Development of a Maintenance Supplier Selection Model for the Thai Petrochemical Industry

Thareewan Wongthong[1], Asst. Prof. Dr.Naraphorn Paoprasert[2*]
[1]Student, Doctor of Philosophy Program in Industrial Engineering, Kasetsart University
Email: thareewan.ttw@gmail.com
[2*]Adivisor, Doctor of Philosophy Program in Industrial Engineering, Kasetsart University
Email: fengnpp@ku.ac.th
(Note: * Corresponding author)

Abstract

This paper reports on research in progress on development of a supplier selection model for the maintenance department of a petrochemical firm in Thailand. Although there are various supplier selection models available, few if any have addressed the special needs of the petrochemical industry, which is highly competitive and has several conflicting internal factors including high price competition (requiring cost leadership and therefore operational cost controls), mission-critical quality requirements, and at least in Thailand a weak and fragmented supply chain and logistics network that can delay supplies and a shortage of key human resources and skills. The preliminary supplier selection model derived from the literature review incorporates six requirements which sometimes conflict, including cost, quality, time, reliability, flexibility, and human resources. The research in progress uses a mixed methods approach that incorporates interviews with industry experts to provide user, manager, and supplier perspectives, coupled with an industry survey of those involved in supplier selection. This research is expected to deliver a refined and reliable supplier selection model that can be used in practice to meet the needs of the Thai petrochemical industry for maintenance supplier selection and monitoring of outsourcing contracts and performance.

Keywords: supplier selection, outsourcing, petrochemical industry

1. Introduction

This paper presents the theoretical framework that has been developed for a research project in progress. The research project addresses supplier selection in the context of the Thai petrochemical industry.

Thailand's Petrochemical Industry

The petrochemical industry is the global commodity industry that produces useful industry chemicals from the processing of crude oil, particularly aromatics (such as xylene, toluene and benzene) and olefins (such as propylene and ethylene) (Mall, 2006). The petrochemical industry has a complex supply chain, beginning with crude petroleum extraction and continuing through vertically integrated upstream, midstream and downstream operations before reaching end consumers (Leingchan, 2017).

The Thai petrochemical industry, which has been operating since the early 1980s, is mainly located in Map Ta Phut in Rayong Province (Spitz, 2003). It is here that the first ethane cracking plant was established by the Petroleum Authority of Thailand in 1989 and where the center of the petrochemical industry has been since that time. As of 2016, Thailand's petrochemical production was rated 2nd in ASEAN and 16th in the world (Leingchan, 2017). As of 2017, Thailand's petrochemical industry produced 12 million metric tons of upstream petrochemicals, 7.2 million metric tons in the midstream segment, and 10.5 million metric tons in the downstream segment (Leingchan, 2017). Most of this production is olefins, including propylene, ethylene and p-xylene (Leingchan, 2017). The industry is a heavily concentrated oligarchy, with 83% of market share split between the state-owned PTT (54% of production) and publicly-traded (though majority crown-owned) SCG (29% of production) (Leingchan, 2017).

There are several structural problems in the Thai petrochemical industry that affect productivity and efficiency. Historically, the industry has suffered from inefficient logistics and supply chain operations, inadequate human resource availability, supply quality problems and low levels of research and development (R&D) (FTIPC, 2012). In the long term, the industry suffers from mismatches between the short, unpredictable demand cycles and the long-run capital development cycle, as it currently takes six to nine years for a new plant to come online (Leingchan, 2017). Thai petrochemical producers also face an impending supply constraint as Thailand's domestic supplies of feedstocks (natural gas) are nearly depleted, forcing firms to move to Chinese suppliers (Leingchan, 2017). There are also global pressures that affect the whole industry, including engineering and materials safety and the growing importance of sustainability in the face of accelerating climate change (Huang, Yang, & Kao, 2012; Samuel, Agamuthu, & Hashim, 2013).

Rationale for the Study

Thailand's petrochemical industry, like most of the global petrochemical industry, is heavily dependent on external suppliers for supply and materials (Vanteddu, Chinnam, & Gushikin, 2011). The petrochemical industry is also heavily cost-focused, which is essential

because it relies on a cost leadership strategy to gain competitive advantage in the global petrochemical commodity market (Leingchan, 2017). Preliminary interviews with informants at ABC Company, the company that acts as the case study for this research, indicates that these cost pressures mean that cost rather than quality predominates in the critical supplier selection decision. This causes some serious problems in maintenance supply, including materials that do not match the specifications in the Terms of Reference, delayed or missed deliveries, poor engineering practices and poor production quality. Thus, there is a clear practical need for ABC Company to have a balanced supplier selection decision process model that reflects the specific needs of the firm and the industry and that takes into account both cost and other aspects of the company's requirements. However, there has not to date been much academic research directed toward supplier management or supplier selection in the petrochemical industry, meaning that there are no ready models to draw on to assist ABC Company. Therefore, the rationale for conducting this research is to deliver an effective practical tool for supplier selection that meets ABC Company's special needs.

Aims and Objectives of the Study

The aim of the research being undertaken is to develop a supplier selection model for the petrochemical industry of Thailand. Specific objectives of the study include:

1. Investigating factors that influence effectiveness of maintenance engineering supplier selection;
2. Developing and testing the supplier selection model; and
3. Making recommendations for implementation.

The purpose of this paper is to report on the theoretical foundations and research methods developed for this in-progress research and to evaluate the potential contribution of the research to both theory and practice of supplier selection.

2. Literature Review

Supplier selection models

Supplier selection is an organizational process of choosing outsourcing suppliers for specific needs of the firm, e.g. supplies, raw materials, inventory, or parts and equipment (Ravindran & Warsing, 2016). Kim and Wagner (2012, p. 2864) identified supplier selection as a four-stage process of "(1) attention (demand); (2) setting decision criteria; (3) finding or designing suitable alternatives; and (4) evaluating and choosing alternatives". Despite this seemingly simple process, supplier selection is actually a multi-criteria decision process that balances attributes of different suppliers to make the optimal selection decision (Ravindran

& Warsing, 2016). There are also several risks that can be encountered in the supplier selection process, including quality risks, security risks, and risks relating to on-time delivery of orders (Micheli, Cagno, & Zorzini, 2008). Firms can use techniques including supplier relationships and cooperative development to reduce supplier risk (Ravindran & Warsing, 2016), but this may not necessarily be effective, especially under information asymmetries about suppliers or unexpected supplier underperformance (Micheli, et al., 2008). In Thailand, for example, logistics issues and customs delays can impede delivery of supplies even if suppliers perform as expected (FTIPC, 2012). Given these problems, the use of a formal supplier selection model, or a staged decision process model that allows comparison of suppliers for specific requirements using quantitative and qualitative factors, is critical for effective supplier selection (Ravindran & Warsing, 2016). Most such models are based on techniques such as multi-criteria decision analysis (MCDA) or a variant of this technique such as ELECTRE, which effectively balance multiple decision requirements (Almeida, 2007; Lin, 2012; Pleumpirom & Amornsawadwatana, 2013). Supplier selection models are typically developed based on industry-specific requirements, but only a single such model has been developed for the petrochemical industry (Sayfi & Nikbakht, 2016). This model addresses green supplier management rather than providing a general supplier selection mode. Thus, there is an opportunity for the research in progress to contribute to the literature by developing a model that takes into account multiple decision factors for the industry.

Factors in supplier selection

The literature review identified six factors that may be taken into account in supplier selection models and that are relevant to the supplier selection context of the Thai petrochemical industry. These factors include cost, quality, time, reliability, flexibility, and human resources.

Cost. Cost refers to the total cost of acquisition of supplies and services, including external costs (products/services and delivery) and internal management costs (Christopher, 2016). Although outsourcing has historically been used to reduce costs, today firms may prefer other criteria such as quality or supplier relationships (Wilcocks, Cullen, & Craig, 2016). Nevertheless, cost is commonly used in supplier selection models (Almeida, 2007; Amid, Ghodyspour, & O'Brien, 2011; Demirtas & Üstün, 2008; Lin, 2012; Pleumpirom & Amornsawadwatana, 2013).

Quality. Quality, or the extent to which the service or product supplied meets the expectations of the customer, is the most commonly identified factor in a review of supplier selection models (Ho, Xu, & Dey, 2010). Quality requirements are typically set out in the terms of reference (TOR) or service level agreement (SLA), (Goo, Huang, & Hart, 2008;

Martinez-Noya, Garcia-Canal, & Guillen, 2013). Quality is often a trade-off with cost, as high-quality products or services are typically higher-cost (Lee, Yeung, & Hong, 2012).

Time.Time represents the ability of the supplier to meet time commitments for deliveries (Wilcocks, et al., 2016). On-time delivery is particularly important for maintenance operations, since such operations may not keep a large parts inventory and therefore deliveries are highly time-sensitive (Pleumpirom & Amornsawadwatana, 2013). There are several on-time delivery risks that can occur even with optimal supplier selection, including long and uncertain lead times and inconsistent delivery performance (Venkatesan & Kumanan, 2012).

Reliability. Reliability, or dependability, refers to the degree to which suppliers routinely meet requirements for cost, quality, and on-time delivery of products (Tate & Ellram, 2012). Reliability or dependability constructs are not always included in supplier selection models (Ho, et al., 2010). However, reliability is particularly important in the Thai petrochemical industry precisely because suppliers can be highly unreliable, according to the preliminary interviews.

Flexibility. Flexibility refers to the ability of suppliers to change production and supply plans

based on changing market conditions; for example, providing additional capacity or reducing production in response to demand (Demirtas & Üstün, 2008; Pleumpirom & Amornsawadwatana, 2013). Although flexibility is not always included in supplier selection models (Ho, et al., 2010), the volatile conditions of the petrochemical industry requires that this factor be considered here.

Human resources. Human resources refers to the access of the supplier to the labor power, skills and knowledge required to meet the requirements of the contract (Bruel, 2017). As with reliability and flexibility, this factor is not always included in supplier selection models. However, given that the petrochemical industry in Thailand operates under constant human resources shortages, especially for skilled and technical workers (FTIPC, 2012), this is a critical factor in the industry.

Conceptual framework

The conceptual framework developed for the research is shown in Figure 1. This shows the six hypotheses that have been derived from the literature review, which will be evaluated in the research process conducted below. Thus, there may be further adjustments to the conceptual framework during the process of the research.

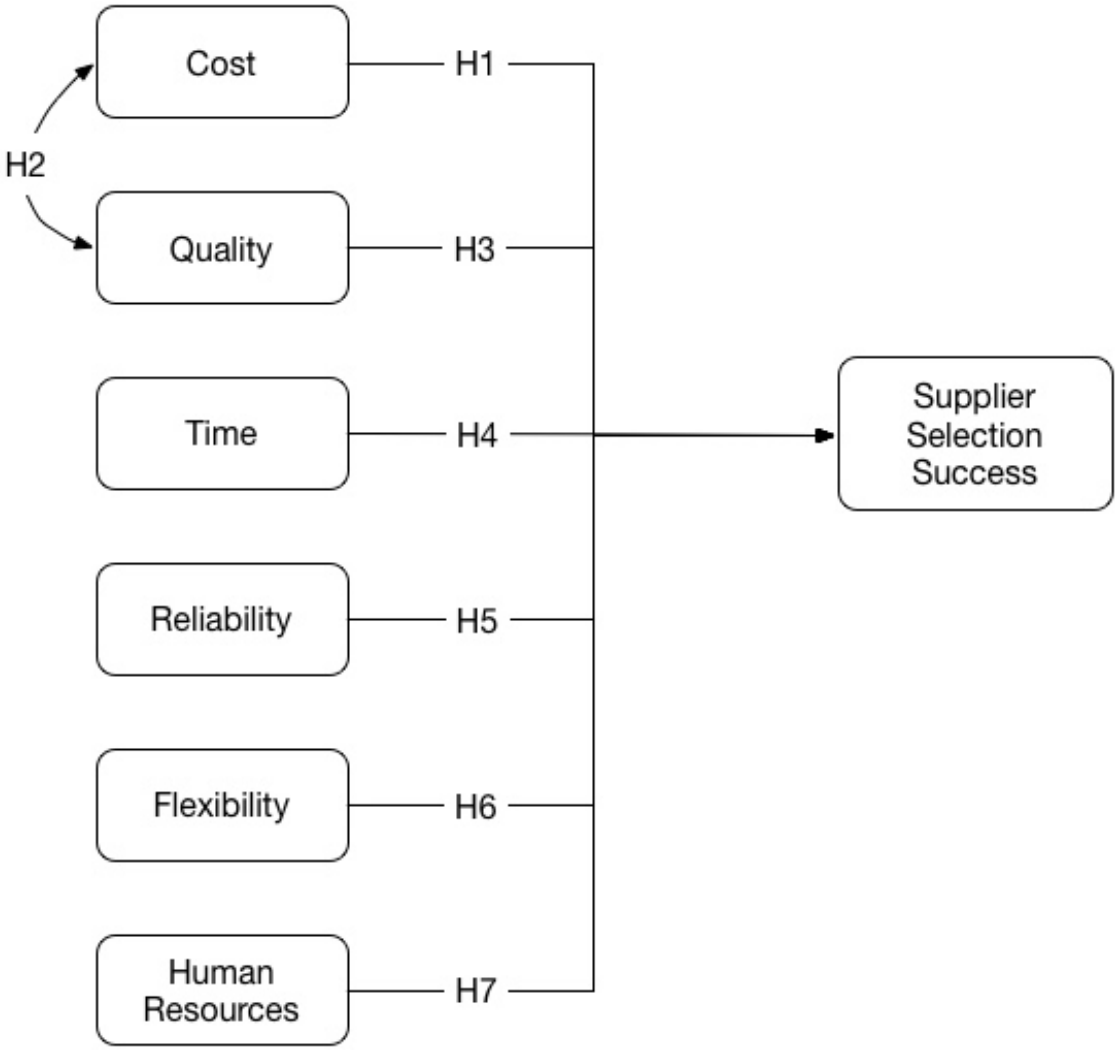

Figure 1 Conceptual framework of the research

3. Methodology

The research in progress uses a qualitative-led mixed methods design, which was selected because of a need to establish industry needs from the perspective of experts before testing the model. Qualitative research is used to begin the study, and the output from the qualitative analysis is used as input to adapt and test the proposed supplier selection model in the quantitative research. The qualitative and quantitative research streams are described in brief below.

Qualitative research stage

The qualitative research uses a purposive sampling (Eriksson & Kovalainen, 2016) of industry experts, including procurement specialists and managers in the maintenance

engineering department at ABC Company (minimum n = 5). Data is collected using in-person semi-structured interviews, which are intended to balance shared perspectives on the proposed model and the inclusion of new information. Data analysis is conducted using qualitative content analysis (QCA), a technique that seeks to interpret rather than just describe the meaning of texts (Eriksson & Kovalainen, 2016). The output of the quantitative research is used to adapt the conceptual framework, which is then presented to the same experts in a second round of interviews for final adjustments (if required) prior to the quantitative research.

Quantitative research stage

The quantitative research stage tests and evaluates the supplier selection model derived from the qualitative research. The survey draws on an expert population of supplier management experts in the Thai petrochemical industries, including procurement specialists and managers, buyers, and others who work with them. A minimum sample of 200 members is sought to ensure adequate sample size for the structural equation modeling (SEM) process (Westland, 2010). The sparse and relatively small sample size does present a challenge for collecting a large sample. The snowball sampling technique (Collis & Hussey, 2013) is used to overcome this problem. Analysis is conducted on the data collected in the survey using SEM techniques. SEM was selected because it allows a whole model to be developed and tested rather than testing individual relationships (Kline, 2011). The SEM process will include exploratory factor analysis (for item reduction and relationship testing) and confirmatory factor analysis (for model confirmation). The items used for each variable is presented in Table 1 below.

Table 1: Questionnaire Items

Scale	Items	Measure
Cost	1. Supplier cost is competitive compared to other possible suppliers. 2. The supplier offered the lowest cost. 3. The supplier cost was good considering the quality provided.	5-point Likert scale
Quality	1. The supplier uses good quality assurance procedures. 2. The supplier's work is known to be good compared to other possible suppliers. 3. The supplier's work quality meets our needs.	5-point Likert scale
Time	1. We can trust this supplier to deliver on time. 2. This supplier's communications and work is timely.	5-point Likert

Scale	Items	Measure
	3. This supplier can work within our production schedule.	scale
Reliability	1. This supplier has a reliable stock of parts and equipment. 2. If needed, this supplier can supply specialists. 3. We trust this supplier to get the work done on time and on budget.	5-point Likert scale
Flexibility	1. This supplier can respond to emergency needs. 2. This supplier is flexible to meet our needs. 3. This supplier can cope with changes in demand.	5-point Likert scale
Human Resources	1. This supplier employs the appropriate specialists and technicians to perform our maintenance properly. 2. This supplier's employees are up to date with the latest techniques and knowledge. 3. This supplier's employees are a major advantage.	5-point Likert scale
Supplier Selection Success	1. This supplier fully meets our maintenance needs. 2. We would renew an existing maintenance contract with this supplier. 3. This supplier is preferable to other available suppliers.	5-point Likert scale

4. Conclusion

This paper has reported on an in-progress research study designed to develop a supplier selection model for maintenance engineering in the petrochemical industry of Thailand. This model development process will result in a practical multi-criteria decision model that balances the requirements of suppliers in this industry and the trade-offs required between the different requirements. This supplier selection model will be of the most use within the industry and market where it was developed, as it is designed to overcome specific challenges including logistics unreliability, poor supplier quality, and human resources shortages that are endemic to the industry. Currently, the qualitative stage of the research is ongoing, with interviews being conducted in the maintenance engineering department of ABC Company to establish the challenges of supplier selection and the firm's current process. These insights will be used to develop a final supplier selection model, which could be different from the preliminary model proposed here.

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