A Systematic Approach to Implementing Multi-sourcing Strategy in Engineer-to-Order Production

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Abstract. Engineer-to-order (ETO) manufacturers operate in an increasingly volatile, uncertain, and complex business environment, which has added more complexity to their already complex supply chain operations. As they navigate the ramifications of the COVID-19 pandemic, they need knowledge-based guidance on selecting and implementing approaches to increasing resilience. Based on a clinical management design, this study develops a systematic approach for a case firm that recently transitioned from single sourcing to multi-sourcing. The goal is to strike a balance between the total cost of acquisition and supply chain resilience. The study reveals that effective implementation of multi-sourcing in ETO production requires involving the purchasing and supply function (PSF) right from the design stages. Besides, it is essential to deploy a cloud-based procurement system that facilitates interactions between PSF and the suppliers, as well as other critical organisational functions involved in an ETO project.

Keywords: Multi-sourcing, Single sourcing, Engineer-to-order production, Clinical management research.

1 Introduction

The outbreak of the COVID-19 pandemic and the subsequent measures by authorities to stop the spread quickly led to the disruption of supply links, which in turn caused material shortages and delivery delays. A clear message sent by the pandemic is that supply chains need to be more resilient [1], and thus, supply chain recovery scenarios and approaches must be developed [2]. This is understandable because it appears that some of supply chain management "best practices" partly contributed to the heightened vulnerability of supply chains. For instance, it is argued that lean practices, globalised

structures, single sourcing, and offshoring strategies made many companies prone to the pandemic [3][4]. In their report, Kilpatrick and Barter [5] note that "a decades-long focus on supply chain optimisation to minimise costs, reduce inventories, and maximise asset utilisation has removed buffers and flexibility to absorb disruptions, and COVID-19 illustrates that many companies are not fully aware of the vulnerability of their supply chain relationships to global shocks" (p. 14).

As the pandemic is forcing many companies to rethink and transform their supply strategies, various approaches have been proposed to address the repercussions of major supply chain disruptions. The measures include balancing global sourcing with nearshore and local sourcing, increased collaboration with suppliers, the adoption of multiple sources [3], and greater utilisation of supply chain technologies such as the Internet of Things, artificial intelligence, and robotics [5]. Conceivably, navigating through the ramifications of the pandemic requires knowledge-based guidance on the selection and implementation of these strategies. This study develops a systematic approach for implementing a multi-sourcing strategy in the context of engineer-to-order (ETO) production. The study is based on a clinical management research design (CMR) [6], where a framework is developed for an ETO firm that initially relied on a single sourcing strategy but recently decided to implement a multi-sourcing strategy.

The remainder of this chapter is organised as follows. The next section describes single-sourcing versus multi-sourcing, followed by Section 3 that describes sourcing in ETO production. Section 4 describes the methodology deployed in the study, while Section 5 presents the case firm and its decision to multisource. Section 6 provides the framework, followed by a conclusion.

2 Theoretical foundation

2.1 Single sourcing versus multi-sourcing

Besides inputs produced internally, firms rely on external sources to obtain other inputs – goods or services - required to make their final product. According to the Chartered Institute of Procurement & Supply (CIPS), sourcing is the process of finding, evaluating and engaging suppliers to achieve cost savings and the best value for goods and services is what we refer to as sourcing [7]. The supply chain operations reference model (SCOR) identifies sourcing as one of the essential elements of supply chain management, along with planning, production, delivering and returning. To be successful, supply chain management must have an effective sourcing strategy that allows it to combat uncertainties in both supply and demand [8]. This is important because lack of an effective sourcing strategy can lead to supply breakdown and excessive downtime of production resources, upstream and downstream supply chain. As such, strategic sourcing – a process that directs all sourcing activities toward opportunities that enable the firm to achieve its long-term operational and organisational performance goals – is highly promoted [9].

One of the decisions made under strategic sourcing is whether to obtain inputs from a single supplier or multiple suppliers. Obtaining supplies from a single supplier has its own advantages. Such advantages include the possibility of forming a long-term relationship with a supplier based on trust and shared benefits, low purchase price due to economies of scale, and increased supplier's commitment. With such deepened relationship, the supplier can even make costly specific investments to maintain the relationship. However, reliance on a single supplier may have negative consequences such as the increased risk of supply disruption, particularly for asset-specific products, and potential opportunistic behaviour due to significant dependency on the supplier [10].

Conversely, sourcing from multiple suppliers provides flexibility to respond to one supplier's inability to supply due to unexpected events. It also increases competition among suppliers, leading to better quality, price, delivery, product innovation and buyer's negotiation power. Nevertheless, multi-sourcing increases transactional costs due to supplier searching costs, negotiation with multiple suppliers, and a greater number of orders [11]. Besides, individual suppliers may reduce their effort to match buyer's requirements due to reduced volume.

Thus, the choice between single versus multiple sourcing calls for a cost-benefit analysis. That is, weighing the advantages and disadvantages of the two approaches, given the circumstances of the buying firm. Burke et al. [8] conclude that single sourcing is a suitable strategy only when supplier capacities are high compared to the product demand and when the buying firm does not obtain benefits through multi-sourcing. Additionally, it works well without natural or man-made disruptions in supply chains [12]. In recent years supply chains have been facing increased vulnerabilities due to trade tensions, natural disasters, and other geo-economic disruptions [13]. Under such circumstances, therefore, single sourcing is quite risky, which is why even before the pandemic, the multi-sourcing strategy had become a significant trend in the contemporary outsourcing landscape [11].

2.2 Sourcing in ETO production

ETO production strategy involves designing, engineering, and producing a product to meet the needs of a specific customer [14]. Therefore, such products are highly customised and often produced in low volume [15]. Given the high level of customisation, the design of ETO products begins when a customer places an order. This way, ETO production is characterised by complex environments, high demand variability, multifaceted design stages, and intensive project life cycles [14]. Given these characteristics, PSF can play a strategic role in ETO production [16]. However, the PSF working under this strategy faces an entirely different dynamic compared to working in a production system where production volumes are based on sales forecasts. Therefore materials and components can be purchased in advance based on predicted demand. Having an estimate of demand allows PSF to enter long term contracts with suppliers and commit to buy specific volumes.

Conversely, PSF operating under ETO production strategy does not have the possibility of buying all inputs in advance as it is difficult to identify and source all the required materials and components before a customer places an order. Thus, while some standard components can be purchased in advance, PSF can only determine all the requirements after a bill of materials (BOM) for a project has been created following a customer order. This implies that negotiating long-term contracts and committing specific volumes with suppliers is challenging due to demand uncertainty associated with ETO production. To deal with such uncertainty, Moretto et al. [16] suggest that PSF must have a flexible approach that allows it to implement a responsive sourcing strategy. This means that implementing a multi-sourcing strategy in ETO will be different from a multi-sourcing strategy in a forecast-based production system. For PSF in an ETO production, multi-sourcing means having multiple suppliers who can provide the same input(s) required for a specific project. In other words, for each component needed for a particular project, two or more qualified suppliers are boarded, and optimal quantities are allocated between them. Such a system requires striking a balance between the total costs of acquiring inputs and supply risk. The aim is to create a strategy that allows an ETO firm to bounce back from unforeseen disruptions while still minimising costs.

3 Methodology

This study deploys clinical management research (CMR), a method that involves 'observing, eliciting and reporting of data which are available when the researcher is engaged in a helping relationship in the management of change' [17]. The method is suitable because it allows case firms and their management to gain deeper and richer insights into a particular problem [6]. This is because this type of research constitutes both an investigation and a response to a problem faced by the case firm. In principle, CMR operates within the realm of practical knowing where 'knowledge is contextually embedded, and there is a primary concern for the practical and the particular' [18]. Thus, regarding case selection, CMR is not based on random sampling; instead, there must be a firm that has a specific problem to be addressed. Unlike case study design, where a researcher initiates a project to explore or generate theory, CMR is initiated by a firm that has experienced a challenge and wants to solve it. In this study, the firm (henceforth Superprop) is an ETO firm that produces custom-made propulsion, positioning and manoeuvring systems for domestic and international shipyards and ship owners. This study is part of a larger research project where among other things, the purpose is to apply research-based insights in solving logistics-related challenges faced by the case firm and its suppliers. Two of the researchers involved in this project have previously worked with the case firm in projects that addressed other logistics-related problems. This is valuable because the long-term relationship these researchers have had with the case firm has provided a deeper understanding of the circumstances surrounding the current decision to switch to a multi-sourcing strategy. Thus, the analysis conducted in this study is based on current and past data collected through

semi-structured interviews, document reviews, and workshops. Informants were managers of critical functional areas. More precisely, interviews were conducted with the procurement manager, the production manager, the design and engineering manager, and a manager from the aftersales and service department. In total, eight hours of interviews were conducted and later analysed. To further enhance our understanding of Superprop operations, the study also involved direct non-participant observations. In terms of analysis, the collected data were synthesised and aggregated to determine an appropriate sequence of activities that would form a systematic approach to multi-sourcing strategy.

4 The case firm and the decision to multisource

Superprop follows an ETO strategy, where they design, engineer, produce and deliver products to meet customers' unique requirements. Thus, customisation and ultimately value generation is achieved through an iterative engineering design process, whose degree is different for the thruster systems produced. This is because some variants have extensions while others do not. For example, a tunnel is one of the customised components, as it has a complex mechanical interface and integration to the vessel hull, making it impossible to fit in other new projects. Another example is the control system that also has many interfaces and is specified to the vessel's electrical interface and motor starter. Some propeller hubs and blades are also customised, as their designs are optimised for a specific individual ship.

In the past years, Superprop had a stable supply chain, and it mostly implemented a single sourcing strategy where the focus was on forming and maintaining close relationships with suppliers, preferably in close proximities. However, in recent years the firm experienced changes that compelled it to consider multi-sourcing. Competition has increased in the market, and new strategic approaches are needed to increase Superprop's competitiveness. The firm has recognised the potential strategic role that PSF can play to improve competitiveness. The goal is to use this function to maximise value. As an ETO firm, they recognise that maximising value depends not only on delivering customer's perceived value but also on minimising total production costs. Thus, Superprop decided to implement multi-sourcing. Before the pandemic, the main reason for this decision was to avoid potential opportunistic pricing behaviour from single suppliers. Following the pandemic, and its impact on supply chains, Superprop, like other firms across the globe, has realised that they need a multi-sourcing strategy also for hedging against disruptive risks.

Under Superprop's single-sourcing strategy, each externally sourced component or material that goes into a product (e.g., a thruster) is provided by one supplier who covers 100% of the requirements. Examples of such inputs include hydraulic cylinders, electronic components, and toothed rings. Given challenges associated with this strategy, Superprop wants to attain a situation where each externally sourced component or material that goes into their customised products is sourced from two or more suppliers, hence implementing multi-sourcing strategy. However, they are

concerned that sourcing materials and components from previously "unknown" suppliers may compromise the quality of their final products and eventually compromise their competitiveness. As such, Superprop is strict on quality and lead time. Therefore all selected suppliers must guarantee high quality and high delivery precision. Thus, the challenge is to maximise two variables: the quantity and total cost of acquiring inputs for each project. For each project, the goal is to meet all input requirements at a lower total cost of acquisition compared to the single-source strategy. It is important to note that the multi-sourcing strategy is intended only for the non-standard inputs that cannot easily be sourced. Figures 1 and 2 summarise Superprop's desired transition from single sourcing to multi-sourcing strategy.

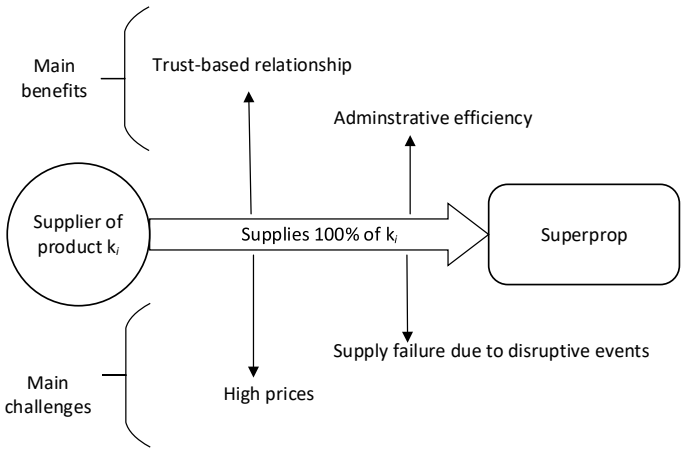

Figure 1: Superprop's single sourcing strategy, its benefits, and challenges

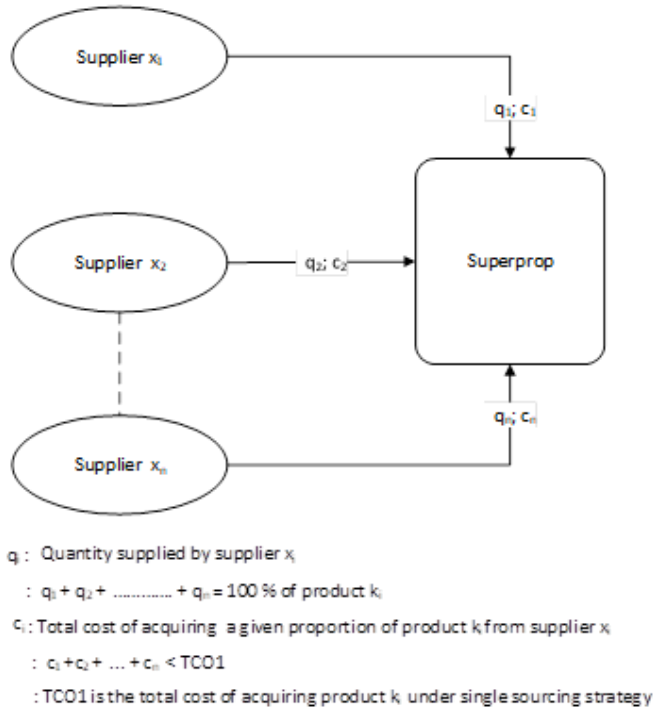

Figure 2: Superprop's desired multi-sourcing strategy

5 A systematic approach to multi-sourcing strategy

Based on the collected data from Superprop, this section provides the framework to guide the transition from single sourcing to multi-sourcing. Figure 3 summarises the proposed approach, and the explanation follows.

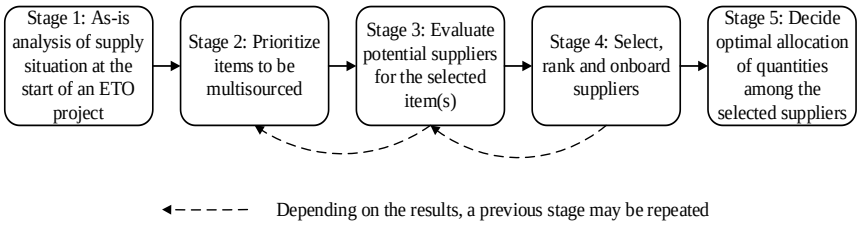

Figure 3: Systematic approach to multi-sourcing strategy in ETO production

As-is analysis of supply situation. This is the first step in the transition to multi-sourcing, where the current supply state is assessed. Two activities are critical. First, all typical materials and components used in the final product must be identified. Second, the specified items must be categorised according to their total cost of acquisition and supply risk. In the case of Superprop, the focus is their main product – propeller. Thus, all externally sourced materials and components used to make it were identified and categorised. As part of this process, product availability, the potential number of alternative suppliers, switching costs, competitive structure, and consequence of delay are assessed [19]. Each of these criteria must be evaluated by assigning a score to show its current state. For instance, for the product availability criterion, one end of the scale represents the easy availability of inputs in the market, and the other end represents a state where inputs are highly customised. Likewise, for the switching cost criterion, one end of the scale represents zero cost of switching to another supplier, and the other end represents a state where Superprop would incur a substantial cost to switch to another supplier. The same evaluation logic is applied to the other criteria. A result of this stage was an overview of Superprop's supply base for the chosen project, positioning procured items according to their overall scores.

Prioritise items to be multi-sourced. Given the information obtained in the first stage, it was quickly realised that Superprop embarking on multi-sourcing for all materials and components would be practically impossible as it would radically increase the complexity of supplier management. Thus, it was essential to prioritise and select which items that would be multi-sourced. The selected items were mainly those that score high on both financial value and supply risk.

Evaluate potential suppliers for the selected item(s). Once the priority items have been selected, the next stage is to evaluate potential suppliers. For example, one of the items prioritised by Superprop was initially supplied by a local supplier; therefore, the assessment of alternative suppliers included checking price, quality, location of the supplier, the total cost of acquisition, and delivery precision. Each of the potential suppliers is compared with the local supplier.

Select, rank and onboard suppliers. At this stage, suppliers that meet the criteria are selected and ranked accordingly. In cases where none of the potential alternative suppliers beats the incumbent supplier, the next two best suppliers are chosen. Next, all suitable suppliers should be notified that they have fulfilled the selection. Thus, information and necessary documents will then be collected to add the suppliers to the approved vendor list. Contracts with the selected suppliers must be flexible in terms of volumes. Supplier information must also be shared with all key functional areas involved in the projects. For Superprop, these would be product engineering, purchasing, production, logistics, and sales. To be effective, a dedicated cloud-based procurement software (CBPS) must be in place. This will facilitate interaction with suppliers and across the organisation.

Decide optimal allocation of quantities among the selected suppliers. Once an order is received and preliminary BOM is created based on the initial drawings, the procurement must be involved to start estimations from the pool of suppliers through simultaneous requests for information. A CBPS can make this process very efficient and effective. At this stage, Superprop must determine an optimal number of suppliers

that minimises the total cost of acquisition without compromising quality and delivery precision. Using information generated in the previous step, Superprop must determine an optimal number of suppliers and their respective quantities. Based on the results, the sales unit can create a final offer to the client. Hence, the allocation of amounts is not subject to a long-term contract; instead, it is tied to the project at hand. This means an evaluation must be conducted for each new project to renew the allocation. However, since Superprop wants to ensure that multi-sourcing is viable in every project, it must maintain relationships with at least two potential suppliers. This can be achieved by assuring at least 20% allocation of supplies in each project. The remaining 60% should be contested between suppliers based on the total cost of acquisition.

6 Closing remarks

In response to increased uncertainties and competition, firms worldwide seek ways to maximise value through strategies such as multi-sourcing. In this study, a clinical management study guides an ETO firm to implement a multi-sourcing strategy. The study is part of a larger project that aims to address logistics-related challenges faced by the case firm and its suppliers. Based on knowledge derived from previous collaborations with the case company and the data collected from this current project, a systematic approach is developed for implementing multi-sourcing. Of the five stages, the case firm has implemented the first three. Besides, so far, only one major component has been considered. In the next steps of the project, the final two stages will be implemented for the selected component and subsequently extend the approach to other items. Although the study is based on a single case, the developed framework can be applied by other ETO firms when transitioning from single sourcing to multi-sourcing strategy.

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