

# **Lean Manufacturing Adoption in the Transport and Logistics Sector of Thailand – An Exploratory Study**

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## **Abstract**

This paper investigates the adoption status of lean manufacturing (LM) in the transport and logistics sector of Thailand. A survey questionnaire was design, validated and distributed among Thai transport and logistics companies. In total, 120 useable responses were received and analysed using descriptive statistics. The results of the study indicate that the implementation of LM is relatively high, with PDCA, 5S and root cause analysis being the most implemented LM approaches and tools. However, the LM's implementation was found to be mainly contained within individual departments or improvement projects, rather than being a company's wide strategy. Main challenges to LM implementation included: organisational structure of companies, misalignment between goals of individuals and their companies, and lack of sustainment of a lean culture. Main benefits were the ability to identify and reduce waste, increased productivity and better organisation of workstations. On the other hand, lack of understanding, knowledge and expertise in LM were the main reasons for not implementing it, plus the use of technology-based tools instead of LM. Non-LM companies showed interest in adopting LM in the future, with JIT, Kaizen and Six Sigma being the most likely to implement. This study is among the very first of its kind. It offers academics, researchers and practitioners interested in LM and/or the transport and logistics sector with some initial evidence of the adoption of LM in this industrial sector of Thailand.

## **Keywords**

Exploratory study, implementation, lean manufacturing, Thailand, transport and logistics sector

## **1. Introduction**

Lean manufacturing (LM) born from the Toyota Production System (TPS) as a strategy developed by this organisation to gain competitiveness through the fierce elimination of waste and the creation of an efficient process flow (Jasti and Kodali, 2015). Nowadays, lean manufacturing is considered the most influential new paradigm in manufacturing (Hines et al., 2004), and hence its concepts, methods and tools have been adopted as best practices by many manufacturing companies (Forrester et al., 2010). The positive results obtained from the implementation of LM, which are extensively reported from empirical and theoretical research in the academic literature (Belekoukias et al., 2014), have resulted in LM gaining popularity in a wide range of industrial sectors, other than only manufacturing, all around the world (Garza-Reyes et al., 2012).

Despite the manufacturing sector has generally been one of the main industries driving the economic growth of nations, current global markets, and their increased competitiveness, have made the transport and logistics sector an also significant player in the effective and efficient management of a company's operations. This is because transport and logistics represent the backbone of global supply chains (Pejić et al., 2016). In a globalised market, transport and logistics make the demand and supply closer and more connected between markets. Therefore, this activity represents and opportunity and challenge for organisations to increase productivity with less cost while still meeting their customers' expectations. In this line, even though transportation and logistics are considered as a tertiary economic activity (Chase and Apte, 2007), it can nowadays play a significant role as a differentiating factor that adds service value to customers (Villarreal et al., 2009).

Despite its current importance and the competitive edge that it can now represent for organisations, transport and logistics activities, specially road transport ones, have been considered inefficient (Villarreal et al., 2017; Villarreal et al., 2016a). These inefficiencies, and indeed the general improvement of transport and logistics operations, have been traditionally addressed through the use of operations research, mathematical modelling, and simulation methods (Villarreal et al., 2017; Villarreal et al., 2016a; Sternberg et al., 2013). However, since most transport and logistics networks suffer from significant wastes and unnecessary costs (McKinnon et al., 2003), the application of lean manufacturing principles, methods and tools has recently been explored as an opportunity to supplement the traditional improvement approaches, with positive results obtained from such application (e.g. Villarreal et al., 2017; Garza-Reyes et al., 2017; Villarreal et al., 2016a; Villarreal et al., 2016b; Garza-Reyes et al., 2016). Therefore, LM has been found to have the potential to enhance the capability of the transport and logistics sector to make it more competitive through the elimination of wastes, increased productivity, and reduced lead times.

Based on the potential benefits that LM may bring to the transport and logistics sector, this study investigates the application status of this approach, particularly, in the Thai transport and logistics industry. This includes an exploration of the benefits experienced and challenges faced by companies in this sector and country when implementing LM, their reasons for embarking or ignoring such implementation, LM tools they have adopted, etc. Thailand has a competitive advantage in terms of geographical location when compared to other neighbouring countries as its location for distribution centres can offer organisations with an exceptional opportunity to optimise both exports and imports (Thai and Grewal, 2005). In this case, LM may offer Thai companies in this sector a complementary opportunity to enhance the physical location advantage that this nation offers to them by making their transport and logistics activities more effective and efficient, and hence competitive.

In terms of scholarly research, various studies have explored the implementation of LM in various industrial sectors of Thailand, but predominantly in manufacturing. For instance, Rahman et al. (2010) conducted a study that investigated the extent to which LM practices have been adopted by manufacturing organisations in Thailand and their impact on their operational performance. The study results suggested that LM represents an essential factor for Thai manufacturing companies to improve their operational performance. Furthermore, Laoha and Sukto (2015) conducted a lean assessment for manufacturing small and medium size enterprises (SMEs) of 2 industrial groups in the Northeast of Thailand. The results of their study indicated the 'leaness' level of two different industries in Thailand, i.e. shoes and garments. Lertwattanapongchai and Swierczek (2014) developed an integrative conceptual framework of Lean Six Sigma (LSS) as a project and an organisational change process. The framework was tested through a case study in a Thai organisation, offering an example of the integration of Lean Six Sigma (LSS) project design and the change management process in this country. Choomlucksana et al. (2015) employed LM methods such as Kaizen and 5S to improve the work efficiency of a sheet metal stamping process carried out by a Thai manufacturing organisation. Lila (2012) conducted a study on the attitude and level of understanding of automotive manufacturers in the Eastern region of Thailand in relation to the implementation and benefits of LM. In general, the results suggested that Thai manufacturing companies in this region were aware of and employed LM as almost 62%

of the 76 studied companies had adopted LM, or at least used some of its principles, methods and/or tools. Pradabwong et al. (2012) investigated the current stage of LM adoption in Thailand and the barriers to its implementation experienced by companies in this country. Their qualitative research involved interviews with 10 industrial companies practicing LM, and the results showed that most of these understood the principles of this approach. Kiatcharoenpol et al. (2014) identified and prioritised critical success factors (CSFs) for the adoption of LM in Thai SMEs. The results of their investigation indicated that ‘technology resource’ is the most important CSF for Thai SME manufacturing companies to enhance the implementation of LM into their operations. Despite the aforementioned researches provide evidence that shows the interest of researchers in understanding the implementation of LM in Thailand, similar investigations in the transport and logistics sector of this country are almost non-existent, with only Punnakitikasem et al. (2013) paying attention to this under-researched area. However, Punnakitikasem et al. (2013) investigation only focused on determining the factors affecting the success of LM implementation in Thai logistics companies, but ignored other dimensions of its implementation status, e.g. awareness, benefits, barriers, results obtained, reasons, tools deployed, etc. This study therefore aims at complementing the study of Punnakitikasem et al. (2013) and expand the knowledge regarding the implementation of LM in the Thai transport and logistics industry.

## **2. Literature review**

The adoption of LM in the manufacturing and service sectors has been extensively and well documented. However, its application in the transport and logistics sector is limited and in early stages (Villarreal et al., 2017). The transport and logistics sector is a highly competitive industry where the market is limited and cost is a major crucial factor. Pejić et al. (2016) suggests that logistics operations have a great impact on operational costs, and hence organisations are constantly searching for potential approaches to effectively reduce these costs. In this context, De Haan et al. (2012) suggest that LM can help the transport and logistics sector to effectively control costs and increase the value of its processes by eliminating non-value added activities in its operations. Therefore, implementing LM can optimise routes to create efficiency and environmentally sustainable transportation by identifying and eliminating wastes with effective strategies.

In terms of the work carried out in the field of ‘lean logistics’, some researchers have concentrated on adapting the Toyota’s seven wastes to transport operations (e.g. Sternberg et al., 2013; Sutherland and Bennett, 2007; Guan et al., 2003), whereas others have focused on proposing lean performance measures (e.g. Taylor and Martichenko, 2006; Simons et al., 2004; Mason et al., 2001; Villarreal, 2012) and frameworks to assess and improve road transport operations. For example, Sutherland and Bennett (2007) defined excess transport/conveyance, space, overproduction, delay/wait, motion, errors, and motion as the ‘Seven Deadly Wastes of Logistics’. In the same way, Guan et al. (2003) identified five transport wastes, namely: fill losses, excess load time, speed losses, driver breaks and quality delays. Finally, Sternberg et al. (2013) developed the Seven Transportation Extended Wastes (STEWs) by including uncovered assignments and resource utilisation as part of the original wastes proposed by Toyota. The STEWs have been extensively used in the works of Villarreal et al. (2017), Villarreal et al. (2016a) and Villarreal et al. (2016b) to drive the improvement of transport and logistics operations.

On the other hand, Taylor and Martichenko (2006) suggested four laws for lean transportation, i.e. daily event management, transportation waste, transportation strategy, and transportation performance. These laws explain how LM can positively impact transport and logistics operations by identifying where, and how, these operations may be sub-optimal. Simons et al. (2004) and Mason et al. (2001) adapted the lean’s overall equipment effectiveness (OEE) (Nakajima, 1988) metric commonly used in production environments to develop a metric suitable to transport and logistics environments called overall vehicle effectiveness (OVE). Later on, Guan et al. (2003) modified OVE to also consider the efficiency of a route. This was done by dividing the performance factor into two components, i.e. time and route efficiencies. Finally, Villarreal (2012) also developed a transportation metric called transportation overall vehicle effectiveness (TOVE), which derived from the OVE metric. In this case, and unlike OVE, TOVE considers total calendar time instead of loading time. Consequently, although both metrics still measure performance based on the availability, performance and quality elements, TOVE adds the administrative availability element. Thus, TOVE separates the availability component into operating and administrative availability.

In terms of frameworks to improve transport and logistics operations, Hines and Taylor (2000) developed a four stages methodology to eliminate waste in, and increase the efficiency of, transport operations. Later on, Villarreal et al. (2009) employed this methodology, which helped a Mexican company leader in the production and distribution of frozen and refrigerated products to save \$1.4 million US dollars per year of operations cost and over \$700,000 US dollars of capital investment. In particular, the organisation experienced an improvement in the availability and

capacity utilisation of its distribution vehicles (Villarreal et al., 2009). Villarreal (2012) proposed a tool called Transportation Value Stream Mapping (TVSM), derived from the traditional Value Stream Mapping, to facilitate the improvement of efficiency in transport operations. Villarreal et al. (2012) also developed a methodology to reduce transport waste. This methodology integrates algorithms for vehicle routing optimisation with the Just-in-Time (JIT) approach of milk runs. Other recent works that have focused on proposing various methods to improve transport and logistics operations include those of Villarreal et al. (2016a), Garza-Reyes et al. (2016) and Villarreal et al. (2016b).

From the review literature previously discussed it can be concluded that most of the work on the application of LM in the transport and logistics sector has been concentrated in road transport operations, whereas its application in air, sea and rail transport and logistics operations has not been explored. Additionally, as discussed in the introduction section, studies related to the investigation of the implementation status of LM in the transport and logistics sector are almost non-existent. These gaps in the academic literature served as a motivation for the author to undertake the study presented in this paper.

### **3. Research methodology**

#### **3.1 Data collection – survey questionnaire**

In order to investigate the adoption status of LM in the transport and logistics sector of Thailand, a survey questionnaire was considered the most appropriate method for collecting empirical data since it would enable the collection of a large sample data from geographical dispersed areas within Thailand (Bryman and Bell, 2007). To facilitate the accessibility to the questionnaire via web browser or mobile device, it was electronically designed using the Qualtrics software. This also facilitated the later tabulation of data into Excel spreadsheets for easy statistical analysis. Due to the similarities with the present research, the questionnaire used to conduct this study was adapted from those of Antony and Desai (2009) and Garza-Reyes et al. (2012), who investigated the implementation status of Six Sigma and LM in India. The questionnaire instrument was comprised of a total of seventeen questions that were divided into three sections. The questions/sections intended to gather general information regarding the demographics of the participants and their organisations (section 1), and different aspects of the implementation (section 2)/non-implementation (section 3) of LM. The last included specific LM tools adopted, level of LM adoption, challenges faced by the organisation during the LM adoption, benefits obtained from LM, satisfaction of the company with LM, reasons for not having implemented LM, among others.

#### **3.2 Survey questionnaire validity and reliability**

Before a survey instrument is distributed, it is essential to inspect the questions derived from the literature and that constitute the instrument in order to gain its validity and reliability (Lancaster, 2008). In the case of the survey questionnaire developed for this research, reliability threats, i.e. subject or participant error, observer error, subject or participant bias, and observer bias, were addressed through a small scale pilot study as recommended by Robson and McCartan (2016). In this line, the survey questionnaire was sent to six subject experts that included three supply chain/logistics managers and three academics. Based on their feedback, the survey questionnaire was amended and improved to remove participant bias and errors. Overall, feedback from the academic experts contributed in ensuring that the questions in the instrument were clear, comprehensive and that these addressed the fundamental research objectives of this research. This resulted in ambiguities and irrelevant questions being eliminated. The feedback of the industrialists was taken into consideration to make sure that all questions used the right terminology employed in the Thai transport and logistics sector and that these were clear to people working within that industrial sector.

Observer bias and error were not applicable to this study as the survey questionnaire was designing based on fixed-alternative questions, for which interpretation was not needed. Thus, observer error and observer bias were irrelevant for this study (Binti Aminuddin et al., 2016).

#### **3.3 Survey questionnaire distribution**

As this was an exploratory research that investigated the application of LM in the Thai transport and logistics sector, the questionnaire was mainly posted in LinkedIn groups related to transport and logistics companies operating in Thailand. It was posted alongside a cover letter that introduced the research and its aim. Due to the wide reach of LinkedIn, which nowadays has become a reliable platform to collect research data (Papacharissi, 2009), the population sampled was considered to include more than 1,000 potential participants. To increase the response rate, the survey questionnaire was also distributed, via e-mail, among personal contacts of the authors. In total, 120 usable responses were obtained. Based on similar exploratory studies, e.g. Antony and Desai (2009) and Garza-Reyes et al.

(2012), the sample size of 120 responses was considered acceptable to draw some initial conclusions regarding the implementation of LM in the Thai transport and logistics industry.

## 4. Results, analysis and discussion

### 4.1 Respondents and companies' profiles

Figure 1 presents the demographics, i.e. profiles of the respondents, and their organisations, who participated in the study. In particular, Figure 1 illustrates (a) the position of the respondents within their companies as well as the (b) size, (c) continent of origin, and (d) main type of transport and logistics service provided by their organisations.

As it can be seen in Figure 1(d), most of the companies that participated in the study have road linkage as the main type of transport and logistics service provided. This is in line with the fact that road is still the primary transportation mode in Thailand (Kunadhamraks and Hanaoka, 2008). For example, Pongthanaisawan and Sorapipatana (2013) suggest that Thailand relies heavily on road transportation as it provides the highest proportion compared to other modes. The preference of road transport seems to be favoured by Thailand's national infrastructure as roads in this country connect many regions locally and other neighbouring countries (MarketLine, 2016). Furthermore, sea cargo represented the second highest service mode provided by the companies of the respondents. This may come from the fact that this mode supports the transportation of large quantities of products with lower costs. Air freight was found to be the third type of transport and logistics service most commonly provided by the companies of the respondents. Air freight serves a smaller customer-base due to its high cost and lack of efficiency in terms of routes and scales (MarketLine, 2016). However, Feng et al. (2015) suggest that the usage and provision trend in sea and air freight transportation in Thailand will increase due to the rapid growth of global commerce and markets, and the fact that these transportation modes facilitate trading between countries. Finally, there was a limited number of companies that offer railway services as it is mainly a state-owned industry. This creates barriers and restrictions for companies to provide and use this type of service, even though it has the ability to carry high volumes of products at a relatively cheap cost. Additionally, the current railway service in Thailand is still inefficient due to poor service quality and lack of accuracy in arrival times.

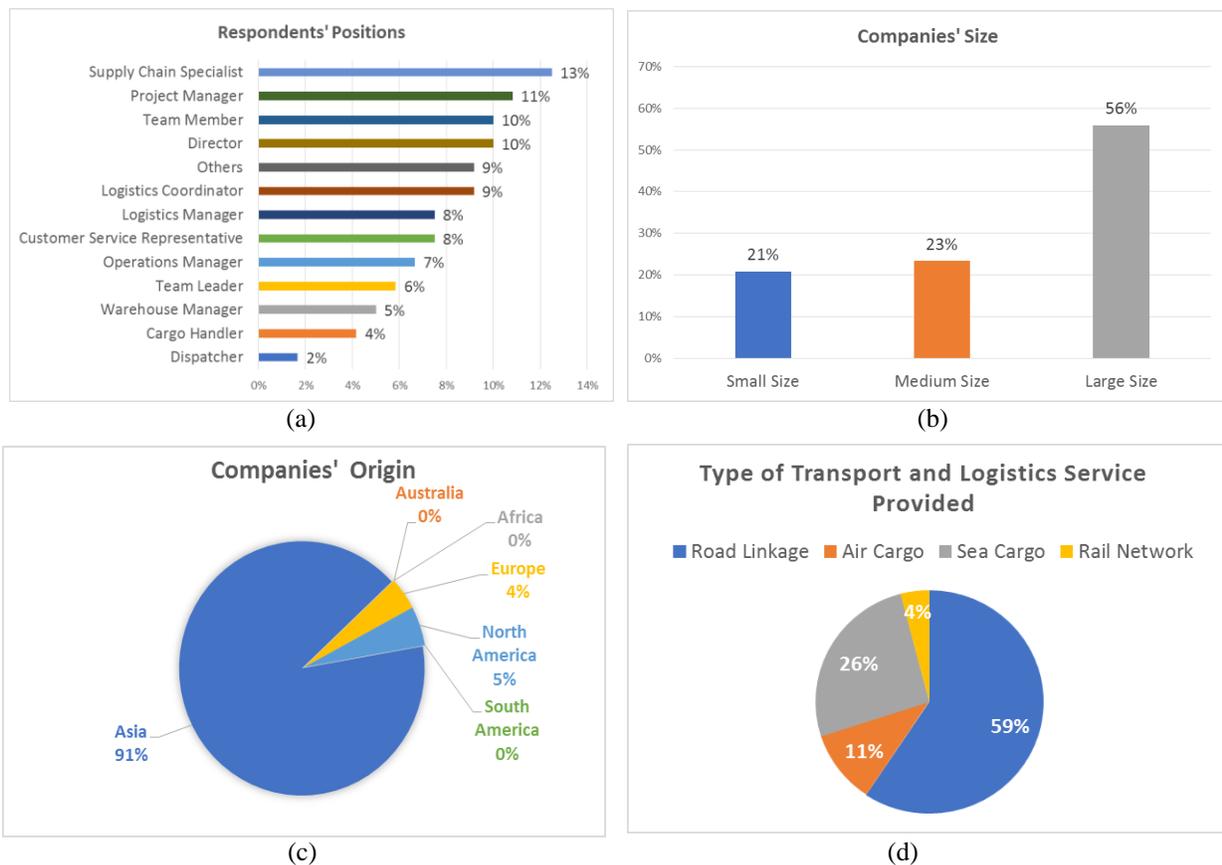


Figure 1. Respondents and companies profiles

#### **4.2 Lean manufacturing implementation**

Respondents were asked whether their organisations had implemented LM. In this case, out of the 120 Thai transport and logistics companies surveyed, 74% (i.e. 89) had implemented LM while 26% (i.e. 31) had not. Since 2013 Thailand's economy has gradually declined and become uncertain, resulting in lower exports and financial difficulties for the transport and logistics industry, and indeed for the entire country. For this reason and the advantage of location, which has the potential of turning Thailand into an important logistics' hub in Asia, the government and Thai transport and logistics organisations have aimed at reducing costs and become more competitive (Frost&Sullivan, 2017). This may have contributed to a relatively large implementation of LM in this specific industry, which also contradicts the scholarly literature that suggests that the application of LM in the transport and logistics sector is still limited (Villarreal et al., 2017).

From the 89 companies that had implemented LM in their transport and logistics operations, Figure 2 illustrates the different aspects that were investigated in this study in relation to such implementation. These included the: (a) LM approaches and tools deployed by the companies, (b) level of LM implementation, (c) challenges that the companies faced during the adoption of LM, (d) benefits achieved through such adoption, and (e) level of satisfaction experienced with its implementation. In relation to the LM approaches and tools implemented by the surveyed companies, see Figure 2(a), the Deming's PDCA (plan-do-check-act) approach was found to be the most utilised. Silva et al. (2017) suggest that the PDCA approach provides a good foundation for LM and creates a better performance based on continuous improvement. In terms of transport and logistics operations, Thammatucharee (2013) mentions that the PDCA model enhances the quality of logistics processes to ensure that these meet their expectations. Moreover, FedEx uses the PDCA model as a daily transportation management approach to ensure that the plans are correctly executed to reduce errors (Taylor and Martichenko, 2006). Thus, it is not incongruent to find that the PDCA model is the most LM approach/tool deployed by Thai transport and logistics companies. The second and third most commonly used approaches/tools deployed by Thai transport and logistics companies were 5S and root cause analysis. 5s is a LM approach that has been found to be highly used among companies that have embarked in the LM journey (Andreadis et al., 2017). The results of this study show that this is the case not only for manufacturing and service companies but also for transport and logistics firms. On the other hand, the European Association of Chemical Distributor (2015) suggests that root cause analysis can help the transport and logistics sector in identifying and eliminating the root cause of problems so operations are effectively and efficiently improved. The use of this tool can also contribute to the reduction of transportation costs (Supaprasert and Aussawakulchai, 2007). Due to the relative simplicity and effectiveness of this tool it is not surprising to see that it is one of the main choices of Thai transport and logistic companies to improve their operations.

Figure 2(b) indicates that most of the Thai transport and logistics companies (i.e. 69%) surveyed had implemented LM only in isolated functional departments (i.e. 40%) or to facilitate individual improvement projects (i.e. 29%), rather than throughout the entire organisation. This suggests that although LM has been adopted by a relatively large number of Thai transport and logistics companies, its implementation has not been considered as part of the strategic priorities of such companies. This may result in the implementation of LM fading in the short or medium term, and hence the benefits obtained from LM eroded. The understanding of the reasons for the lack of full embedment of LM into the strategic priorities and culture of Thai transport and logistics organisations still requires further and a more extensive research.

On the other hand, the surveyed organisations were also asked to state the main challenges/barriers that they faced during the implementation of LM, the results are shown in Figure 2(c). In this case, their current organisational structure, different goals and values of employees, and the embedment and maintenance of LM as part of the organisational culture were found to be the three main challenges/barriers experienced by the companies. These barriers refer more to the characteristics and DNAs of the companies rather than to the availability/lack of resources (e.g. capital and human), knowledge, expertise and training, which are factors that have been established as some of the most common barriers that organisations must overcome when implementing operations or quality improvement programmes (Winck Jacques et al., 2014; Garza-Reyes et al., 2012; Antony and Desai, 2009). Thai companies are quite reluctant to embrace new working practices as they are resilient in business but still maintain rigid hierarchical systems (Nolan et al., 2016). Moreover, the Asian culture has complex relations and networks in social life, but especially in formal businesses. These aspects can be considered as some of the most challenging factors for Thai companies to address when implementing LM. If effectively overcome, Thai workers would be more willing to accept changes in the organisational structures of their companies and to embed the adoption of new working practices and approaches, such as those that underpin LM.

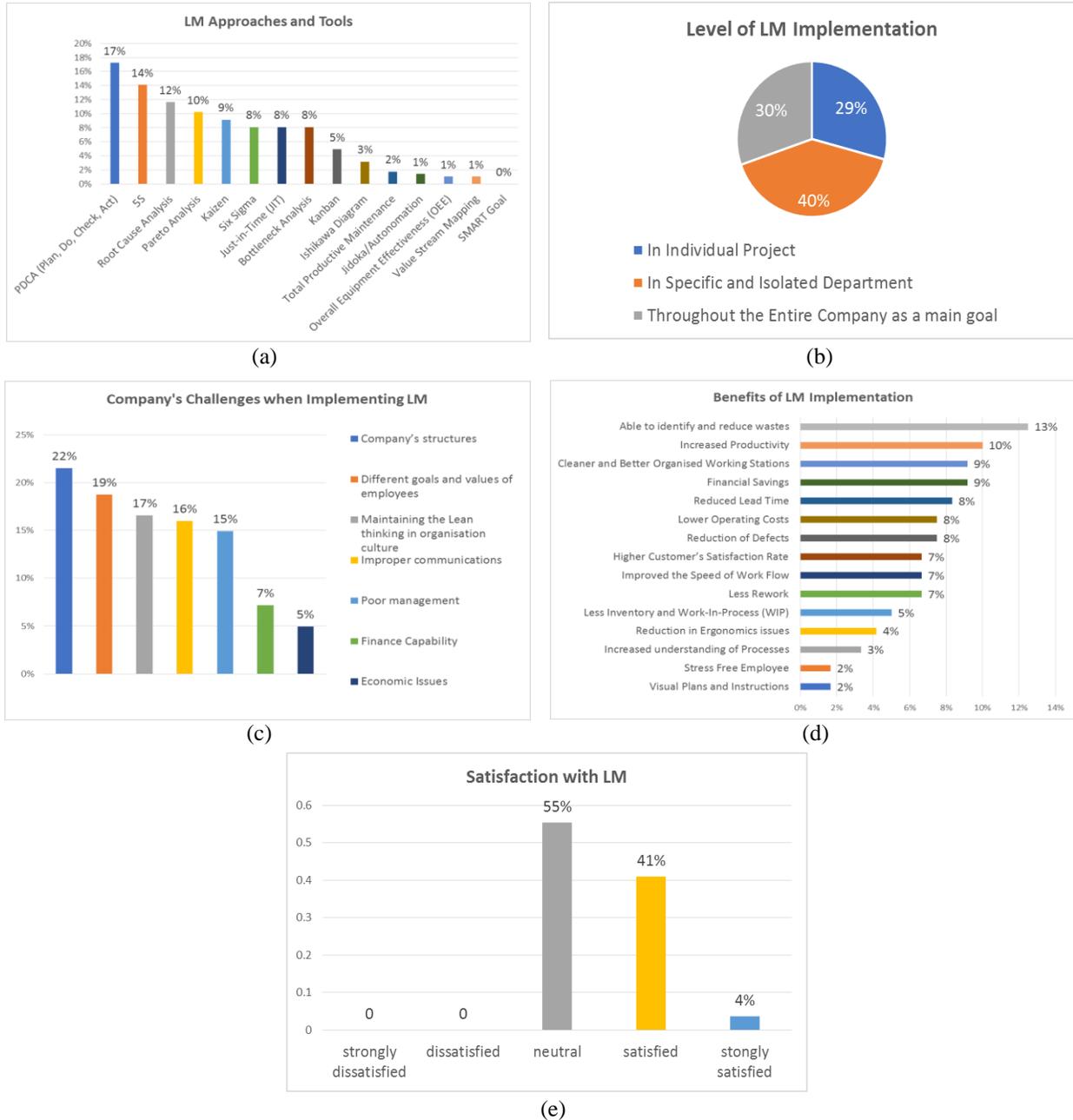


Figure 2. Different factors investigated related to the implementation of LM

Figure 2(d) presents the main benefits that the surveyed Thai transport and logistics companies acknowledged after the implementation of LM. The results of the study indicate that ability to identify and reduce waste (i.e. 13%), increasing productivity (i.e. 10%), and better organised workstations (i.e. 9%) were the main benefits experienced by such organisations. This is in line with the most commonly adopted LM approaches and tools by the same companies, see Figure 2(a), as the reduction of waste is one of the main benefits associated with the PDCA model (Silva et al., 2017). For example, Júnior et al. (2016) found that the PDCA cycle contributed in reducing waste by 30 percent as it improves efficiency in processes and operations. It also optimises equipment usage, which increases the productivity of companies. Similarly, an organised workstation may be due to the high implementation of 5S in Thai transport and logistics companies as it creates a safe work environment and enhances the productiveness of employees (Andreadis et al., 2017). For instance, Patel and Thakkar (2014) found that 5S changes companies in a positive manner, helping them to improve machines maintenance, safety, and security. 5S also helps to achieve and

sustain a more organised and tidier workplace, which in turn improves effectiveness and organisation of workstations. Therefore, it can be concluded that the benefits that the respondents found in their organisations have been achieved from implementing PDCA and 5S. The rest of the gains are also common benefits linked to LM, which confirm that the same benefits obtained by manufacturing and service companies when implementing LM will also be obtained by companies in the transport and logistics sector.

### 4.3 Non-implementation of lean manufacturing

From the 31 Thai transport and logistics companies that had not implemented LM, different aspects related to the lack of such implementation were investigated, see Figure 3. These aspects corresponded to the (a) reasons as to why these companies had not implemented LM, (b) other tools that they had implemented instead of LM to improve their transport and logistics operations, (c) future plans for implementing LM, and (d) potential LM approaches and tools that these companies may adopt if they decide to embark in the LM journey.

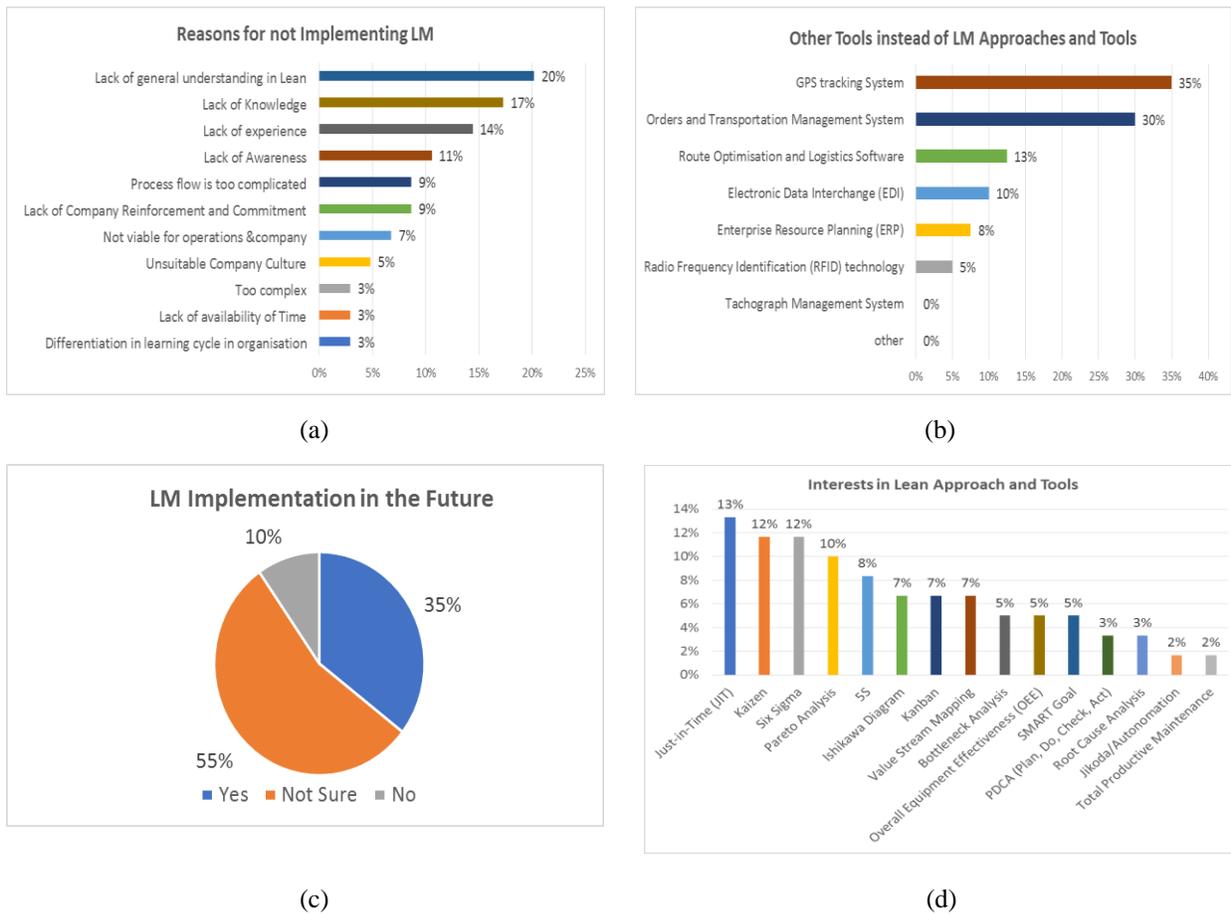


Figure 3. Different factors investigated related to the non-implementation of LM

Figure 3(a) illustrates the reasons/barriers as to why the surveyed organisations had not implemented LM. As shown by this figure, the main contributors included the lack of understanding (i.e. 20%), knowledge (i.e. 17%), and experience (i.e. 14%) in LM. These reasons are commonly reported as some of the main barriers that stop companies from implementing operations and quality improvement approaches (e.g. Garza-Reyes et al., 2015; Winck Jacques et al., 2014; Garza-Reyes et al., 2012; Antoni and Desai, 2009). Besides financial constraints and lack of support from top management, Prasad and Tata (2009) comment that lack of understanding, knowledge, and experience are also common barriers found in developing countries. Particularly, in countries like China and India these barriers have arisen due to the fact that research and application of LM has not properly expanded beyond formal academic and research environments such as universities and research institutes (Garza-Reyes et al., 2012; Pingyu and Yu,

2010). However, in this case, since a larger proportion of the surveyed organisations had adopted LM, this seems not to be the case in Thailand. The non-implementation of LM in the 31 companies surveyed may be explained based on the fact that these organisations may have considered other alternative tools to improve their transport and logistics operations. In this line, Figure 3(b) shows the main tools that companies that have not implemented LM have employed to improve their operations. Unlike LM, these are technology-based tools commonly used by transport and logistics companies.

From the 31 companies that had not implemented LM, 35% of the respondents suggested that their companies were interested in adopting this approach in the future, see Figure 3(c). Figure 3(d) illustrates the specific LM approaches and tools that these companies may adopt in the future as part of embracing LM within their companies' operations. From the results, the respondents indicated that the three main approaches and tools to be potentially implemented by their companies are Just-In-Time (JIT), Kaizen, and Six Sigma. JIT is one of the most common approaches and strategies employed by companies in the manufacturing industry to reduce inventory (Dubey and Singh, 2015). However, it can also be implemented within the transport and logistics sector in terms of goods movement between suppliers to be delivered at the right time and in the most efficient quantities (Pejić et al., 2016). JIT may be a significant LM approach for Thai companies to implement because traffic conditions in this country are extremely poor.

Kaizen is also a common approach not only in the manufacturing sector but also in the service sector. It helps in leading organisations towards innovation, which improves operational performance. Similarly, Agmoni (2016) suggested that Kaizen can help the logistics sector in improving its financial capability by increasing productivity and reducing wastes and errors. On the other hand, Lean Six Sigma can be used as an initiative for cost reduction in the transport and logistics sector as it helps to eliminate waste and make supply chains flow more efficiently (Goldsby and Martichenko, 2005). Six Sigma can optimise the ongoing processes, resulting in the reduction of waste and route time variability as it can help logistics companies to understand the source of defects and find the right solution for the problem. Therefore, it can be implied that all these advantages of the aforementioned LM approaches and tools are the reasons as to why the surveyed Thai organisations are considered the implementation of these in the future.

## **5. Conclusions**

LM has been an approach which has gained popularity in a wide range of industrial sectors due to its effectiveness in driving operational improvements. However, its application in the transport and logistics sector is still relatively unknown, especially when compared to other sectors such as manufacturing and services. This study therefore intended to provide some light into this subject by investigating the adoption status of LM, and its approaches and tools, in the transport and logistics sector of Thailand. The study is among the very first of its kind. Thus, it will provide academics, researchers and practitioners interested in LM, and/or the transport and logistics industry, with initial evidence of the adoption of this approach in a developing country like Thailand. In particular, the results of the study indicate that LM is relatively well known among Thai transport and logistics companies, and hence its implementation is also relatively high, e.g. 89 of the 120 surveyed organisations had adopted LM, with PDCA, 5S and root cause analysis being the most implemented LM approaches and tools. However, the results of the study also suggest that such implementation is mainly contained within individual departments or improvement projects, rather than being a company's wide strategy to operational improvement. Barriers related to the organisational structure of companies, misalignment between the goals of individuals and their companies as well as lack of sustainment of a lean culture were the main challenges to LM implementation, whereas the main benefits were related to LM's ability to identify and reduce waste, increase productivity and provide a better organisation of workstations. On the other hand, lack of understanding, knowledge and expertise in LM were the main reasons for not implementing it, plus the fact that most of the companies used technology-based tools to improve their operations. Despite this, some companies commented that they would be interested in adopting LM in the future, with JIT, Kaizen and Six Sigma being the most likely approaches and tools they would implement.

This study has presented some interesting evidence regarding the adoption of the LM in the Thai transport and logistics industry. However, the results obtained need to be interpreted with caution. Limitations of the study in terms of the survey's sample size, response rate and analysis do not allow the generalisation of conclusions. Budget and time constraints acted as factors that limited the scope of this research. Therefore, future research can conduct a more robust and extensive study to validate the results obtained from this research. Additionally, the same study can be conducted in other countries to compare their level of adoption of LM in their own transport and logistics industry with that of Thailand.

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