Robotic Process Innovation as Mediator between Technical Traits and Lean Supply Chain Performance: An Empirical Study in Thailand

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Abstract--- Thailand is not just thriving due to its tourism but the country's manufacturing sector is also leaning towards robotic process innovation. Such innovation is strengthening due to technological advancements and resulting in enhanced firms' productivity. This idea of bringing robotic process innovation is action can be really helpful for lean processes in organizations. This study has aimed to check the role of direct and indirect usefulness of technological traits on lean supply chain performance in mediating role of robotic process innovation. Study has taken only those Thailand's manufacturing organization in sample who have already included robotic processes in their production system and their employees have surveyed through questionnaire. CFA and SEM were used to analyze model fitness and hypotheses. Results have enlightened that Both direct and indirect usefulness have significant impact on lean supply chain performance and also flagged significant mediating role of robotic process innovation in same relationships. Novelty in this study has come due to including a unique outcome lean supply chain performance as an output of robotic process innovation and technical traits. This study has its implications for not only for manufacturing but service sectors too to adopt such robotic practices to improve their performance levels.

Key Words: *Technical Traits, Direct Usefulness, Indirect Usefulness, Robotic Process Innovation and Lean Supply Chain Performance*

1. Introduction

The study is aiming to know about the impact of technical traits on lean supply chain performance. Technical traits in any organization are all of the traits and expertise that an organization owns in the form of its information technology characteristics [1]. A firm is mainly driven by the number of the information technology expertise it possesses [33-34]. Technical traits are becoming more and more important as the external environment is changing and innovating. The external environment is engaging in innovation process all the time and this heavy engagement needs the organization to change according to it whenever any change is required. Robotic process is something whose implementation needs to be done for the sake of making the organization able to compete with the external environment and in order to make the organization immune to the competitive and innovating environment [2]. Lean supply chain performance is the process by which the organization takes the supply chain forward in such a way that the products and the orders are supplied just according to the demand of the customers. The lean supply chain refers to the supply chain method in which the organization manufactures and provides the products to the customers exactly according to the demand of the customers [35-36].

This supply chain process is different from the traditional supply chain process which involves the production and the storage of the products whereas, lean supply chain is processed just according to the need of the customers and according to the time requirements of the customers [3].

International Journal of Supply Chain Management
IJSCM, ISSN: 2050-7399 (Online), 2051-3771 (Print)

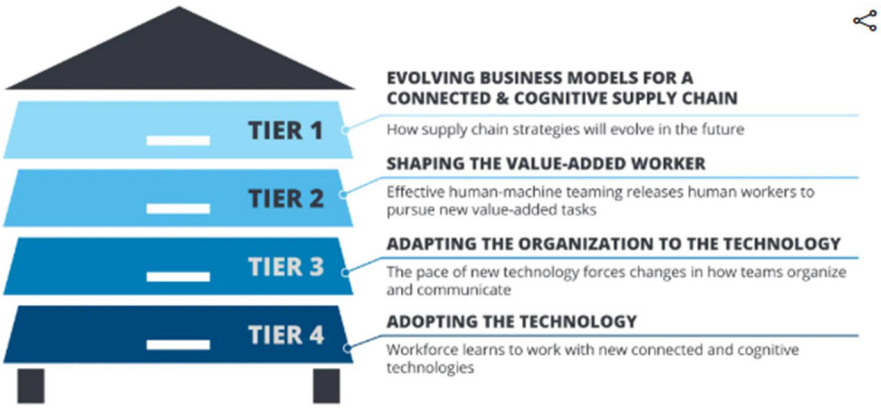


Figure 1: Technical traits development for LSCP (Source: Deloitte Analysis)

The lean supply chain requires technical traits as the technical traits are the things that integrate the supply chain process and this process involves everything from the manufacturing of the products to the supply of the products to the customers. The robotic systems not just only provide speed in the process but also provide accuracy in the process. Accuracy also brings in cost effectiveness as it will result in just the right amount of each product and material added in the production process. This study will be conducted in Thailand's small and medium enterprises (SMES) the ones that have hosted intelligent robots in their systems. The feedbacks from such organizations will be taken in order to know about the performance of the robotic systems and in order to know about the fact that whether it is sustainable to implement such systems in the organizations or not [4]. It will also be helpful for the organizations to assess the validity of such systems. The problem here is to check the validity and sustainability of the robotic systems and their application in order to improve the lean supply chain performance through the technical traits that an organization owns. This kind of study was almost never conducted in the past before as no other study is found to be discussing the same traits like technical traits and robotic process innovation in order to improve the lean supply chain performance [5]. The topic and the variables are very novel in their nature because they are almost found nowhere in the past studies. The study aims to know about the impact that technical traits cast on the lean supply chain performance and the study also aims to know about the mediating role that robotic process innovation will cast between the technical traits and lean supply chain performance. The study will contribute to the factors that are responsible for enhancing the performance of the lean supply chain. This study will be significantly contributing to the literature material of the robotic process innovation and has increased its importance. This study will be contributing to the theoretical material that how technical traits will help in the improvement of the lean supply chain performance and how the robotic process innovation will be mediating significantly between them [6]. After going through this study, it will be beneficial for the organizations to seek guidance from the results and analysis of this study in order to know whether it is sustainable to implement such systems or not. This study will also help them doing the practical implication of the robotic systems in their organizations and in order to enhance the technical traits in their organizations [7].

2. Literature Review

2.1. Resource Dependent Theory (SCM THEORIES)

Theoretical based evidences develop a combination of resource dependent theory [8] and agency theory [9] that are facilitated by supply chain management theories. This theory draws a connection between firm's sustainability, firm innovation strategy, supplier's product innovation and business performance. Resource dependent theory (RDT) hypothesize [10] that a buyer's innovation strategy enhances supplier innovation focus and a buyer-supplier relationship that supports product innovation. Positive impact on buyer product innovation has significant business outcomes and

business performance. Ref [11] explains SCM theories that elaborate the function and application of different theories regarding lean manufacturing principle. The areas of SCM theories need more improvement in the field of IT infrastructure, sustainability performance, gaining competitive advantage and performance capabilities of business and firms. This theory [12] can only be implemented and practiced by managers and practitioners or innovators working in an organization. SCM theories can be understood by them very easily and can be implemented into an organization appropriately. However, studies believe that in the current intelligence and information based society use of RD theory [13] is increasingly being used in the field of IT, where mostly technical work is done on the availability of theoretical background regarding information technology, robotic performance and usage as a workforce. Intelligent based services usually prefer IT infrastructure [14] where they can easily replace human workforce with automatic, technical or computerized workforce machines, to make working in an organization easy, smooth and comfortable. Computerized workforce decreases the use of manual workforce to manage both external and internal environment of firms and companies at the same time, which will perhaps save time and cost investment. Computerized machinery is used as an alternative to employ voluntary actions with the help of machines or robots [15] that enhances robust robots innovation processing. Theory of resource dependence collaboratively works with other SCM theories to develop theoretical analysis regarding the use of robots as an emerging technical trait within the field of business capabilities and performance. Theories analyzes the importance of machinery as an alternative way to increase the work efficiency and simultaneously to enhance cognitive services however, still a lot of advancement is needed in the machinery as well as in technology which can be easy to handle.

2.2. Direct Usefulness Relationship with lean Supply Chain Performance

[16] suggests that Direct Usefulness is one of the important components of technical traits that deals with direct technicalities and issues received through the implication of latest technology and installation of IT infrastructure. Theory of RD [17] influences the performance of direct usefulness and supply chain due to advanced manufacturing capabilities as well as performance. Industrial automation applications implements the idea introduced by IT infrastructure and technology development plan that forces the use of machinery workforce in all the organizations, that will essentially replace the manual labor to make working of firms and huge organization more easy and simple. Those organization who are multi-national and earns a lot more than expected in a year, can easily replace its manual labor with the automatic machines like robots, to decrease work load and increase [18] efficiency in performance, product sustainability and production of services and goods. Direct usefulness of various policies regarding technology and information suggests increasing the utilization of industrial robots within organization or huge industries that mainly perform simple and repetitive tasks, such as assembling, welding, coating and semiconductor manufacturing. These tasks however, increase the supply chain performance of industries, firms and organizations. Many well-developed countries like USA and China has advised to make use of industrial robots in their industries and firms, to provide a source of facility for human workforce who works for long hours. These industrial robots have artificial intelligence systems that are innate and they are programmed according to it; however Japan has already introduced a robotic revolution as the core policy of its industrial growth strategy and has large-scale national and international projects in progress that can make use of these robots in the medical, social, technical and safety fields. However, direct technical traits [19] have a great value in the usefulness of robots that will perhaps influence the performance of supply chain within an organization or an industry. Thus, the following hypothesis is proposed:

H1: Direct usefulness has a significant impact on lean supply chain performance

2.3. Indirect Usefulness Relationship with Lean Supply Chain performance

[20] elaborates the performance of Indirect usefulness is also considered one of the technical traits of using robotic machinery in the mechanization and unmanned robotic industry. Robotic revolution [21] includes the technicalities that involves indirect usefulness trait for maintaining

organization size, management structure, quality of human resources, degree of centralization, formalization, complexity of management organization and internal communication. These all are the usefulness of indirect technical trait that follows environmental, economical and social business context [22]. Indirect usefulness provides organization business activities that are performed by IT infrastructure, regulation of environment and which depend on TOE framework. However, framework of resource dependence theory also includes the scale, value and structure of the industry to which the organization actually belongs. Indirect technical traits also depend upon the sudden changing of the environment, climate or business capabilities and organizations that will further influence the SCP. Human disturbance is also considered one of the aspect of technical trait that is indirect, if the indirect traits are beneficial to the business orientation and performance than it will have a positive impact on the performance of supply chain [23], therefore yet it is to be confirmed by the studies regarding the implications and implementation of indirect technical traits and their influence on SCP. Thus, the following hypothesis is proposed:

H2: Indirect usefulness has a significant impact on lean supply chain performance.

2.4. Mediating Role of Robotic Process Innovation between Direct usefulness and Lean supply chain performance

According to past studies [24], technical characteristics of robotic process innovation (RPI) leads to form a mediating role between the two variables like direct usefulness and lean supply chain performance (LSCP). Theory of resource dependence drives the literature towards the study findings of hypothesis about the efficiency of [25] LSCP and its effect on direct usefulness with the help of technical capabilities. Robotic process innovation has a significant influence on the accommodation of technologies and its innovation. This type of innovation usually carry out further linking process that develops between the function of direct technical trait and LSCP. Technical habits of RPI relies on perceived benefits, cost efficiency and perceived costs that further study the organizational characteristics along with technical characteristics to have significant influence on organizational readiness, imitation of competitors pressure and normative pressure that further enhances the impact of RPI [26] on the performance of direct usefulness capabilities as well as on the performance of lean supply chain that will increase the business productivity and organization performance. Studies suggest that RBI or automation is a type of business process automation that is primarily, related to the level of artificial intelligence (AI) that drives the LSCP to the next level of direct technical trait. Thus, the following hypothesis is proposed:

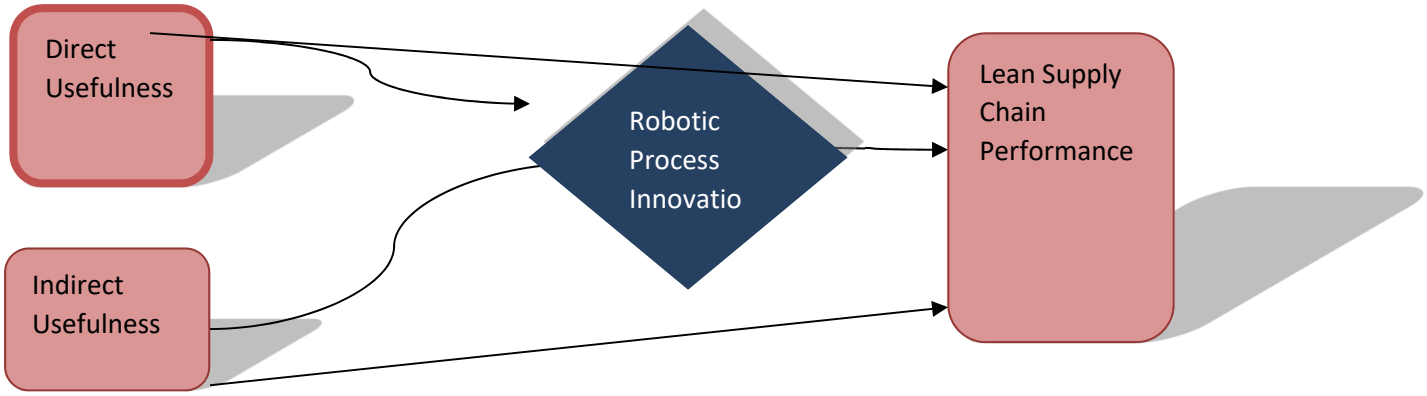
H3: Robotic process innovation has a significant mediating role between the relationship of direct usefulness and LSCP.

2.5. Mediating Role of Robotic Process Innovation between Indirect Usefulness and Lean supply chain performance

[27] analyzes the effect of BPI and automation in the business process of automation that uses artificial intelligence to increase the efficiency of an organization or a firm by decreasing or reducing manual repetitive risks that are based on manual tasks, to gain more benefits from the AI process and machinery [28]. RPI and automation is not only affiliated with job performance related to any enterprise or a company, but however it is also affiliated with UIpath that describes working with an organization which utilizes RPI that focus on the customer-centric activities. According to theory [28] of resource dependence and agency theory the role of RPI focuses more on customer activities and customer requirements that moreover influences the capabilities of indirect usefulness or technical traits and LSCP. Indirect usefulness usually focus on customer demands and suppliers performance due to the spread of latest technology that basically highlights the theoretical model of TOE framework and RDT to analyze the potential of robotic process automation [29] because it can be implemented for various technical techniques, related to various organizations and environmental factors in accordance to IT infrastructure that as a result links indirect usefulness and LSCP with RPI. However, still studies and literature are using various invocation and supply chain management models to briefly understand the role of RBI between the two significant variables. Thus, the following hypothesis is proposed:

H4: Robotic process innovation has a significant mediating role between the relationship of indirect usefulness and LSCP.

Model:
Technical Traits



3. Research methodology

3.1. Population and sampling

In this research study, researcher has been observed mediating role of robotic process innovation in relationship among technical traits and lean supply chain performance. The targeted population for this study was Thailand, researcher has been selected the manufacturing sector of Thailand for observing role of robotic innovation in supply chain. As the automotive and electronic manufacturing industries of Thailand have fully documented supply chain and almost all the parts of the top brands vehicle such as BMW, Volkswagen and Ford manufactured in the Thailand. Researcher observed how the integration of robotic process innovation in supply chain enhanced the supply chain performance. Further, researcher has been selected the employees as respondents from these manufacturing industries by using stratified random sampling techniques in order to maintained the balance among three industries. In sampling, researcher selects the sample size on the bases of (Klein, 2015) idea, according to which formula number of questions*10 generated exact sample size. After the calculation 300 questionnaires have been distributed among the respondents, but researcher collected only 274 responses. Out of which, researcher has been considered only 274 responses valid because other were considered invalid.

3.2. Data collection procedures

In this research study, questionnaire has been used for the data collection. Questionnaire has been composed of closed ended questions, which were related to the survey items of the study. Before finalizing the questionnaire, researcher conducted pilot study in which researcher include almost 43 respondents from sample and items have been verified by them on the bases of understanding the perspective of each item. Further, content validity of the scale has been ensured by collecting the feedback from the other research authors and industrial practitioners. Questionnaire has been administered by using online questionnaire method. Questionnaires have been mailed to the whole sample and respondents solved it according to their own perspective.

3.3. Measurement Model

In the measurement model, researcher analyzed the reliability and validity. Reliability has been assessed by SPSS and two criteria have been examined for the assessment. One is composite reliability which has to be greater than 0.70 in order to ensure the satisfactory level of internal consistency (Hair et al., 2010). Second one is Cronbach's α which has to be exceeded than 0.70 in order to ensure the desirable level of items reliability (Hair et al., 2010). Coming towards validity, convergent validity has been

assessed by criterion which states that Average variance extracted has to be greater than 0.50 because its values were stronger above the 0.50. As far as the discriminant validity is concerned, square root of the AVE of each construct has to be greater when compared with the inter-correlated coefficients of all other remaining constructs. Because it indicated that latent constructs can explained more of the variance in its items than it shares with other constructs.

Coming towards common bias, which has been observed in the study, if respondents were provide same measures recommended by the common rater [11] for dependent and independent variables. The risk of common bias has been generated as the same measures used in this study for the variables such as lean supply chain performance, technical traits and robotic process innovation. Harman's single factor test has been used for checking whether most of the constructs accounted for by single factor or not. If the 50% of variance accounted for by single factor than common bias has been observed. According to outcomes of the test, 81% of the variance accounted for by factor solution and 24% of the variance accounted for by one factor. Hence, inexistence of common bias has been ensured because 50% of variance not interpreted by single factor.

3.4. Hypothesis testing

Hypothesis testing is mandatory part of research methodology because the results of hypothesis testing decide which hypotheses accepted or rejected. It has been performed by structure equation modeling, which runs on AMOS. Covariance based approach used by AMOS in order to run the operations of SEM. In this structure model, hypotheses have been tested by two steps. First step is to observe direct effect and second step is to observe moderation effect. In direct effect, researcher has been tested impact of technical trait on lean supply chain performance. On the other hand, moderation effect observed to test the impact of robotic process innovation on lean supply chain performance. After the hypothesis testing, researcher assessed the acceptance or rejection status of hypotheses.

3.5. Measures

DU was measured with the scale developed by [13] with the help of five items that were taken on a five-point Likert scale. Then IU was assessed by the scale developed by the researcher [15] and here four items were taken on a five-point Likert scale and were assessed. LSCP was measured by a scale developed by [17], four items were taken and measured on a five-point Likert scale. Finally, RPI was measured by the scale developed by [25] and five items were taken which were measured on a five-point Likert scale.

4. Empirical results

4.1. Demographical results

The study was conducted in Thailand and data was from 300 participants and the number of respondents was 274. The associations with the help of a self-organizational questionnaire were analyzed by using SPSS and Amos. It is very important to conduct the prerequisite analysis in order to check the reliability, normality, and validity of the data. The researcher applied the frequency distribution test in order to check the respondent profile. The findings showed that 117 males and 157 females participated in this study. 23 of the participants had graduation degree, 137 respondents had done post-graduation. Whereas, 105 respondents had master's degree and 9 had another degree. The participants included 205 people in age range 21 to 30 years, 44 people in age range 31 to 40 years, 24 people in age range of 41 to 50 years and only 1 participant was of age more than 50.

4.2. Descriptive Statistics

Table 1 is showing that there is no out lair in the given data as the maximum values lie in the threshold range of 5-point Likert scale, as the skewness value is somewhere between -1 and +1 which is the threshold range of normality assumption and so the data is normal and is valid to go for further testing.

Table 1. *Descriptive Statistics*

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
PPI	274	1.00	5.00	3.6365	1.03880	-.917	.147
DUN	274	1.00	5.00	3.6551	1.07572	-.905	.147
IUN	274	1.00	5.00	3.6515	1.06941	-.952	.147
LSP	274	1.00	5.00	3.4635	1.11477	-.550	.147
Valid N (listwise)	274						

4.3. Rotated Component Matrix

The above table is showing the RCM values, almost all of the indicators are showing the factor loading more than 0.7, it means that all of the indicators are eligible to be added in the further hypothesis testing because all factor loadings are in suitable threshold level and in a suitable and valid range. Moreover, there is no cross-loading data shown in RCM so, data is good to go for further testing.

Table 2. Rotated Component Matrix

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
PPI1	.723			
PPI2	.780			
PPI3	.836			
PPI4	.818			
PPI5	.793			
DUN1			.797	
DUN2			.842	
DUN3			.824	
DIN4			.810	
IUN1				.803
IUN2				.856
IUN3				.865
IUN4				.802
LSP1		.823		
LSP2		.849		
LSP3		.861		
LSP4		.867		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

4.4. Convergent and Discriminant Validity

The results of convergent and discriminant validity show that the overall model is a good fit because the composite reliability of each variable is more than 70% and average variance extracted is more than 50% while the discriminant validity shows that loading of each variable discriminates from others. Every variable has maximum loading with itself as compared to with others so these validities prove the authenticity of collected data.

Table 3. Convergent and discriminant validity

	CR	**AVE**	**MSV**	**MaxR(H)**	**DUN**	**PPI**	**IUN**	**LSP**
DUN	0.931	0.772	0.441	0.933	**0.878**			
PPI	0.930	0.726	0.441	0.965	0.664	**0.852**		
IUN	0.930	0.769	0.377	0.976	0.614	0.578	**0.877**	
LSP	0.926	0.757	0.321	0.982	0.459	0.567	0.495	**0.870**

Table 4. CFA

Indicators	Threshold range	Current values
CMIN/DF	Less or equal 3	1.684
GFI	Equal or greater .80	.924
CFI	Equal or greater .90	.981
IFI	Equal or greater .90	.981
RMSEA	Less or equal .08	.050

4.5. Confirmatory Factor Analysis

Here, CMIN is less than 3, GFI is greater than .924, CFI is greater than .90, IFI is greater than .981 and RMSEA is less than .80. So, the table 4 is showing that the indicators lie in the valid range so the data is good to go. Screenshot of CFA is given below:

4.6. Structural Equation Modeling

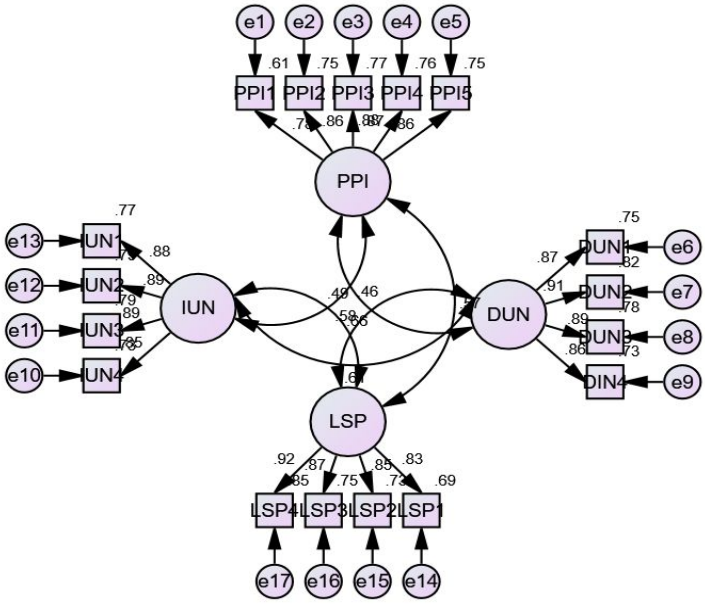


Figure 2: CFA

Table 5. SEM

Total effect	IUN	DUN	PPI
PPI	.268**	.477***	.000
LSP	.324***	.239**	.358***
Direct effect	IUN	DUN	PPI
PPI	.268**	.477***	.000
LSP	.228**	.069	.358***
Indirect effect	IUN	DUN	PPI
PPI	.000	.000	.000
LSP	.096*	.171**	.000

The total effect of IUN on PPI and LSP is 26.8% and 32.4% respectively which is significant and positive. The impact of DUN on PPI and LSP is 47.7% and 23.9% respectively and is significant and positive

which means that with 1 unit increase in DUN, PPI and LSP will increase by 47.7% and 23.9% respectively. There is a 35.8% impact of PPI on LSP. Directly IUN has 26.8% and 22.8% impact on PPI and LSP respectively. Directly DUN has 47.7% and 6.9% impact on PPI and LSP respectively. Directly PPI has 35.8% impact on LSP. Indirectly, IUN impact LSP by 9.6% and DUN impact LSP by 17.1%. Following is model of SEM:

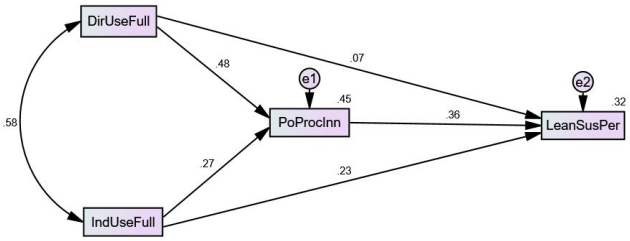


Figure 3: SEM

5. Discussion and Conclusion

5.1. Discussion

The aim of this research was to know about the impacts of technical traits on lean supply chain performance (LSCP). Technical traits involve direct usefulness (DU) and indirect usefulness (IU), the study aimed to know the impact of both of these on LSCP and the mediating role of robotic process innovation (RPI) between these technical traits and LSCP. The first hypothesis proposed in the study was that, "DU has a significant impact on LSCP". This hypothesis is accepted according to the authors, LP. Willcocks, M. Lacity and A. Craig, DU contributes highly in LSCP and contributes highly in improving it [30]. The second hypothesis proposed was that, "IU has a significant impact on LSCP". This hypothesis is accepted as well according to the proposed studies of M. Lacity, IU improves LSCP when RPI is implemented through this. The third hypothesis proposed was that, "RPI act as a significant mediator between DU and LSCP". This hypothesis is accepted as well, A. Rodriguez concluded that RPI acts significantly when it comes to improvement in LSCP, it is because RPI increases efficiency and effectiveness of the business with lesser cost and even in lesser time, so DU when applied through RPI will result in increased LSCP [31]. The fourth hypothesis proposed was that, "RPI has a significant mediating role between IU and LSCP". This hypothesis is accepted according to the study of A. Salter, IU when applied through RPI increases the efficiency and effectiveness of business increases and it is cost effective as well [32].

5.2. Conclusion

The main aim behind conducting this study was to know about the impact that DU casts on LSCP and also to know about the impact of IU on LSCP. This study tool RPI as a mediator between these technical traits and LSCP. The research was conducted in Thailand's small and medium enterprises (SMEs) the ones that have hosted intelligent robots in their systems and the survey was conducted by the fulfilment of questionnaires from the employees working in these firms. The sample size was almost three hundred people, 274 responses were valid. The data was collected and it was exposed to different testing and analyzing techniques. After the analysis and testing it was concluded from the study that DU has a positive impact on LSCP and IU has a positive and significant impact on LSCP as well. It is also concluded that RPI significantly mediates between the two technical traits and LSCP.

5.3. Implications of the Study

This study has its wide applications in the literature as the technical traits are the least focused area when it comes to LSCP, in this study the benefits of the technical traits in improving the LSCP is highlighted and the data about the importance of the mediating role of RPI is analyzed and stated. This study can be helpful in the future for the policy making process and the practical implication process of RPI for the

betterment of LSCP in the small and medium enterprises all over the world.

5.4. Limitations and Future Research Indications

This study was conducted by keeping a limited nature of sector under study that was only the small and medium enterprises of Thailand. Future researches can be conducted on a much diverse nature of sectors and on a larger number of samples as well. Future researches can be conducted by taking different mediators under study such as role of organizational support, this study can be conducted in other countries as well to see the application of RPI and the changes in LSCP respectively.

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