The Influence of Lean Success Factors and Innovation on Competitiveness: A Structural Equation Modeling

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Abstract

The primary goal of this research is to investigate the positive impact of Lean success factors and product innovation on competitiveness in terms of cost & price, products quality, and delivery. The information was gathered through questionnaires from 409 executives of automotive industry and analyzed using a structure equation model (SEM). The results correlated to the empirical evidence in a good level. CMIN/DF = 2.627, GFI = 0.949, NFI = 0.950, RFI = 0.916, IFI = 0.968, TLI = 0.946, CFI = 0.968, RMSEA = 0.063. According to the findings of this study, the Lean success factors had positive effects on competitiveness in terms of cost and price (0.65), products quality (0.19) but no statistically significant effects on delivery. Product innovation benefited from lean success factors (0.67). Product innovation improved competitiveness in terms of product quality (0.80) and delivery (0.90), but had no statistically significant effects on competitiveness in terms cost and price of Thai automotive industry.

Keywords: 1) Lean success factors 2) Innovation 3) Competitive advantage 4) Automotive Industry

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Introduction

The automotive industry is highly important to Thailand, which is one of the world's predominant car production bases. In 2020, the number of cars produced in Thailand was ranked twelfth in the world, fifth in Asia, and first in ASEAN, while the automobile market in Thailand itself was placed twentieth in the world, sixth in Asia, and second in ASEAN (Organisation Internationale des Constructeurs d'Automobiles, 2021). The automotive industry is highly competitive, forcing businesses to develop ever more efficient manufacturing technology, create systematic management plans, and undergo continual development in order to remain competitive in the market. The good management of production and product innovation are driving forces for increasing competitiveness in this industry (The Office of Industrial Economics, 2018). Production management is an important activity for the automotive industry, and is considered to be the heart of supply chain management in the industry. Good production efficiency will affect the costs, the optimal use of resources, and the competitiveness of an organization. For this reason, the development of greater production efficiency and reduction in production system waste are of great importance and a modern necessity. In this regard, lean manufacturing is a system that is considered to be among the best production management systems in industry. Originating from the Toyota Production System (TPS), it is widely used in many industries, especially the automotive one, driving improved production standards and helping to reduce waste in operations while increasing productivity. The Lean Manufacturing System (LMS) focuses on reducing waste in the work processes at each production stage, based on the concept of creating value from work at the lowest cost and also increasing competitiveness in based on product quality, price, and costs, including in the goods delivery process to ensure customer satisfaction (Koloszár, 2018, pp. 26-41). The adoption of a lean system in the production process can help to create a systematic work culture without any unnecessary overlap of work, enabling all the people in an organization to realize their own duties and make improvements in their work, thus making all the work in the process flow continuously and efficiently, while driving continual improvements, turning the internal culture into a lean culture, and increasing the competitiveness of the organization (Prado-Prado, et al., 2020, p. 4981). The well-recognized potential benefits of the LMS have led to a large number of executives in factories, especially those in the automotive industry, to seek to apply lean manufacturing in their factories, with an aim to increase their competitiveness (Lewis, 2000, pp. 959–978; Prajogo and Olhager, 2012, pp. 514–522; Prajogo, Oke and Olhager, 2016, pp. 220–238).

However, to apply the LMS effectively, the company executives should understand the Lean Success Factors (LSFs), because the application of the LMS requires there to be an understanding among all personnel and cooperation from every part of the organization. Also, the implementation of the LMS will not only change the relevant parts of the work system where it is applied, it will

also impact the work culture of the whole organization. Therefore, several considerations need to be taken into account to benefit most from these changes, such as work motivation, the executives' involvement, staff training, and communication inside and outside the organization. All of these are key factors that will influence the organization's development to become successful in adopting the LMS, ultimately leading to increasing its sustainability in developing every aspect of its competitiveness in the market (Suksamarnwong and Wanarat, 2017, pp. 109–128). Furthermore, the business organization may still face tough competition to continue in the market and may need to remain creative by developing new products in order to satisfy the changing and evolving needs of customers. For this reason, product innovations are needed to differentiate an organization from its competitors and these may play an important role in the organization's ongoing operation. Here, innovations both inside and outside the organization need to be created and continually developed.

From the information above, it is clear that as the automotive industry needs to constantly adapt and is characterized by intense competition, the application of lean systems could assist in improving process management and support further product innovation and hopefully improve the applying firms competitiveness. With this in mind, the researcher was interested in studying the success factors for an organization applying an LMS and their effect on product innovation and ultimately the organization's competitiveness, with a special focus on the automotive industry, which is one of Thailand's main industries, as well as the wider benefits for business organizations, both in the automotive and other industries, so that they can apply the concepts investigated by this research to enhance their efficiency and make operational improvements.

Research Objectives

To study the effects of the Lean Success Factors on competitiveness in prices and costs;

1. To study the effects of the Lean Success Factors on competitiveness in product quality;

2. To study the effects of the Lean Success Factors on competitiveness in delivery;

3. To study the effects of the Lean Success Factors on competitiveness in product innovation;

4. To study the effects of product innovation on competitiveness in prices and costs;

5. To study the effects of product innovation on competitiveness in product quality; and

6. To study the effects of product innovation on competitiveness in the delivery process

Literature Review

The LMS is a tool designed to promote excellence in production processes, specifically aimed at improving process management efficiency by minimizing loss, which would otherwise result in wastage and thus increased costs, from each process in the overall production process or in the work system, in order to enable an immediate adaptation to market needs and to increase the efficiency of an

organization over its competitors in the same market. The lean system tries to optimize all types of resources by reducing the spend on costs while still achieving the desired results as required by customers. In the lean system, the focus is on the production stages that have an opportunity for a decrease in the production parameters, including waste, lead time, human labor, equipment, time, and work space.

Although the lean system is widely applied in many industries to improve the efficiency of production processes, work processes, and service-providing processes, many organizations fail to apply the LMS due to a lack of understanding about the factors needed for successfully adopting lean manufacturing. Therefore, before applying the lean system, it is essential to study its success factors in order to increase the chances of it succeeding and to ensure it will bring the highest benefits for the organization (Achanga, et al., 2006, pp. 460–471). From previous study, it has been reported that there are four main factors that must be considered to ensure a successful adoption of the LMS:

1) Communication inside the organization: Good communication inside the adopting organization can help create a good understanding of the executives' policies and the relationships among the personnel in the organization. This will positively support efficiency drives and support the effective adoption by the organization and lead to success in applying the lean system. The executives of the organization need to make plans to ensure good communication with all the personnel and staff. Good and clear communication inside the organization will proceed the operation of the LMS, give the personnel in the organization a clear understanding of the policies, and should lead to success in applying the LMS and increase work efficiency.

2) Creating work motivation: It is important to make the staff understand the benefits and realize the significance of applying the LMS because the staff represent an important variable for implementing the lean theory in practice. It is important that the staff realize its significance and understood that the organization and the staff need to work together, interdependently. If the organization can manage to manufacture products efficiently and reduce losses, it will obtain a major benefit. As long as the organization can move on, so can the staff. The advantages obtained by the organization will benefit all the staff in the organization, raising buy in to the LMS and full collaboration to help it become successful. In contrast, if the staff do not understand or realize the significance of the LMS, they can feel confused and may oppose the system, ultimately leading to failure of the entire process.

3) Staff training: This activity needs to be heavily emphasized and promoted. As it helps increase each individual's knowledge, skills, and capabilities, the staff will better understand how to operate, manage, and promote the lean system to obtain the best benefits for the organization and for the staff alike.

4) Involvement of the executives: The executives need to thoroughly understand the production and work systems so that they can improve and develop them through applying

the lean system, and so they will be able to transfer their ideas to the operating staff. By doing so, it is more likely that the application of the lean system will be successful (Nopakao, 2010, pp. 32-46; Wiriyagrochai, 2012, pp. 48-58; Mukdajaroenchai, 2013, pp. 32-85; Suksmarnwong and Wanarat, 2017, pp. 109–128).

All four lean success factors mentioned above have obvious effects on the operation of an organization. The objective of most organizations is to create a sustainable business, starting from ensuring customer satisfaction. To promote customer satisfaction, an organization may need to carry out product or process innovation together with improving efficiency in its operation, with an initial focus on the four factors above. In the lean system in the automotive industry, lean activities should be promoted in the supply chain too, including supporting and introducing a lean system for reducing waste in order to bring about efficient management and to support the process of collaborative product development and product innovation. All of these will be the main drivers for helping the organization to become successful more rapidly and promoting sustainability.

Product innovation refers to the capability of an organization to present to the market new goods, products, or services or to introduce new properties to existing products or services for the industrial market. New technology or concepts can be adopted to improve and develop products in order to satisfy customers' needs and the needs of the market. New innovations can be pushed by technological changes. An organization's level of innovation can be measured by its efficiency in introducing innovative products before its competitors (Wanarat, 2018, pp. 105–127). Innovation, particularly product innovation, can be considered from three aspects:

1) Technology: This aspect is related to scientific knowledge, equipment and tools, and investment, including the processes and stages of new product development. It can be said that this aspect shows the technological potential of an organization.

2) Customers: This aspect is related to the addressing the market needs for new products in order to satisfy the needs of customers in all forms in both current and future situations.

3) A mix between technology and customers: This aspect is related to an organization exploiting its technological potential together with taking actions to meet the market or customer needs for product development, done in an appropriate manner for the different situations and durations of product life or services. This can include the organization adopting new operational methods, product development, and new services resulting from research and development carried out inside the organization in order to satisfy customer needs.

If an organization is capable of manufacturing goods or services that are innovative and protected by copyright or patents, this is regarded as building on its strengths and making profits from products, which can protect the business against competition. Nowadays, innovation is regarded as an important strategy that plays an important role in an organization's operation and also an important variable that can increase its competitiveness (Minoja,

Zolla, and Coda, 2010, pp. 395–405; Udriyah, Tham and Azam, 2019, pp. 1419–1428).

Competitiveness refers to a context where an organization is capable of competing with its competitors in the same business or industry through it taking advantage of technological differences in its products or services or by focusing on costs. At present, it is accepted that cost and quality are the most important factors that can maintain competitiveness, and, more importantly, provide customers with dependable and fast service and delivery. Competitiveness can be assessed from the aspects of an organizations' responsiveness, cost reduction, product quality, profitability, and the performances of the members in its supply chain. Several researchers have categorized competitiveness according to the following three factors (Li, et al., 2006, pp. 107–124; Wook Kim, 2006, pp. 241–248; Ince, et al., 2013, pp. 1124–1133; Suksamarnwong and Wanarat, 2021, pp. 80–106):

1) Competitiveness in prices and costs: This is related to an organization's ability to compete with its competitors by price, often by focusing on efficiency to ensure lower production costs, which can allow a more competitive price of the end product to appeal to the customers and more profit for the company. Market leaders need to prevent their competitors from capturing the market from them, and they often do this by focusing on their own efficiency to achieve lower costs of products or services to maintain their end price points as competitive. However, in some organizations, no attention is paid to the real costs, which are the sum of various activities and products. Moreover, this reflects the organization's productivity, resource use, and profitability rates. Any company with lower costs than its competitors, while the qualities of the products and services are at the same level, can make more profits than their competitors. This results in their greater competitiveness, and the profits gained can be used for developing and investing in other activities of the organization.

2) Competitiveness in product quality: This is related to an organization's ability to present better quality products or services to the market and new products or functions that add value to customers. The quality of products and services are important for overcoming competition, and can be categorized into 8 dimensions: workability, special qualities, reliability, alignment with requirements, durability, service provision, beauty, and quality perception dimensions.

3) Competitiveness in the delivery process. This is related to an organization's ability to deliver goods and products to customers correctly and rapidly in accordance with their needs, at the right place and right time.

Research Framework

From the research and literature review, the research framework was set out to identify the key lean success factors and their effect on competitiveness in the automotive industry in Thailand, as summarized in Figure 1. The estimation model for the structural equation was run using the AMOS program and the results were analyzed.

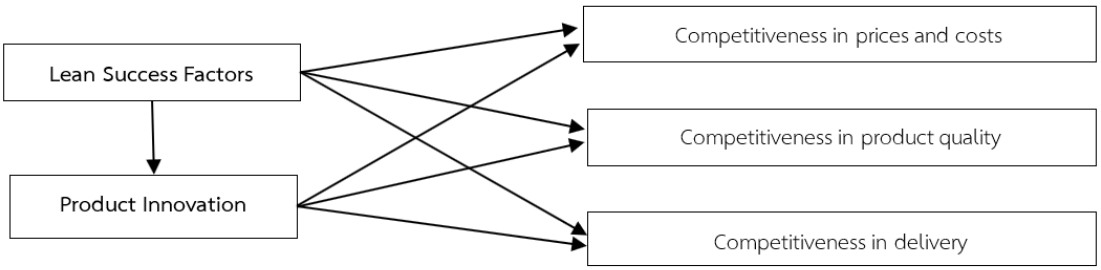

Figure 1 Research framework

Hypotheses

The following hypotheses were made for and then investigated through the research to assess their validity:

H1: Lean Success Factors have direct and positive effects on competitiveness in prices and costs;

H2: Lean Success Factors have direct and positive effects on competitiveness in product quality;

H3: Lean success Factors have direct and positive effects on competitiveness in delivery;

H4: Lean Success Factors have direct and positive effects on competitiveness in product innovation;

H5: Product innovation has direct and positive effects on competitiveness in prices and costs;

H6: Product innovation has direct and positive effects on competitiveness in product quality;

H7: Product innovation has direct and positive effects on competitiveness in the delivery process.

Methods

The present study on the effects of the lean success factors on competitiveness in the automotive industry in Thailand involved quantitative research. Data were collected from questionnaires developed from reviews of related concepts, theories, and research. In this article, the researcher presents the research methods utilized, which are given in detail below.

Population and Sampling

This research utilized a survey format, in which the population comprised the factories involved in the automotive industry, and the sampling supported the study of the causal relationships between variables. An appropriate sample size was determined based on Hair, et al. (2010, pp. 105-127) 's maximum likelihood estimation method, with which the confirmatory factors, including 300 samples, were analyzed. Multi-stage sampling was used. In the first stage, letters were mailed to factories to invite them to take part in the survey and to collect data. Stratified random sampling was employed, and the data from 165 companies were obtained. In the second stage, the remaining data were accessed with purposive sampling, and finally 286 samples were obtained from 286 companies.

Methodology

The main tool used in this research was a questionnaire developed from the reviews of the lean concepts, theories, and the literature. Back translation was also used for the questionnaire before it was submitted to the three thesis committee members who rechecked, corrected, and improved it for content validity. Its reliability was tested by using it as a pre-test with 35 executives of organizations that were involved in resource planning, and which were not in the sample group. The reliability of the questions in the questionnaire was analyzed by using Cronbach's Alpha Coefficients, and it was found that the Alpha Coefficient was 0.931 for the lean success factors, 0.727 for product innovation, 0.813 for competitiveness in prices and costs, 0.785 for product quality, and 0.845 for competitiveness in the delivery process, all of which it could be noted were over 0.70.

In the part of the questionnaire regarding the lean success factors, seven rating scales were used for 16 questions, for which the possible answers were ranked by a Likert rating scale with 7 choices: Extremely likely, Likely, More or Less Likely, Neutral, More or Less Unlikely, Unlikely, and Extremely Unlikely. The questions were developed in line with the findings of other studies identified in the literature review, including Nopakao (2010, pp. 32-46), Wiriyagrochai (2012, pp. 45-68), Chusri (2013, pp. 48-64), Suksmarnwong and Wanarat (2017, pp. 109–128), and Jeyaraman and Teo (2010, pp. 191–215). Similarly for product innovation, a seven-item Likert rating scale was employed for answering a set of questions. The three questions in this part were also developed following the literature review and considering in particular the research conducted by Vorhies and Morgan (2005, pp. 80–94), and Li, et al., (2006, pp. 107–124). In terms of the information about the perception of competitiveness, and 9 questions were asked and again a seven-item Likert rating scale was applied for the responses. These questions were again developed from the literature review, and in particular from the research conducted by Vorhies and Morgan (2005, pp. 80–94) and Li, et al., (2006, pp. 107–124).

Data Analysis

Descriptive and inferential statistics were used to analyze the data. Confirmatory factor analysis was applied to study the structures of the variables. The other analytical method used in this research was structural equation modeling (SEM), and the SPSS program version 21.0 and AMOS program version 22.0 were applied together. A p-value less than 0.05 indicated statistical significance.

Results

For the data collection, questionnaires were sent to 570 factories in the automotive industry, and 451 (79%) replied. The Mahalanobis Distance Statistical method was used to inspect the outliers. As the p-value of 42 samples was lower than 0.05 (Hair, et al., 2010, pp. 105-127), they were removed. The remaining 409 questionnaires from 409 companies were included in the data analysis. The normality of the data was examined by considering the skewness value and kurtosos, in which the plus (+) and minus (-) signs show the direction.

Kline (2015, pp. 188-195) suggested that the skewness value should be between -3 and +3, whereas the kurtosis should be between -10 and +10. The value obtained from inspecting the skewness of the variables was between -0.251 and -1.529, and the skewness value was between -0.936 and 2.452, which were within the acceptable criteria. That is, the data distribution of all the variables was within the normal curve range.

The structural equation model analysis involved analyzing the rating and structural models. Before the analysis was performed, the manifest variables were reduced; that is, each of the questions was changed into composite variables in the lean success factors by calculating the average of each question for each variable (Chou, 2015, pp. 110–122). The results were analyzed using IBM SPSS AMOS Program Version 22 in order to check how much the models developed met the criteria used for adapting the structural equations of the study and in accordance with empirical research data, namely, factor loading and modification indices (MI) (Hair, et al., 1998, pp. 105-127). The results of the model are shown in Figure 2 and listed in Table 1. Also, the results of the accordance test of the structural equation models are shown in Figure 2, and the names and abbreviations are shown in Table 3.

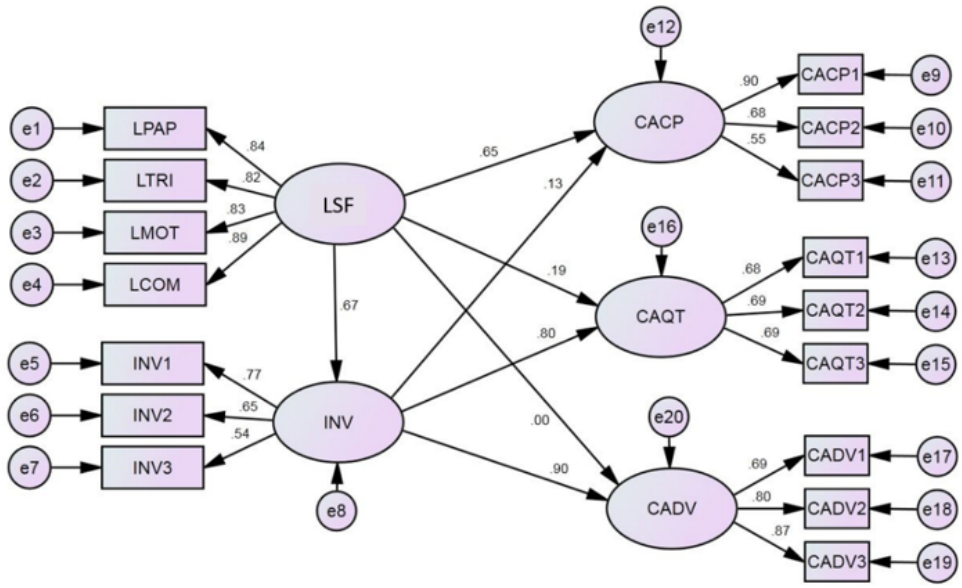

Figure 2 Structural equations of the models

From Table 1, it can be seen that the model results showed good accordance with the evidence-based data, with the CMIN/DF value of 2.627, GFI of 0.949, NFI of 0.9950, RFI of 0.916, IFI of 0.968, TLI of 0.946, CFI of 0.968, RMSEA of 0.063, and RMR of 0.027. All of these statistical values met the criteria for empirical research, as specified according to the conditions at the statistical acceptability level.

From the test results shown in Table 2 regarding the factor loading values of the variables, the appropriate value for analyzing the composite models should be higher than 0.5 (Hair, et al., 1998, pp. 105-127). It was

found that the factor loading values of all the components were higher than 0.5. The composite/construct reliability (CR) was taken into account, where the CR value should be higher than 0.6 (Fornell and Larcker. 1981, pp. 39–50) and the average variance extracted (AVE) should be higher than 0.5 (Hair et al., 1998). However, if the AVE value is lower than 0.5, but the CR value is higher than 0.6, the values are considered to be in the acceptable range (Fornell and Larcker, 1981, pp. 39–50; Lam, 2012, pp. 1328–1334; Safiih and Azreen, 2016, pp. 41–51).

Table 1 Results for accordance of the constructed equation models with the evidence-based data

Accordance Level Indices	Criteria/Reference	Results
CMIN/DF	< 5.00	2.627
Goodness of Fit Index (GFI)	≥ 0.90	0.949
Normalized Fit Index (NFI)	≥ 0.90	0.950
Relative Fit Index (RFI)	≥ 0.90	0.916
Incremental Fit Index (IFI)	≥ 0.90	0.968
Tucker Lewis Index (TLI)	≥ 0.90	0.946
Comparative Fit Index (CFI)	≥ 0.90	0.968
Root Mean Square Error of Approximation (RMSEA)	< 0.08	0.063
Root Mean Square Residual (RMR)	< 0.05	0.029

N.B. The criteria for accordance with the structural equation modeling are referenced from Hair et al. (1998, pp. 105–127).

From the test results, it was found that the CR values of all the variables were higher than 0.6, and the AVE values of all the values were higher than 0.5 and therefore in an acceptable range, except for the AVE value of the product innovation variable, which was equal to 0.44, while the CR value was 0.7 and the AVE value of product quality competitiveness was 0.73. The CR and AVE values revealed that the errors caused by delivery resulted in a lower variance of indicator variables than the latent ones being measured. It could be concluded that the variables in the structural equations for the effects of the lean success factors on effectiveness were in accordance with the configuration criteria. That is, the measurement model had good validity.

Table 2 Results of the loading for the factor analysis, average variance, and structural reliability values

Variables	Abbreviations/ Components	Keyword/Questions	Loading factor	CR	AVE
Lean Success Factor (LSF)	LCOM/ Communication inside the organization	1. Communicate clearly about the lean system, such as 'What does lean mean?' 2. Communicating regularly about good practices 3. Sharing good practices regularly 4. Provide opportunities for employees to express their opinions.	0.89	0.91	0.72
	LMOT/Creation of work motivation	1. Promoting and praising staff success 2. Thanking and complimenting staff when they achieve goals 3. Showing determination to improve performances 4. Awarding the staff when they achieve goals	0.83		
	LTRI/ Organizing staff trainings	1. Organizing staff training to improve their understanding of lean production 2. Organizing training to increase production 3. Organizing training across work lines so that staff can do other kinds of work better 4. Knowing more information that is useful for production	0.82		
	LPAP/executives' participation	1. Determining the executives' goals clearly 2. Giving staff opportunities to express opinions 3. Showing work determination to achieve goals 4. Showing a good example of problem-solving	0.84		
Product innovation (INV)		1. Making adaptations to meet customer needs 2. Designing products to meet customer needs 3. Responding well to new forms of needs	0.77 0.65 0.54	0.70	0.44

Variables	Abbreviations/ Components	Keyword/Questions	Loading factor	CR	AVE
CACP/ Competitiveness in prices and costs		1. Being capable of competing on the basis of costs and prices	0.90	0.76	0.53
		2. The prices are in an acceptable range.			
		3. The company can give lower price quotations than its competitors	0.68		
			0.55		
CAQT/ Competitiveness in product quality		1. Being capable of competing on product quality	0.68	0.73	0.47
			0.69		
		2. Presenting customers with high-quality products	0.69		
		3. Presenting reliable products to customers			
CADV/ Competitiveness in the delivery process		1. Delivering goods punctually as required by customers	0.69	0.83	0.62
		2. Delivering goods correctly as required by customers	0.80		
		3. Managing product delivery reliably			
			0.87		

A discriminating validity check was done by comparing the square root of the AVE for each component with the correlation between those components. It was found that the square root of the AVE in every component was higher than the correlation between components. This means the measurement form had good discriminating validity, as shown in Table 3

Table 3 Results of the discriminating validity analysis

Variables	CR	AVE	LSF	INV	CACP	CADV	CAQT
LSF	0.91	0.72	.333				
INV	0.70	0.44	.157	.163			
CACP	0.76	0.53	.317	.171	.550		
CADV	0.83	0.62	.173	.179	.188	.245	
OPQT	0.73	0.47	.240	.213	.253	.235	.324

Structural models can by analyzed by causal or pathway analysis in order to study the structures of the relations between variables and to see if the influences of different variables have direct or indirect influences among the variables. The researcher tested the hypotheses according to the p-value and analyzed the results of the standardized path coefficients of each latent variable, as shown in Figure 3 and 4. It was found that for the first

hypothesis, the lean success factors had direct and positive effects on the LMS' effectiveness in raising competitiveness in prices and costs, with statistical significance. The p-value was 0.000, and the standardized path coefficient was 0.65; therefore this hypothesis was accepted. As for the second hypothesis, the lean success factors had direct and positive effects on competitiveness in product quality, with statistical significance at 0.05, with a p-value of 0.000, and standardized path coefficient of 0.19. As for the third hypothesis, the lean success factors had effects on competitiveness in the delivery process. However, it was found that this hypothesis should be rejected, as there was no statistical significance, as the p-value was 0.981, which was higher than 0.05, while the standardized path coefficient was 0.000. As for the fourth hypothesis, the lean success factors had direct and positive effects on product innovation, with a p-value of 0.000, while the standardized path coefficient was 0.67, and this hypothesis was thus accepted. For the fifth hypothesis, product innovation was found to have direct and positive effects on competitiveness in prices and costs, with a p-value of 0.057, while the standardized path coefficient was 0.13, which showed it had no statistical significance. Therefore, this hypothesis was rejected. As for the sixth hypothesis, product innovation was found to have direct and positive effects on competitiveness in product quality, with a p-value of 0.000, while the standardized path coefficient was 0.80. Therefore, this hypothesis was accepted. As for the seventh hypothesis, product innovation was found to have direct and positive effects on the delivery process, with a p-value of 0.000, while the standardized path coefficient was 0.90. Therefore, this hypothesis was accepted.

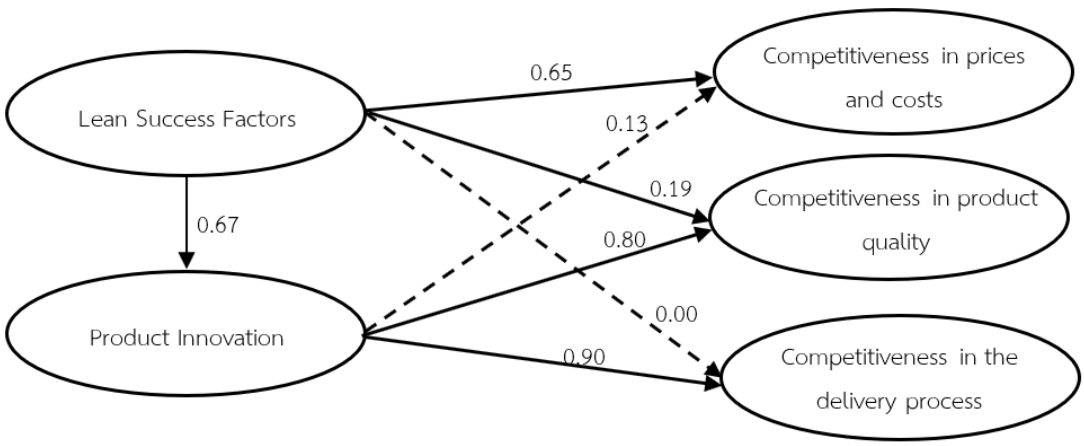

Figure 3 Results for testing the hypotheses for the models

N.B. Solid lines refer to the influence between the hypotheses of the models

Table 4 Results of the standardized path coefficient and the results from testing the hypotheses

Hypotheses	Path Coefficient	P-Value	Test Results
H1: Lean Success Factors have direct and positive effects on competitiveness in prices and costs	0.65	0.000	Supported
H2: Lean Success Factors have direct and positive effects on competitiveness in product quality	0.19	0.013	Supported
H3: Lean Success Factors have direct and positive effects on competitiveness in delivery	0.00	0.981	Not Supported
H4: Lean Success Factors have direct and positive effects on competitiveness in product innovation	0.67	0.000	Supported
H5: Product innovation has direct and positive effects on competitiveness in prices and costs	0.13	0.057	Not Supported
H6: Product innovation has direct and positive effects on competitiveness in product quality	0.80	0.000	Supported
H7: Product innovation has direct and positive effects on competitiveness in the delivery process	0.90	0.000	Supported

Conclusion and Discussion

From the study, it was found that the results from the structural equation models accorded well with the evidence-based data (CMIN/DF = 2.627, GFI = 0.949. NFI = 0.950, RFI = 0.968, TLI = 0.946, CFI = 0.968, and RMSEA = 0.063). The results of the analysis can be summarized according to the research objectives as follows:

For the first hypothesis, it can be concluded that the lean success factors had direct and positive effects on competitiveness in prices and costs with statistical significance at 0.01. The explanation for this is that the lean system is a continual process of trying to optimize every resource to lower costs while still obtaining the results that will meet customer needs. In the lean system, the focus is placed on reducing the production steps to minimize waste, cycle times, human labor, equipment, overall time, and operation areas. The lean system does not aim to increase the workload or speed, but instead helps find waste and changes it into value as required by customers. This is in accordance with the view expressed by Hines, Holweg and Rich (2004, pp. 994–1011), who stated that adoption of a good lean system can help reduce waste and costs. Therefore, if an organization follows the four aforementioned success factors for adopting the LMS, that is, good work motivation, executives' involvement, staff training, and internal communication, they can drive organizational development to ensure the successful application of the lean system, which will ultimately help reduce production and operation costs. Moreover, costs are not only a sum of various kinds of activities and products but also a reflection of the organization's manufacturing capacity, resource use, and profit-making

rates. If a company spends less on costs than its competitors, while maintaining a similar quality of products and services, the company can gain more profits than its competitors. This results in their higher competitiveness, and will enable the organization to spend the higher profits on developing and investing in other activities. This concept also conforms to the research conducted by Prajogo, Oke and Olhager (2016, pp. 220–238).

For the second hypothesis, it can be concluded that the lean success factors had direct and positive effects on competitiveness in product quality with statistical significance at 0.01. The explanation for this is that the lean system helps promote development and continual improvement. This can be seen from the four lean success factors, which focused on the executives' involvement, creation of work motivation, organization of staff training, and clear internal communication. All of these helps increase the staff's knowledge so they can learn the analytical process for solving problems systematically themselves. Thanks to the improved knowledge and skills, confusing and complicated work processes can be continually improved, resulting in a stable quality of production or assembly. This will lead to improved competitiveness in product quality, which is a finding that accords well the findings of many researchers, such as Blackmore, et al. (2013, pp. 99–105), who considered that the lean system will help organizations develop work processes that help promote development in quality and increase their competitive potential.

For the third hypothesis, it can be concluded that the lean success factors were no direct positive effects on competitiveness in delivery with statistical significance at 0.05. It was thus noted that adoption of the four success factors for applying the LMS in an organization will result in good work processes, stable operations, and fixed work schedules. This will enable the organization to deliver goods, products, or services to customers correctly, punctually, and rapidly, in accordance with their desired types and quantities of products, at the right time and right place. However, competitiveness in delivery involves other factors which are important too, such as the planning process, delivery of the raw materials to be used in production, and uncertainty in the logistic system. It was also found that many organizations have adopted lean systems only in the production department, but not in the warehouse management and transport processes. For this reason, effects between the lean success factors and competitiveness in delivery were not found in this research, in accordance with the studies conducted by Li, et al. (2006, pp. 1328–1334) and Ince, et al. (2013, pp. 1124–1133) who stated that improvements in work process management had no effects on competitiveness because overall competitiveness results from several factors.

For the fourth hypothesis, it could be concluded that the lean success factors had direct and positive effects on product innovation, with statistical significance at 0.01. The explanation for this is that the key success factor for the LMS is the process that helps promote the organization to improve its product design capabilities, including the production process and supply chain manage-

ment. The development of product innovation needs to be pushed from the top executives by them promoting an innovation mindset and motivating the staff, in accordance with the four lean success factors. Moreover, the lean system helps develop the product design staff's skills via training, thus reducing their waste in working, and helping them to create useful and quality products for customers from the highest efficiency work, in conformity with the findings of Chen and Taylor (2009, pp. 826–834), stating that the lean system is also a process that creates a body of knowledge and the development of more efficient work processes, including for the development of new products.

For the fifth hypothesis, it could be concluded that there were no effects between product innovation and the effectiveness of the LMS on raising competitiveness in prices and costs, with statistical significance at 0.05. It was noted that the product innovation process requires investment in the development of knowledge, equipment, and human resources. Production businesses, especially in the automotive industry, require a large amount of money for adapting innovation and new technology, including a rather long period of operation. Therefore, when product innovation development is adopted, there may be no effects on competitiveness in prices and costs.

For the sixth hypothesis, it could be concluded that product innovation had effects on competitiveness in product quality, with statistical significance at 0.01. The explanation for this is that the development and presentation of new product innovation, both in technology and usage, including the improvement of old products, will focus on producing products of higher quality and efficiency. Therefore, it is certain that product development will have positive effects on product quality, especially in the automotive industry, where the development of product innovation and quality usually go together, in accordance with the findings of Minoja, Zolla and Coda (2010, pp. 395–405), Udriyah, Tham and Azam (2019, pp. 1419–1428) and Wanarat (2018, pp. 105–127) who reported how innovation will help improve the work processes or forms by the use of new technology, which will result in product quality development and the promotion of higher competitiveness.

For the seventh hypothesis, it could be concluded that product innovation had effects on competitiveness in delivery, with statistical significance at 0.01. The explanation for this is that in developing and presenting new product innovation, designers tend to have good consideration of the various steps in the production process, because production innovation and technology are related to the use of machinery and production methods, which are important parts of the innovation production process. The time needed to be spent on production will then tend to be reduced as the systems become more stable. This results in clear work schedules and easy planning, which are good for the delivery process. Therefore, product innovation has effects on effectiveness in delivery, in accordance with the concepts put forward by Minoja, Zolla, and Coda (2010, pp. 395–405); Udriyah, Tham and Azam (2019, pp. 1419–1428) and Wanarat (2018, pp. 105–127), considering that innovation helps improve production technology, reduces the

complexity of the work processes, and drives competitiveness in many areas.

From the conclusions described for the seven hypotheses as our key research objectives, it could be concluded that the lean success factors for the LMS offer an important foundation for making effective changes in the organization, from reducing waste into value and making continual improvements. This helps to continuously improve the work processes (Hines, Holweg and Rich, 2004, pp. 994–1011). The lean success factors ensure the lean system can be successfully adopted in the production processes and can allow systematic work improvements to be made. Also, there will be no overlapping of work, and all the staff in the organization will realize their own responsibilities, resulting in work improvements, and ensure the continual and effective flow of work in the process, including changing the internal culture into a lean culture. This will benefit product innovation development and increase the organization's competitiveness in prices and costs. Ensuring product quality is an important strategy for an organization to create sustainability in its business operations, especially in the automotive industry, which involves intense competition among various autopart manufacturers, classified into the first, second, and third tiers, including automotive assembly factories, which require continuous developments in prices, costs, product quality, delivery processes, and product innovation development. Achieving competitiveness requires good and efficient work processes, the least amount of waste, and cooperation from all personnel throughout the organization. In every section, these drivers are the most important parts to increase the organization's efficiency in order to create business sustainability for the organization. The results from this study can be used as a guideline for executives in both the automotive and other industries by getting them to pay attention to the four lean success factors to ensure a successful implementation of the lean system, including the important parts in product innovation development and the creation of business competitiveness for the organization (Lewis, 2000, pp. 959–978; Minoja, Zollo and Coda, 2010, pp. 395–405; Prajogo and Olhager, 2012, pp. 514–522; Prajogo, Oke and Olhager, 2016, pp. 220–238; Udriya, Tham and Azam, 2019, pp. 1419-1428; Prado-Prado, et al., 2020, pp. 1419–1428).

Recommemdations

The techniques that form the lean manufacturing system help an organization develop its competitiveness. If the break-even point for investment in the lean system operation could be calculated and considered within the analysis, it would make this research very interesting.

Organizations should pay attention to the product innovation development, which could help increase their potential competitiveness.

Since this is a quantitative study, conducting more qualitative research would help create more understanding and give a clearer confirmation of the model results.

Bibliography

Achanga, P., Shehab, E., Rajkumar, R. and Nelder, G. (2006). Critical success factors for lean implementation within SMEs. **Journal of Manufacturing Technology Management,** 17(4), 460-471.

Blackmore, C. C., Bishop, R., Luker, S. and Williams, B. L. (2013). Applying lean methods to improve quality and safety in surgical sterile instrument processing. **The Joint Commission Journal on Quality and Patient Safety,** 39(3), 99-105.

Chen, H. and Taylor, R. (2009). (August 2-6, 2009). Exploring the impact of lean management on innovation capability. In **Portland International Conference on Management of Engineering & Technology** (pp. 826-834). Portland: IEEE.

Chou, P. (2015). Transformational leadership and employee's behavioral support for organizational change. **European Journal of Business and Management,** 7(3), 110-122.

Chusri, P. (2013). **The impacts of lean production system on the production efficiency in XYZ company limited.** Independent Study, M.B.A., Kasetsart University, Bangkok.

Fornell, C. and Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. **Journal of marketing research,** 18(1), 39-50.

Hair, J., Andreson, R., Tatham, R. and Black, W. (1998). **Multivariate data analysis** (5th ed.). New Jersey: Prentice-Hall Inc.

Hair, J., Black, W., Babin, B. and Anderson., R. E. (2010). **Multivariate data analysis: A global perspective** (7th ed.). New Jersey: Pearson Education.

Hines, P., Holweg, M. and Rich, N. (2004). Learning to evolve: a review of contemporary lean thinking. **International Journal of Operations & Production Management,** 24(10), 994-1011.

Ince, H., Imamoglu, S., Z., Keskin, H., Akgun, A. and Efe, M. N. (2013). The impact of ERP systems and supply chain management practices on firm performance: case of Turkish companies. **Procedia-Social and Behavioral Sciences,** 99, 1124-1133.

Jeyaraman, K. and Teo, L. K. (2010). A conceptual framework for critical success factors of lean Six Sigma: Implementation on the performance of electronic manufacturing service industry. **International Journal of Lean Six Sigma,** 1(3), 191-215.

Kline, R. B. (2015). **Principles and practice of structural equation modeling** (4th ed.). New York: The Guilford Press.

Koloszár, L. (2018). Opportunities of lean thinking in improving the competitiveness of the Hungarian SME sector. **Management and Production Engineering Review,** 9(6), 26-41.

Lam, L. W. (2012). Impact of competitiveness on salespeople's commitment and performance. **Journal of Business Research,** 65(9), 1328-1334.

Lewis, M. A. (2000). Lean production and sustainable competitive advantage. **International Journal of Operations & Production Management,** 20(8), 959-978.

Li, S., Ragu-Nathan, B., Ragu-Nathan, T. S. and Rao, S. S. (2006). The impact of supply chain management practices on competitive advantage and organizational performance. **Omega,** 34(2), 107-124.

Minoja, M., Zollo, M. and Coda, V. (2010). Stakeholder cohesion, innovation, and competitive advantage. **Corporate Governance,** 10(4), 395-405.

Mukdajaroenchai, K. (2013). **Structure equation models of factor in lean production on performance in the automotive industry.** Master thesis, M.B.A., Kasetsart University, Bangkok.

Nopakao, R. (2010). **Lean manufacturing operating performance: Case study of production department OLIC (Thailand) limited.** Independent Study, M.B.A., Kasetsart University, Bangkok.

Prado-Prado, J. C., García-Arca, J., Fernández-González, A. J. and Mosteiro-Añón, M. (2020). Increasing competitiveness through the implementation of lean management in healthcare. **International Journal of Environmental Research and Public Health,** 17(14), 4981.

Prajogo, D., Oke, A. and Olhager, J. (2016). Supply chain processes: Linking supply logistics integration, supply performance, lean processes and competitive performance. **International Journal of Operations & Production Management,** 36(2), 220-238.

Prajogo, D. and Olhager, J. (2012). Supply chain integration and performance: The effects of long-term relationships, information technology and sharing, and logistics integration. **International Journal of Production Economics,** 135(1), 514-522.

Organisation Internationale des Constructeurs d'Automobiles. (2021). **Production 2020 Statistics. International Organization of Motor Vehicle Manufacturers.** Retrieved June 7, 2021, from https://www.oica.net/category/production-statistics/2020-statistics/

Safiih, L. M. and Azreen, N. (2016). Confirmatory factor analysis approach: A case study of mathematics students' achievement in timss. **Malaysian Journal of Mathematical Sciences,** 10, 41-51.

Suksmarnwong, N. and Wanarat, S. (2017). Critical success factors for lean implementation on operation performance and customer satisfaction of automotive part manufacturing. **Nida Business Journal,** 21, 109-128.

Suksmarnwong, N. and Wanarat, S. (2021). The causal relationship model of enterprise resource planning, supply chain performance, competitive advantage and organizational performance of Thai automotive parts industry Tier 1. **Thammasat Business Journal, Journal of Business Administration,** 44(169), 80-106.

The Office of Industrial Economics. (2018). **Introduction to the automotive industry.** Retrieved September 15, 2018, from http://www.oie.go.th/publications/EBookIndustBasicKnowledge

Udriyah, U., Tham, J. and Azam, S. (2019). The effects of market orientation and innovation on competitive advantage and business performance of textile SMEs. **Management Science Letters,** 9(9), 1419-1428.

Vorhies, D. W. and Morgan, N. A. (2005). Benchmarking marketing capabilities for sustainable competitive advantage. **Journal of marketing,** 69(1), 80-94.

Wanarat, S. (2018). A structural equation model of total quality management, innovation and supply chain performance. **Business Administration and Economics review,** 14(1), 105-127.

Wiriyagrochai, W. (2012). **Factors relating with the success of lean manufacturing implementation in tissue converting department at ABC Co.,Ltd.** Independent Study, M.B.A., Kasetsart University, Bangkok.

Wook Kim, S. (2006). Effects of supply chain management practices, integration and competition capability on performance. **Supply Chain Management: An International Journal,** 11(3), 241-248.