

# Lean Production Determinants and Performance Consequences of Implementation of Industry 4.0 in Thailand: Evidence from Manufacturing Sector

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**Abstract**— Firms, regardless of their sectors, always try to ensure good financial and operational performance and this is becoming primary reason of implementation of Industry 4.0. Manufacturing sector of Thailand is also quite obsessed about these performance dimensions which were recently declining in absence of Industry 4.0. Such a declined shift can be managed through lean production practices at different stakeholders' level like supplier, customer and internal organization. This study has aimed to analyze the impact of lean production practices on operational and financial performance of manufacturing firms in Thailand in mediating role of implementation of industry 4.0. Data has been collected from employees of 53 manufacturing firms in Thailand through structured questionnaire and then this data was analyzed on SPSS and AMOS for screening and hypotheses testing respectively. The results have shown that all lean production practices increase financial and operational performance of manufacturing firms in Thailand. Moreover, a significant mediating role of implementation of industry 4.0 was also signaled by the results. Originality of this study was to take implementation of industry 4.0 as a bridge between lean production practices and performance dimensions. Implications of this study are expanded on theoretical, practical and policy making fronts.

*Key Words:* Lean Production Practices, Supply Chain, Industry 4.0, Financial Performance and Operational Performance

## 1. Introduction

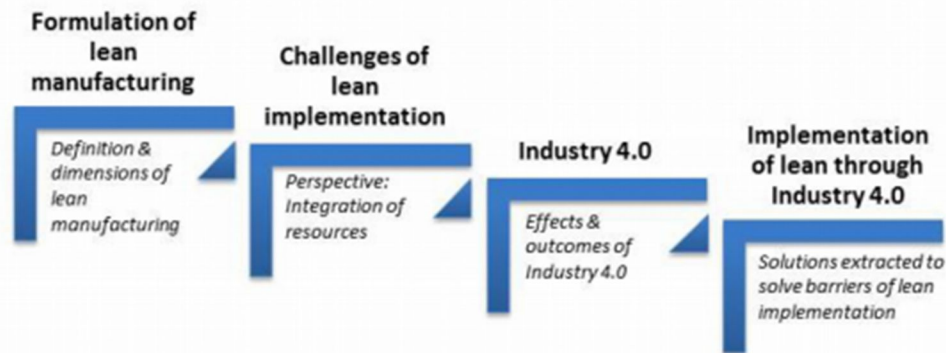
With the advent of technology, industrial sector has also been advancing in technological and applied innovations. Industry 4.0 is one of the industrial upheavals, which is primary based on automation, machine learning, interconnectivity, artificial intelligence, cloud computing, and real-time data [1-3]. It is grounded in cyberspace and digital domains for the purpose of enhancing manufacturing practices and supply chain management [4-6]. It reinforces connectivity among various systems operating inside the industry, to boost entire setup and recital of the manufacturing industry. Various developed as well as developing countries are aiming to integrate the concept of Industry 4.0, including Germany, Thailand, Malaysia, China, etc. [7]. In Thailand, Industry 4.0 is also embattled at ten crucial financial subdivisions, while they are backed up by the research consuming one billion US dollars [8].

Lean production practices are strategies employed along with Industry 4.0, for the betterment of operational performance. Lean practices are human-centered instead of technology focused, which refers to lowering the amount of waste and improving work efficiency by assimilating customers and suppliers [9]. Lean management can either be supplier related, customer related or internal. Supplier and customer related lean practices refer to continuous involvement of supplier and customer for product formation and within operational process. While internal lean

practices refer to minimizing or eliminating waste products or unnecessary activities and variables from operational process [1].

Both lean practices and industry 4.0 have demonstrated efficiency in financial and operational performance of an industry [10; 26]. Operational performance can be observed in form of sales growth, increased market share, higher output, reduced

turnover, diminished errors, etc. While financial performance can be evaluated in terms of return on investment, earning per share, profitability, return on sales, return on assets, etc [4]. Financial and operational performances are key indicators of industrial success and predict future growth of a firm [11].



**Figure 1:** Manufacturing Approach

In developing countries such as Thailand, operational performance and financial performance is required for the development of firsthand industrial innovations and practices [12]. However, operational and financial performance is declining due to the lack of lean practices as well as technological evolution such as Industry 4.0. The problem is prevailed in Thailand as well as internationally in republics such as Brazil, Malaysia, Germany, etc, due to the lack of awareness and implementation of technological and strategic advancement. The amalgamation of lean practices along with industry 4.0 is imperative to determine the level of industrial performance and how their utilization can enhance productivity, performance and efficiency [2].

By reviewing the literature, it was evident that lean practices and industry 4.0 have not been researched in a wider aspect. Although various researches for the current domain have been done in Thailand, however, the implementation of both variables have not been incorporated for the final evaluation of operational and financial performance of the industry. Therefore, thorough research is required in this domain, where the current research will focus on evaluating the impact of lean practices with the mediating role of industry 4.0 for the operational and financial performance of manufacturing sector of Thailand.

Since nations like Thailand are continuously aiming for industrial revolution and performance due to wide attraction of tourists, and to increase economic stability of the country. The research questions formulated for the current study are following:

1. To analyse the impact of lean production practices on operational performance of manufacturing sector of Thailand.
2. To determine the impact of lean production practices on financial performance of manufacturing sector of Thailand.
3. To evaluate the impact of industry 4.0 on operational and financial performance of manufacturing sector of Thailand.
4. To check the mediating role of implementation of industry 4.0 in the relationship between lean practices and operational and financial performance of an industry.

Furthermore, various researches have demonstrated the significance of utilizing lean practices and industry 4.0 for manufacturing sectors for different countries [4]. Lean practices have gain noteworthy competitive advantages as compared to non-lean practices in manufacturing sectors, distribution structures, information communications, transportation systems, customer-supplier

relationships, containerization, on-time staging as well as delivery performance [13]. Industry 4.0 is a stimulating and leading strategy to reorganize the manufacturing sector of Thailand, moving from labor intensive to basic technology for creating high value-added and sophisticated services and products for operational and financial growth of the businesses,

## 2. Literature review

### 2.1. SEM modeling and Theory

Theoretical contributions in certain studies whose variables depend on the dependents and independent variables are connected to each other through a theory that enhances the role of one variable on another. In this study Lean Production (LP) show a positive impact on the implementation of Industry 4.0 IOI, therefore in which IOI 4.0 act as a mediator between LP, Customer Production (CP), Internal Production (IP), Financial Performance (FP) and Operational Performance (OP) [10]. This theory highly depends on the manufacturing technologies that are emerging as per demand by the customers, which portrays the high practical and theoretical relevance of digital world connected to the Lean production and IOI 4.0. In this study Structure Equation Modeling SEM [1] will be used to develop a connection between industry 4.0 implementation that depends on the different perspective of companies characteristics. Through SEM, industry 4.0 promises to provide manufacturers with profitable business models, higher efficiency and quality as well as to improve workplace conditions. Social dimension of Industry 4.0 has several benefits to promote various dependents and independents variables like Lean production, Customer production, internal production, Financial performance and Operational performance under the circumstances of determinants and performance consequences. According to strategic perspective [2], current literature agrees that Industry 4.0 has wide reaching capabilities related to business competitiveness and performance [5, 13, 15-19]. Current literature examines the research area regarding industry 4.0 from technical, manufacturing and social perspectives. SEM predominantly acts as a source of sustainability for three dimensions of Triple Bottom Line (TBL). SEM shows the outcome of industry 4.0 which is expected to transform industrial production as well as its impact on society that aims at

driven by advanced technologies, creativity, knowledge, development, revolution, as well as novelty [14]. Industry 4.0, when combined with lean practices, results in greater income, improved work output, higher financial progress, which can make Thailand remove the barrier of low income and resources practices [10].

economic, ecological and social achievements promoting industrial revolution. Current business model depends on the theoretical implications of SEM through data-based production which includes customer orientation and service based by data transparency. SEM might face multiple challenges and opportunities which requires standardization of processes within and among countries. SEM promotes ecological dimension of sustainability in which industry 4.0 enables several benefits regarding Lean production, financial performance and Operational performance.

#### 1) Lean Supply Chain Practices Relationship with Financial Performance

[4] depicts that theoretical evidences related to SEM has a significant impact on Lean supply chain and financial performance of business in their manufacturing sector through ecological, environmental and economical/financial dimensions. Lean production increases the product quality which for instance, increases FP through business performance and industrial competitiveness. Manufacturing proficient of industry on the basis of implementation of industry 4.0 at the level of puter-integrated manufacturing systems has a significant impact on financial abilities of technological sector. LP is an approach that widely spread amongst several industries that aims at reducing waste and improving productivity and quality according to customer requirements [5] and customer orientation. SEM depends on the systematic approach that focuses on human centered system of various management principles and practices. As per studies, that suggests that according to the pull of customers and retailers that attract LP, which however increases the production of FP in different sectors of industries that excels the alignment of efficiency and productivity within an industry. Thus, the following hypothesis is proposed that:

**H1:** Lean supply chain practices have a significant impact on financial performance.

## 2) Supply Related Chain Production Relationship with Financial Performance

As per [13], which explains the theory related to Industry 4.0, concerning with the application of SEM in the manufacturing sector relying on the dependent and independent variables. Supply chain performance (SCP) emphasizes the needs for involving and empowering employees do bring change in the financial performance regardless following their hierarchy functions. Studies believe that industry 4.0 describes the main characteristics of connected machines, smart products and systems. SCP increases because of the increase in the employment power and dedication that integrates communication and information technologies (ICT) to enable the mass production which will gradually increase [15] the FP through dynamic production and establishment of intelligent and efficient production of masses. Thus, the following hypothesis is proposed that:

**H1 (a):** Supply chain related lean practices performance has a significant impact on financial performance.

## 3) Customer Related Supply Chain Relationship with Financial performance

According to studies by [16] which establishes a relationship between (CSCP) and FP through the influence of SEM and LP in the production of products according to the emerging economic countries. Studies [16] believe that national culture influences the implementation of industry 4.0 that enhances the practices FP. Assessment model and SME both has a significant impact on the development of CSCP along with FP. In these statistical evidences, shows a relationship between CSC and FP, therefore it increases the growth of high-level performance with the use of latest technologies for the improvement purposes. Thus, the following hypothesis is proposed that:

**H1 (b):** Customer related lean supply chain practices have a significant impact on financial performance.

## 4) Internal Lean Supply Chain Practices Relationship with Financial Performance

Studies by [16] elaborate the findings from their study that ILSCP influences the working, function and practices of FP in an industry or any related enterprise. It works in the form of clusters whose application depends on the effect of SEM on FP. Internal production causes an increase in the

improvement strategy of financial dimensions leading to effective and efficient performance of industries. Sustainability of internal supply chain (ILSCP) [8] influences the level of ILSCP which further enhances the abilities of FP. Organizational implementation of industry 4.0 provides novel requirements for training and education of employees and supply chain managers. Thus, the following hypothesis is proposed that:

**H1©:** ILSCP has a significant impact on financial performance.

## 5) Lean Supply Chain Relationship with Operational Performance

Studies [11] suggest that LSCP is internally related with OP of an organization that causes organizational building, maintenance and management. With the help of lean supply chain production, bodies of scientific industry develops the performance at organizational level and operational level due to effective working of the employees, use of latest machinery and facing different challenges and difficulties with full concern and interest, so that management of operational performance should not be effected. Thus, the following hypothesis is proposed that:

**H2:** LSCP has a significant impact on Operational performance.

## 6) Supply Related lean Practices Relationship with Operational Performance

Authors of the study [8] suggest the implication and practices of supply chain along with its relationship with OP, which on the other hand enhances the productivity of industry 4.0. SEM supports the activity of SCP as per various studies that elaborate the basic function of OP to promote LP and business performance. SCP receives various opportunities that are further classified into multiple categories of strategy building, operational performance as well as the function of environment and the people based on the state of applied theory of SEM. Thus, the following hypothesis is proposed that:

**H2 (a):** Supply chain lean practices performance has a significant impact on Operational performance.

## 7) Customer Supply Chain Relationship with Operational Performance

Ref [20] analyze the positive effect of productivity and economic performance on CSCP which further

has a positive effect on the development of OP related to industry 4.0. Customer orientation develops a strong relation with SME as well as business performance theory. CSCP focuses on the future compatibility, viability of performance by the employees, organizational and production fit as well as employee qualification, knowledge and judgment criteria. CSCP enhances the effect of OP through opportunities that it receives which primarily contribute effectively in the development of OP regarding industry 4.0. Thus, the following hypothesis is proposed that:

**H2 (b):** CSCP has a significant impact on Operational performance.

#### **8) Internal Lean Supply Chain Relationship with Operational performance**

As per past studies [21] whose empirical evidences shows the strategic performance of industries, depends on the development of ILSCP which further enhances its influence on OP, with respect to business strategies, employment strategies, business orientation and national culture of business environment. As per strategic perspective, literature has a widespread influential knowledge regarding business modules, productivity rate and future viability that increases the function of ILSCP therefore; it further has a significant impact on OP. Thus, the following hypothesis is proposed that:

**H2 ©:** ILSCP has a significant impact on Operational performance.

#### **9) Mediating Role of Implementation of Industry 4.0 between Lean Supply Chain and Financial Performance**

Past studies [12] enhances the role of a mediator within the implementation of industry 4.0 that with the help of SEM and assessment model polishes the affectivity of business performance along with functional and financial performance of the organization. Increase in business LP positively affect the practices of financial performance regarding business industries thus, the following hypothesis is proposed that:

**H3:** Implementation of industry 4.0 has a significant mediating role between the relationships of LSCP and financial performance.

#### **10) Mediating Role of Implementation of Industry 4.0 between Supply related Chain practices and Financial Performance**

SEM act as a key partner in the playing role of an industry 4.0 as a mediator between the viability and affectivity of SCP which enhances the function and organizational performance [22] through FP. Industry 4.0 intensifies SCP which than further promotes FP. Thus, the following hypothesis is proposed that:

**H3 (a):** IOI 4.0 has a significant mediating role between the relationships of Supply related lean chain practices and financial performance.

#### **11) Mediating Role of Implementation of Industry 4.0 between Customer Related Supply Chain and Financial Performance**

Business performance further intensifies the effect of customer supply chain practices with the help of industry 4.0 as a mediator that emphasizes the potential of business models along with FP development. Enhanced customization develops the intensified customer relationship with FP. Thus, the following hypothesis is proposed that:

**H3 (B):** IOI 4.0 has a significant mediating role between the relationships of CSCP and Financial Performance.

#### **12) Mediating Role of Implementation of Industry 4.0 between Internal Lean Supply Chain and Financial Performance**

Industry 4.0 with the influence of SME and business performance theory integrates the development of key resources depending on the growth of LSCP furthermore, which enhances the productivity rate of an organization with the help of FP. LSCP accelerates itself in the competitive market environment with the support of industry 4.0. Thus, the following hypothesis is proposed that:

**H3 ©:** IOI 4.0 has a significant mediating role between the relationships of ILSCP and financial performance.

#### **13) Mediating Role of Industry 4.0 between Supply Chain and operational Performance**

Ref [23] suggest the influence of industry 4.0 on the performance of LSCP and Operational orientation that are interrelated with the influence of SME theoretical based evidences. Manufacturing companies increases its function and productivity

with the help of LSCP and OP. thus, the following hypothesis is proposed that:

**H4:** IOI 4.0 has a significant mediating role between the relationship of LSCP and Operational performance.

#### 14) Mediating Role of Industry 4.0 between Supply related lean chain practices and Operational performance

SCP influences the role of OP on the productivity performance and business capability through the competitiveness of SME and industry 4.0. Literature agrees that business model innovation somehow supports the SC along with the development of OP due to increase of resources and employee performance. Thus, the following hypothesis is proposed that;

**H4 (a):** IOI 4.0 has a significant mediating role between the relationship of SRLP and Operational performance.

#### 15) Mediating Role of Industry 4.0 between Customer Related Supply Chain and Operational Performance

Customer performance or customer orientation increases the liability and competitiveness of industry

4.0 which further influences the effect of OP. SME has an opportunity to reunite the function of OP along with CSCP by facilitating the industry 4.0 at the market level. Thus, the following hypothesis is proposed that:

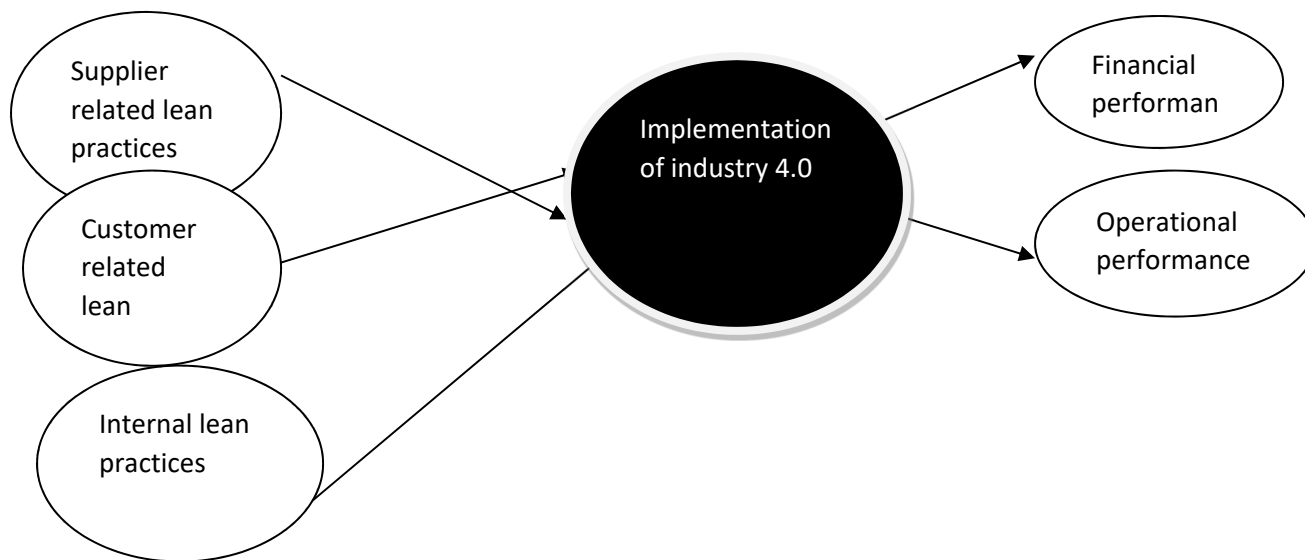
**H4 (b):** IOI 4.0 has a significant mediating role between the relationship of CSCP and Operational performance.

#### 16) Mediating Role of Industry 4.0 between Internal Lean practices and Operational Performance

ILP responds faster to the volatile market demands by increasing the flexibility of OP along with the help of industry 4.0. According to SME if flexibility [5] is being observed in the field of OP which will unfortunately enhances the make-to-order value creation in the business market. Thus, the following hypothesis is proposed that:

**H4 ©:** IOI 4.0 has a significant mediating role between the relationship of ILP and Operational performance.

**Model:**



### 3. Research Methodology

#### 3.1. Population and Sampling

This study has been accompanied in order to observe the operational and financial performance of the organization with the implication of lean production determinants and industry 4.0. For this study, researcher has been selected the manufacturing sector of Thailand because the only limited number of

manufacturing companies implement the lean practices and industry 4.0 in their operations. Researcher has been selected the automotive, electronic manufacturing industries as the sample of the study because these manufacturing industries implement both the LP practices and industry 4.0 in their operations. Moreover, implication of LP practices associated primarily with high volume and

discrete parts manufacturer that's why the electronic and automotive industries have been selected as they were producing high volumes of vehicle and machinery parts. Further, managerial employees of these industries have been selected as respondents because they have complete knowledge about the effects of implication of industry 4.0 and LP practices on organizational performance. In sampling, researcher has to be cautious while selecting the sample size because sample size has to be large enough if SEM approach has been used in analysis (Hazen et al., 2015). The sample size calculation idea has been suggested by (Klein, 2015), according to that number of questions\*10 provide exact sample size. Researcher has been distributed 350 questionnaires among the respondents but after the whole data collection procedures only 303 responses considered valid.

### 3.2. Data Collection and Procedures

Data collection method which researcher has been used for this research study is Questionnaire. Structured questionnaire used by researcher which composed of four parts, first part aimed to collect demographic information of respondents, second part aimed to assess the level of lean production implementation in practice on the bases of Shah and Ward's (2007) assessment model. Third part of questionnaire aimed at measuring degree of implantation of industry 4.0 in selected manufacturing sector of Thailand and final part administered in order to assess the operational performance improvement. Researcher has been used both online and self-administered questionnaire techniques for collecting the data.

### 3.3. Validity, Reliability and Common Bias

Reliability has been assessed through SPSS and criteria used for the assessment states that Cronbach's  $\alpha$  has to be greater than 0.70. Coming towards validity, convergent validity and discriminant validity both have been assessed by AMOS, but different criteria have been used to assess them. For convergent validity assessment three criteria have been used such as (1) items loading whose range is greater than 0.70, (2) composite constructs reliability has to be greater than 0.80 and (3) average variance extracts whose threshold range is greater than 0.50. as far as discriminant validity is concerned, it has

been assessed by criteria which states that square root of AVE must has been greater than all other constructs .

Common bias method has been generated when respondent of the study used same measures in order to assessed variables of this study which are recommended by common rater for explanatory and dependent variables. Risk of common bias has been reduced by using the Harman's single factor test, which has been administered in order to check whether all the constructs accounted for by single factor. Results reports that different factors have been used for interpretation of constructs. 87% of variance accounted for by factor solution and 14% of variance accounted for by one factor. Hence, inexistence of risk ensued when different factors have been used for interpretation of constructs.

### 3.4. Hypothesis Testing

For testing hypotheses of research, structural equation modeling has been used by researcher which has been runs on AMOS. For this research study, researcher test the hypotheses such as test the association between lean production and Industry 4.0 and then test the operational performance improvement due to LP and Industry 4.0 by path analysis, which runs on SEM. In order to check the acceptance or rejection status of hypotheses, researcher perform two steps under path analysis. One is to check standardization of path and second is to check significance of influenced path.

### 3.5. Measures

#### Supplier related lean production

Adapted from [12], measured through the items of supplier feedback, JIT delivery and developing suppliers. All of the items were measured on a five-point Likert scale.

#### Customer related lean production

Adapted from [12], measured through the items of involved customers. All of the items were measured on a five-point Likert scale.

#### Internal lean practices

Adapted from [12], measured through the items of pull, flow, low set-up, controlled processes, involved employees and productive maintenance. All of the items were measured on a five-point Likert scale.

#### 4. Empirical Findings

The purpose of this research was to analyze the role of determinants of lean production in the performance and implementation of industry. For this purpose, the 303 considerable responses were received from manufacturing sector of Thailand among which 125 were filled by male participants while 178 questionnaires were filled by female participants. It means that the number of female participants in the total sample exceeded the number of male participants. As far as the education of participants is concerned, 48.8 percent respondents were post graduated while 40.3 respondents were holding master's degree. Out of 303 respondents, 7.6 percent participants were graduated while only 3.3

percent participants were having some other degrees. It means that there was most representation of master's degree and post-graduation in the overall sample as compared to other educational levels. With respect to the age, most of the respondents were of age between 21 to 30 years because 82.5 percent respondents reported their age between this range. There were 13.9 percent respondents whose ages were ranging from 31 to 40 years while 3 percent respondents were of age between 41 to 50 years. Only 0.7 percent respondents were having age more than 50 years. After analyzing the demographics of respondents, the descriptive analysis was performed to check the normality and suitability of data. Table 1 presents the descriptive statistics against all variables.

**Table 1.** Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
IOI	303	1.00	4.90	3.5799	1.07698	-.858	.140
OP	303	1.00	5.00	3.5439	1.13120	-.745	.140
CLP	303	1.00	5.00	3.5881	1.08664	-.837	.140
ILP	303	1.00	5.00	3.5802	1.06759	-.856	.140
FP	303	1.00	5.75	3.4101	1.05869	-.272	.140
SLP	303	1.00	5.00	3.4491	1.10238	-.617	.140

Descriptive statistics are showing that the mean value, standard deviation and skewness of IOI, OP, CLP, ILP, FP, and SLP are falling within acceptable ranges because the mean value of all variables is between their respective minimum and maximum values thus revealing that there is no extreme value in the data of any of these variables. The value of

skewness is also showing that it is ranging from -1 to +1 for all current variables and the standard deviation is also acceptable against all statistics. It means that there is acceptable variation in the data so, the data is normal and acceptable. The suitability of the data was further confirmed through "KMO and Bartlett's Test" which has been presented in table 2

**Table 2.** KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.954
	Approx. Chi-Square	14494.405
Bartlett's Test of Sphericity	Df	820
	Sig.	.000

The value of KMO for the current data is 0.954 for the present data which is fulfilling the threshold value (i.e. >0.60) and the p-value against it is <0.05 so, the suitability of the current data is confirmed.

After checking the normality and suitability of the data, the convergent validity and discriminant validity was ensured through key indicators for the data. Table 3 provides summary of results regarding discriminant and convergent validity in which the multi-collinearity was confirmed by checking the

discriminant validity of data while the internal consistency was confirmed by checking the convergent validity of the data.



**Table 3.** Discriminant validity

	CR	AVE	MSV	FP	SLP	CLP	ILP	IOI	OP
FP	0.900	0.691	0.566	<b>0.832</b>					
SLP	0.946	0.773	0.566	0.752	<b>0.879</b>				
CLP	0.943	0.768	0.379	0.445	0.455	<b>0.876</b>			
ILP	0.933	0.736	0.366	0.501	0.494	0.521	<b>0.858</b>		
IOI	0.968	0.751	0.341	0.574	0.516	0.527	0.581	<b>0.867</b>	
OP	0.951	0.797	0.379	0.387	0.392	0.616	0.605	0.584	<b>0.893</b>

The indicators of discriminant validity and convergent validity i.e. CR, AVE and MSV against all variables are giving acceptable values because CR for FP, SLP, CLP, ILP, IOI, and OP is more than 0.7 and the AVE is more than 0.5 which means that the more than 50 percent variation in data is explained by this model. The MSV against all current variables is less than respective values of AVE. Hence, the discriminant validity of the data is confirmed because

the variance in each variable is most explained by itself as compared to other variables. The convergent validity is also proved through table 3 because each variable has the highest correlation with itself as compared to the other variables. The “Confirmatory factor analysis” (CFA) was performed to check the model fitness through key indicators. Table 4 provides the summary of model fitness through CFA.

**Table 4.** CFA

Indicators	Threshold range	Current values
CMIN/DF	Less than or equal to 3	1.902
GFI	Equal to or greater than .80	.814
CFI	Equal to or greater than .90	.952
IFI	Equal to or greater than .90	.953
RMSEA	Less than or equal to .08	.055

T

he CFA results are showing that all the indicators of model fitness i.e. CMIN/DF, GFI, IFI, CFI and RMSEA are having acceptable values because the CMIN/DF is less than 3, The GFI is more than 0.8, the CFI and IFI both are greater than 0.9 and the

value of RMSEA for the current model is less than 0.08 (i.e. 0.055) so, the current model containing for FP, SLP, CLP, ILP, IOI, and OP has good fitness. The figure 1 reveals the CFA of the current data.

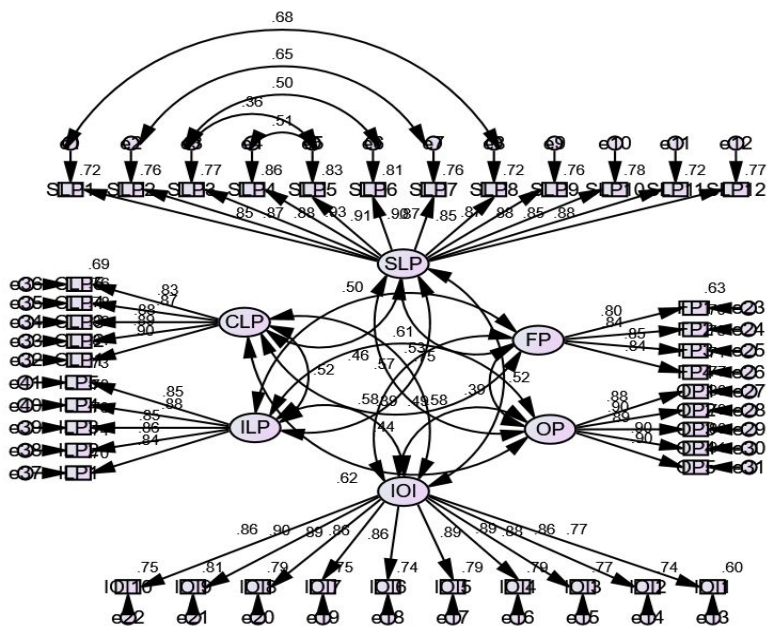


Figure 1: CFA

Finally, the SEM was performed to check the hypotheses, which revealed the results given in table 5.

Table 5. SEM

Total effect	ILP	CLP	SLP	IOI
IOI	.317***	.241***	.245***	.000
OP	.362***	.396***	.033**	.269***
FP	.141*	.084**	.596***	.210**
Direct effect	ILP	CLP	SLP	IOI
IOI	.317***	.241***	.245	.000
OP	.277**	.331***	-.033	.269***
FP	.075	.033	.544	.210**
Indirect effect	ILP	CLP	SLP	IOI
IOI	.000	.000	.000	.000
OP	.085**	.065**	.066**	.000
FP	.067**	.051**	.052**	.000

The results of SEM are indicating that there is significant and positive impacts of ILP, CLP, and SLP on the OP and FP however the total impact of ILP, CLP, SLP and IOI on OP and FP are not equal to the direct impact of these variables on both dependent variables therefore, there is mediation of some variable between these relationships, This mediation is performed by IOI which causes the significant

indirect effects of ILP, SLP and CLP on operational performance and financial performance (p-value<0.05). Hence, there is significant mediation of IOI in the relationships between SLP and OP, SLP and FP, CLP and OP, CLP and FP, ILP and OP, and ILP and FP. Figure 2 reveals the SEM taken from AMOS.

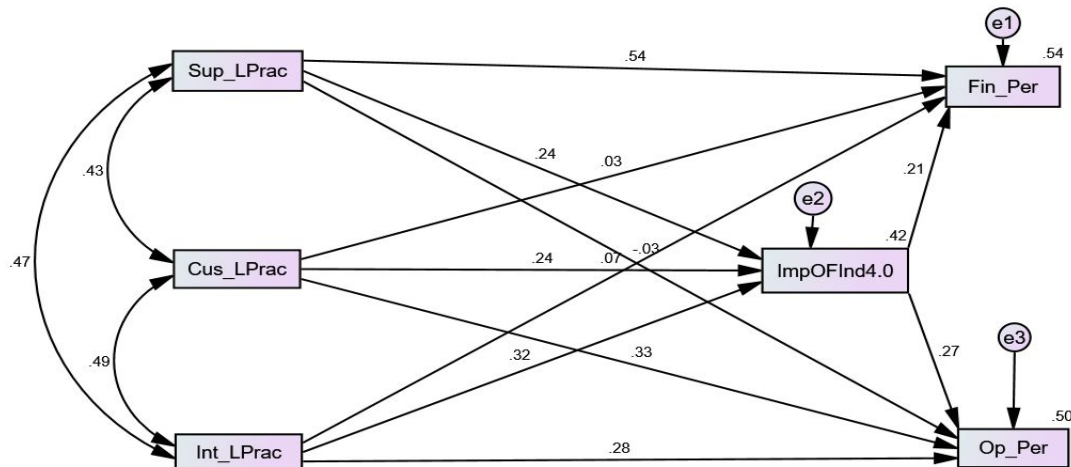


Figure 2: SEM

## 5. Discussion and conclusion

### 5.1. Discussion

This study was aimed to know about the impact of Lean Supply Chain Practices (LSCP) on the operational practices and the aim was also to know about the mediating role of implementation of industry 4.0 (II- 4.0) between LSCP and financial performance and operational performance (OP). LSCP include customer related lean practices (CRLP), supplier related practices (SRLP), internal lean practices (ILP). The study suggested the following hypothesis, the first hypothesis suggested that LSCP has a significant impact on II-4.0. LSCP include CRLP, SRLP, and ILP [17]. This hypothesis was accepted. The implementation of industry 4.0 has resulted in improved production and revenue due to advanced technologies. According to Guilherme Lue Turtom who is a famous researcher the relationship between LSCP and II-4.0 is positive and significant. The second hypothesis suggested that LSCP has a significant impact on operational practices OP and LSCP involve CRLP, SRLP, ILP. This hypothesis was accepted as well. According to Suhang le who is a researcher, he suggested that LSCP has a positive impact on OP. Improved organizational performance and competitive advantages were examples of their significant impact [24]. The third hypothesis suggested that II-4.0 has a significant role between LSCP and financial performance FP. LSCP involves CRLP, SRLP, ILP. This hypothesis was accepted. According to Shahram Taj, there is a significant mediating role of II-4.0 between LSCP and FP. II-4.0

revolutionized the LSCP and increased production and this caused the better financial performance. The last hypothesis suggested that II-4.0 has a significant mediating role between LSCP and OP [25]. LSCP include CRLP, SRLP, ILP. The hypothesis was accepted. A researcher named as sander Adam explained that the role of II-4.0 between LSCP and OP is positive and due to the role of II-4.0 the resulted in economical production and efficient organizational performance.

### 5.2. Conclusion

The aim of this study was to know the impact of LSCP on the OP. This study took intentions to know about the mediating role of II-4.0 between LSCP, FP and OP. Lean supply chain practices also include supplier related lean practices, customer related lean practices, and internal lean practices. The study was conducted in Thailand. The sample size was 350 but only valid responses were counted that were 303 responses from the manufacturing sectors of Thailand. The research data was collected from the questionnaire. The matter under study was the relationship between LSCP, FP and OP with the mediating role of II-4.0. It is seen that SRLP, CRLP, ILP has a significant impact on FP and (OP), and II-4.0 significantly mediates between all of the lean supply chain practices and FP, OP.

### 5.3. Implications of study

This study has significantly contributed in increasing the literature material about the LSCP, II-4.0, OP, FP. This study will be significant for the manufacturing

sector, they can get benefit from this study. They can have knowledge about the LSCP, II-4.0 and their impact on FP and OP. If they implement the LSCP in their manufacturing sectors it will help them in implementing the industry 4.0, by doing so their FP and OP will become better. SRLP, CRLP, ILP and II-4.0 should be included in the policymaking that will enhance the FP and OP.

#### 5.4. Limitations and future research indications

This study was only conducted in Thailand, it can be conducted outside Thailand because financial and operational problems are global so it can be conducted anywhere around the world. The researchers used a very small sample size the future researchers can use a large sample size and collect more reliable data about the manufacturing sector of Thailand. They used only one tool for gathering the information. Future researchers can use different tools like questionnaire and interview, or they can meet people by face.

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