an interconnection between the different types of operational supply chain performance effects of low-cost sourcing. In order to manage product quality problems, low flexibility and long lead times and to improve customer service, it was necessary to have high inventory levels in the supply network.

Thus, based on the conducted study we could propose that the sourcing characteristics affect the operational supply chain performances, but also that the operational supply chain performances affect the sourcing characteristics. There does not seem to be a one-directional cause and effect relationship between sourcing characteristics and operational supply chain performances. In order to fully understand how to decrease the negative performance impact of the sourcing characteristics, this study consequently reveals a need for further research explaining the levels of relationship between sourcing characteristics factors and operational supply chain performances. The results related to the plant role dimension are relatively case specific since the establishment of CM, a Chinese intermediary, is something that is not present in all sourcing relationships. Also the effects of the product quality are case specific depending on castings need to be machined to discover product quality level.

Interconnections between the sourcing characteristics

From analysing the performance effect of a casting supply chain via the sourcing characteristics it was identified that the sourcing characteristics are interrelated and it is thereby of importance to analyse the three categories of characteristics together at the same time. The interrelation between the sourcing characteristics renders it difficult to understand the resulting effect of the

sourcing characteristics on a supply network. This, for example, complicates improvement works in the supply network, since it is hard to identify where to start and how and what effects to expect.

According to Trent and Monczka (2003), the structure of the supply network affects the operative dependencies between nodes in the supply network. This was observed in the case, where EM is dependent on supply from China. However, the Chinese suppliers are not reliable enough, which affect CM's plant role. Thus, based on the conducted study we could propose that the layering and tiering affect the operative dependencies, the operative dependencies affect the plant role and the plant role affect the layering and tiering.

The business relationship between nodes affects what possible plant roles there are for the different plants to take (Ferdows, 1997), especially those in low-cost countries. The business relationship also affects the operative dependencies between nodes in the supply network (Gadde and Håkansson, 2001). This was observed in the case where the business relationship between both CM and the Chinese suppliers and CM and EM led to low customer service and product quality problems. To handle this it was necessary to use CM as an intermediary, which shortens the distances (in time, culture and communication) between the Chinese suppliers and EM. Thus, based on the conducted study we could propose that the business relationship affects the plant role and the operative dependencies and transaction costs.

As explained by Song *et al.* (2007) and Handfield and McCormack (2005)**,** policies and regulations, the interpretation of information such as drawings and orders, and relationships within the supply chain are culture and knowledge dependent. In the studied case, the culture and human capital together affected how information was interpreted and exchanged. To make the cooperation and communication work it was necessary for CM to take the role of an intermediary between the Chinese suppliers and EM. Based on the conducted study we could therefore propose that the sourcing country characteristics of culture and human capital affect policies and regulations, business relationships and the plant role. In the case, infrastructure was not a factor, i.e. it did not affect the supply from China; however, infrastructure may have an effect on possible supply network structures and should therefore be taken into account as a sourcing characteristics in other low-cost country supply contexts.

The sourcing characteristics in the form of sourcing country characteristics, supply network structure and supply network relationships are mutually interconnected and affect each other. Several relationships are proposed but the conducted single case study is not enough for identifying, formulating and validating all existing relationships. Further studies that identify other relationships and tests the proposed relationships are consequently needed.

A practical sourcing assessment framework

To gain positive effects of low-cost sourcing for example, reaching new markets and decreasing labour costs, managers should be aware of the differences between possible sourcing solutions. It is then necessary to assess how the new supply chain will affect the company. Detailed analysis frameworks and practical tools for such assessments are lacking in existing outsourcing and sourcing evaluation tools (e.g. Momme and Hvolby, 2002). This section presents a framework for analysing how the new supply chain affects the company.

Several frameworks describing how to source and outsource are presented in the literature. Figure 2 presents the framework of Momme and Hvolby (2002) which is here used as an example of a general sourcing process framework. It introduces the sourcing process with different phases as well as factors that should be considered during the process. The factors to

consider during the process are issues in areas that are important for the outsourcing decision, both in terms of whether the company should outsource or not and how sourcing should be conducted. Some factors considering operational supply chain performance are included in some of the existing frameworks but they are seldom analysed in detail, which implies a risk for neglecting these in the sourcing process. Following a process like the sourcing process in Figure 2 including consideration of operational supply chain performance could enhance the efficiency and effectiveness of outsourcing projects by providing a structure and detailed guidelines. Such an approach to sourcing projects would most certainly decrease the time required and improve the satisfaction with sourcing relationships. From a managerial point of view the use of a souring assessment framework like this helps to prepare company representatives such as buyers and production managers of how the low-cost country differ from local supply countries. One of the biggest problems for companies today is the expectation of business as usual after changing source.

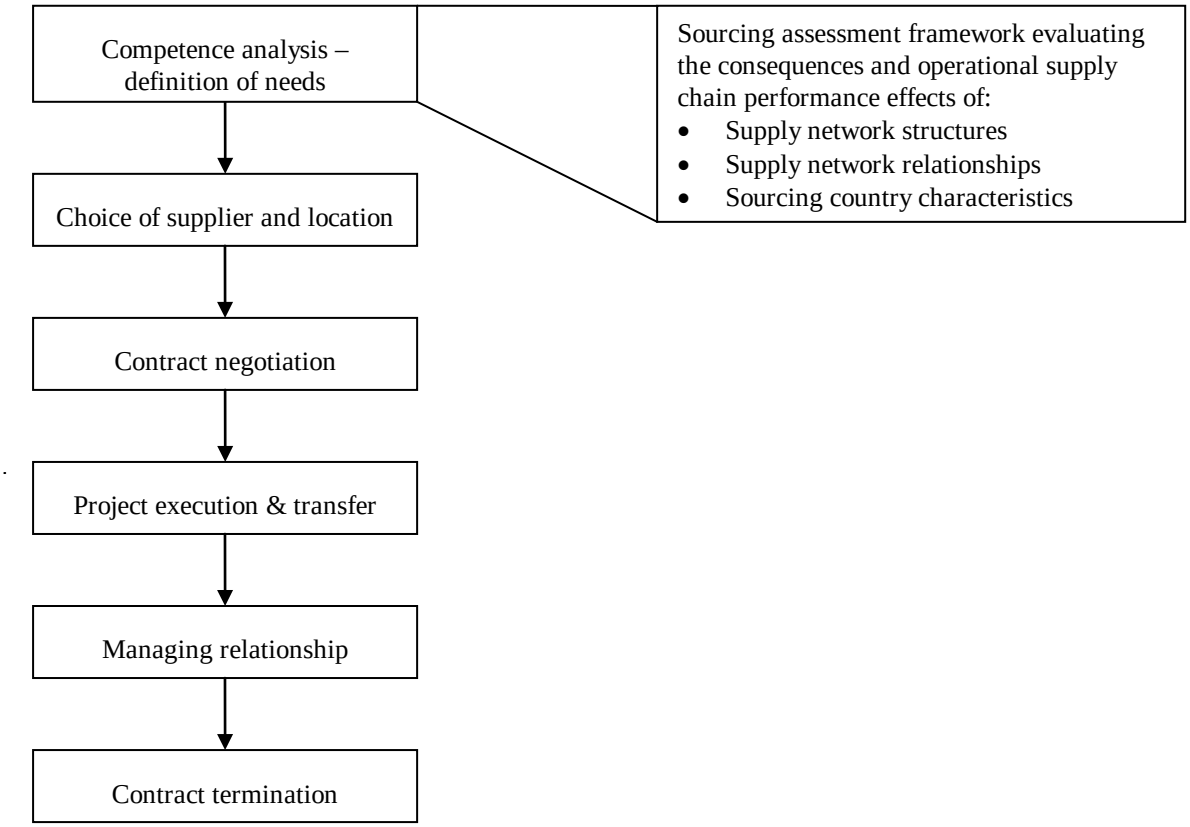

Figure 2: The sourcing process adapted from Momme and Hvolby (2002, p. 193). The right part of the figure describes the extension.

The assessment of consequences and operational supply chain performance effects of a sourcing option should be performed in the first phase of a sourcing process (i.e. the "Competence analysis – definition of needs" phase in figure 2). During the first phase, it is important to conduct an analysis of the current supply chain structure as well as the potential future supply chain structure if the decision will be to outsource. Such an investigation of the potential future supply chain structure is supported by the first phase activities presented by Momme and Hvolby (2002), i.e. strategic analysis, SWOT analysis and core/non-core competence mapping, as well as, the analyses and evaluations during the subsequent phases.

We however propose an extended focus on the first phase analysis and present a three step approach for conducting a detailed "Competence analysis – definition of needs" phase (see right part of Figure 2 and Figure 3).

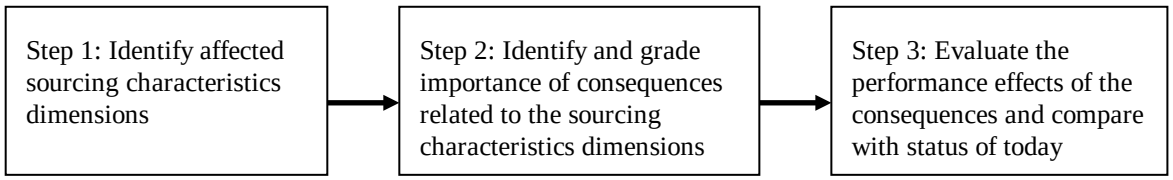

Figure 3: The sourcing assessment framework

Step 1: The first step is to evaluate the sourcing characteristics dimensions one by one. The evaluations of the sourcing characteristics dimensions aim at identifying which of these dimensions are present in the specific case of the company considering outsourcing and the possible geographical areas for locating the outsourced unit or parts. The result of this step is a description of what dimensions need to be further investigated to evaluate the consequences of an outsourcing decision. Also important in this step is to identify if there are any interrelations between the sourcing characteristics dimensions and if so describing them.

Step 2: The second step is to evaluate the consequences of the sourcing characteristics dimensions which in the first step were found to be affected by the decision. The possible consequences for the operational supply chain should be identified for each sourcing characteristics dimension. There is no general list with possible consequences linked to each sourcing characteristics dimension, though examples of possible consequences are presented in Appendix 1. Therefore, when identifying the consequences it is necessary to work in cross functional groups (e.g. Moses and Åhlström, 2008) in order not to miss areas that can be affected within a sourcing characteristics dimension. After having identified the consequences, the consequences should be evaluated based on their importance and likelihood to occur. We suggest using a 7-step Likert scale to rank the consequences. The consequences receiving high numbers are to be seen as the important consequences within each sourcing characteristics dimension. Several consequences can be related to more than one sourcing characteristics dimension and important to notice is that one consequence can receive a low grade within one dimension but a high grade within another dimension.

Step 3: The third and final step of the sourcing assessment framework is to relate what performance effects the identified consequences would result in and compare these performance effects with the status of today. First, possible performance effects should be identified for each consequence graded important in the previous step. This is done by identifying possible relationships between each performance effect (customer service, product quality, flexibility and cost of tied-up capital) and the consequence. Important to notice here is that there are two-directional relationships between the consequences and the performance effects (see Figure 4). It is not enough only to consider which consequences generate which performance effects, it is also necessary to contemplate over if some of the performance effects can create consequences within a sourcing characteristics dimension. The performance effects should be evaluated based on their likelihood to occur and their impact on company businesses.

Both the likelihood to occur and the impact can be graded based on a 7-point Likert scale and thereafter be added together to grade the overall performance effect of the consequence. The present status of performance effects need to be mapped and thereafter compared with how the performance effects are affected by the consequences within each sourcing characteristics dimension. Appendix 2 contains a template for conducting the third assessment step.

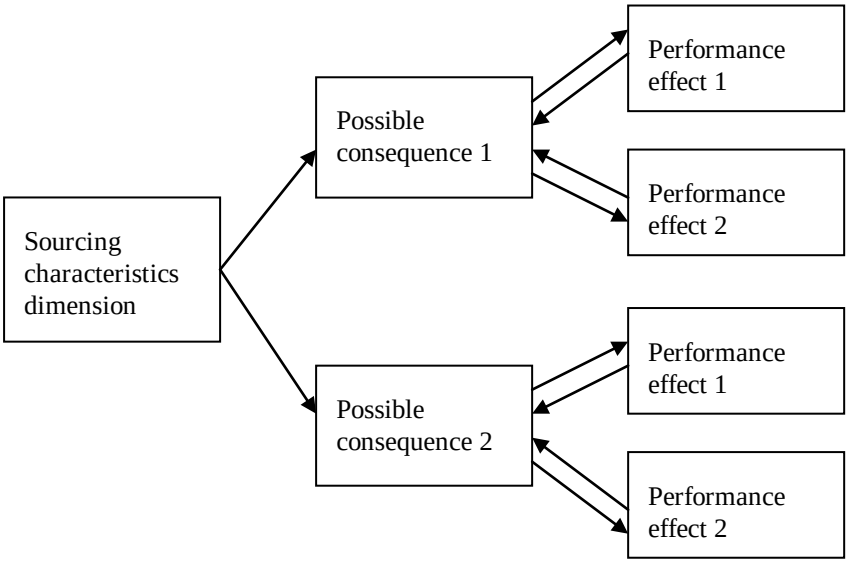

Figure 4: The relationship between sourcing characteristics dimension, possible consequences and performance effects

The results of the sourcing assessment framework are a description of what dimensions of the sourcing characteristics would be affected by sourcing to a specific area of the world and what consequences and performance effects this would have. Appendix 1 and 2 present templates for performing the second and third step of the sourcing assessment framework.

CONCLUSIONS

The characteristics of low-cost-country supply chains affect the operational supply chain performance and decrease the sought-after positive effects of outsourcing, such as cost savings. The question for companies with already established relationships with and companies thinking of starting to source from low-cost-country suppliers is how to make the best out of low-cost-country supply chains. A framework for low-cost sourcing assessment was developed and the experiences of low-cost sourcing in China for a European manufacturer were explored. The findings contain both case unique patterns, proposed relationships, a practical framework for low-cost sourcing assessment and streams for further research.

Based on earlier research of how to analyse and assess sourcing decisions a sourcing evaluation framework containing three categories divided into eight dimensions was developed (see Table 1). The categories are not new or novel; however, what is new is to combine all three into one framework, to detail them into the dimensions and to test them by analysing an existing supply chain. The case study analysis showed how the sourcing country characteristics, supply network structure and supply network relationships by themselves and in combination with each other could create negative effects for the European company (lower flexibility, higher cost of tied-up capital, lower product quality and lower customer service). It

was shown how the sourcing characteristics affected the supply chain and it was seen that to reduce the negative effects of low-cost sourcing, it is necessary to take a holistic view of the sourcing characteristics – it is not sufficient to improve one of the dimensions in isolation since they are interconnected. Further, a two-directional cause and effect relationship was identified and proposed between the sourcing characteristics dimensions and the operational supply chain performance effects.

Based on the empirical analysis we could propose several relationships between the sourcing characteristics, but the conducted single case study is not enough for identifying, formulating and validating all existing relationships. More case based studies that identify further relationships and survey studies that test the proposed relationships are consequently needed. The identified two-directional relationship between the sourcing characteristics and operation supply chain performances also require further research. The present study has identified the existence of the relationships but has not evaluated their levels of impact. In order to fully understand how to decrease the negative performance impact of supply characteristics, it is a need for further research that explains the levels of impact between sourcing characteristics and operational supply chain performances. Based on the research conducted in this paper a practical framework for evaluating the consequences and operational supply chain performance in an early phase of a sourcing process was presented in the end of the discussion section. This framework should have implications on managers involved in sourcing and outsourcing decisions.

There are several limitations of the study. The fact that no interview is conducted at the Chinese suppliers and some of quantitative data is personal estimates and not objective figures limits the study. All collected data was however adjusted and validated by several respondents. A single case study like the one conducted here always result in some limitations and calls for further research, as described above. The single case study was however motivated in order to conduct this explorative study.

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Appendix 1 – Possible consequences related to sourcing characteristics dimensions

Sourcing characteristics dimension	Possible/examples of consequences	Weight of consequence (7 step Likert scale)
Layering and tiering	Geographical distance	
	Inventory and quality control	
	Number of suppliers	
	Third tier logistics suppliers	
	Transport mode	
	Planning horizon	
	Ramp-up/ramp-down times	
Plant role	Supplier role	
	Relationships	
	Market	
Business relationship	Communication	
	Knowledge transfer	
	Cooperation	
	Trust	
Operative dependencies and transaction costs	Time from order to delivery	
	Reliability of supplier	
	Make to stock/make to order	
	Quality controls	
Culture	Employee turnover	
	Language knowledge/modes of expression	
	Similarity in culture	
Human capital	Skilled personal	
	Supply chain management knowledge	
	Language knowledge	
Policies and regulations	Legal abilities	
	Corruption	
Infrastructure	Roads/railways/harbours	
	Computerization/Internet	
	Rainy seasons	

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Appendix 2 – Examples of performance effects related to consequences

Possible operational supply chain performance effects explored in this paper: product quality, customer service, flexibility and cost of tied-up capital

Possible/examples of consequences	Possible performance effects	Likelihood of appearance and impact
Geographical distance	Customer service, flexibility and cost of tied-up capital	
Inventory and quality control	Product quality, customer service, flexibility and cost of tied-up capital	
Number of suppliers	Customer service and flexibility	
Third tier logistics suppliers	Customer service, flexibility and cost of tied-up capital	
Transport mode	Customer service, flexibility and cost of tied-up capital	
Planning horizon	Customer service, flexibility and cost of tied-up capital	
Ramp-up/ramp-down times	Customer service, flexibility and cost of tied-up capital	
Supplier role	Product quality and customer service	
Relationships	Product quality and customer service	
Market	Customer service	
Communication	Product quality and customer service	
Knowledge transfer	Product quality and customer service	
Cooperation	Product quality and customer service	
Trust	Product quality and customer service	
Time from order to delivery	Customer service, flexibility and cost of tied-up capital	
Reliability of supplier	Customer service, flexibility and cost of tied-up capital	
Make to stock/make to order	Customer service, flexibility and cost of tied-up capital	
Quality controls	Product quality, customer service and cost of tied-up capital	
Employee turnover	Product quality and customer service	
Language knowledge/modes of expression	Product quality and customer service	
Similarity in culture	Customer service	
Skilled personal	Product quality and customer service	
Supply chain management knowledge	Product quality, customer service, flexibility and cost of tied-up capital	
Language knowledge	Product quality and customer	

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	service	
Legal abilities	Customer service	
Corruption	Customer service	
Roads/railways/harbours	Flexibility and cost of tied-up capital	
Computerization/internet	Customer service	
Rainy seasons	Customer service and flexiblity	