

# Improving Sustainability Performance through Internet of Things Capability in Thailand: Mediating Role of IOT Enabled Supply Chain Integration

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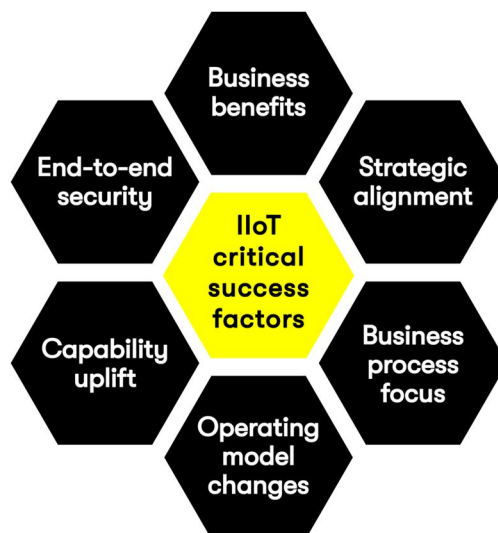
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**Abstract**--- It is pretty hard to counter this fact that Internet of Things (IOT) is integrating boundary less businesses with technology. The same IOT is probably a long-term solution for enhancing sustainability performance in manufacturing sector as it can integrate various supply chain components in a way which was never done before. Purpose of this study is to check the impact of IOT capability on sustainability performance in manufacturing sector of Thailand in mediating role of IOT enables supply chain integration like internal, supplier and customer integration. Respondents were the employees of 62 manufacturing firms of Thailand whom opinion has been taken through structured questionnaire. SPSS and AMOS are used to analyze the data through confirmatory factor analysis and structural equation modeling. Results have affirmed that IOT capability can enhance sustainability performance while all three dimensions of IOT enabled supply chain integration have shown significant positive mediating role in the relationship between IOT capability and sustainability performance. This study is unique due to its novel outcome of sustainability performance which was not previously tested with IOT capability. The results have implications not only for manufacturing sector but can also facilitate policy making too.

*Key Words:* Internet of Things, IOT Capability, Supplier Integration, Customer Integration, Internal Integration and Sustainability Performance

## 1. Introduction

Performance of a firm does not merely depend on its efficiency, but also on the market where it operates. Performance is the basic tool of knowing how well a company is doing or how adverse is its condition [1]. Every company's basic goal to be in the market is just to improve its performance more and more and make profits and increase productivity [26]. Many operations of the firm collaboratively describe the performance of a firm so it is necessary to be very efficient in all the operations of the firm [2].



**Figure 1: IoT Capability**

Figure 1 shows the success factors that can be achieved by using internet of things and improve the performance. IoT capability refers to the capabilities owned by a supply chain because of the involvement of daily things with technology and communicating with other devices and services through internet [3]. IoT capability is very important aspect in modern organizations and is used to communicate in and through organizations and transmitting information in more advanced way. So, the importance of IoT can be illustrated by the above-mentioned factors. To improve performance of any organization, IoT must be adopted and used effectively. In Thailand though, IoT is not that popular yet but many organizations are willing to adopt it to enhance their performance [4]. Supply chain integration can be defined as the collaboration of different business processes in any organization to make its operations efficient and increase customer value by providing them best products or services at best price [27]. We can say that supply chain integration is the combination of business processes in and between firms which also involves suppliers and customers [5]. Supply chain integration has three dimensions i.e. internal integration, supplier integration and customer integration. Internal integration involves the sharing of information and collaboration of different departments of a business firm with each other to make certain efficient operations and improve the performance of the firm [28]. Supplier integration refers to the transfer of information between supplier

and business firm for the better handling and supply of products and for better relations of suppliers with the firm [6; 30]. Customer integration means the sharing of useful information between firm and customer so that customer is well aware of firm's vision and mission and firm is well aware of the customers wants so that it can cope with them effectively in future. The purpose of supply chain integration is to maintain good relations with both suppliers and customers and using these relations to increase the efficiency, effectiveness and performance of the firm [7].

IoT capability can be used to improve the supply chain integration of any firm and this integration helps firms to improve their performances and increase profits. The use of IoT is increasing gradually in the whole world but in Thailand its popularity is relatively low [8]. The use of traditional business processes and integration processes, the performance of the firms has been affected adversely. Obviously in this era of technology and internet, old methods of business do not work well. In addition to Thailand, other developed and under developed countries are going through same issues. If these problems are not overcome soon, they will decrease the performances of firms gradually and will create difficulties for them [9]. It will also have negative impacts on customers and suppliers because they are an essential part of any supply chain. So it is necessary to leave the old business practices and adopt new technology, IoT, which will have positive

effects on the performance of the firms in Thailand [10]. There are some studies done in context of performance sustainability and to check the impact of IoT capability on sustainability performance, but no research has been made in order to check the mediating role of supply chain integration between IoT capability and sustainability performance. A research paper has recommended checking and studying in detail the mediating role of supply chain integration between IoT capability and sustainability performance [11]. The main objectives to conduct this study are as follows:

- Analyze the significant impact of IoT capability on sustainability performance of firms in Thailand
- Analyze the significant mediating role of supply chain integration between IoT capability and sustainability performance of firms in Thailand
- Analyze the significant mediating role of supplier integration, internal integration and customer integration between IoT capability and sustainability performance of firms in Thailand

Thailand's future growth is expected to remain 3% to 4% as many investors are interested in investing there. Thailand is also working on Thailand 4.0 policy, according to which, the businesses will be digitalized [29]. The govt. is supporting this by making favorable policies and providing enough funds [10]. Under this policy business operations will be revolutionized and new technologies will be introduced that will help them make digital Thailand. They are currently working on many plans in which they will adopt IoT in their firms to increase performance and productivity [12]. Theoretical significance involves many studies and researches made in this context. These studies are helping the businesses and organizations a lot in adopting the new technologies such as IoT in order to shift their businesses to complete digitalization. Organizations are making many improvements in their business practices an improving the supply chain integration by communicating with suppliers and customers well to improve their impact on performance of the firms [13]. In addition, the govt. is also using these studies and researches positively and making policies favorable for IoT adoption by business firms. Govt. is

also interested in providing certain funds for this purpose. It will boost overall economic performance and profits [14].

## 2. Literature Review

### 2.1. Organizational Capabilities Theory

The internet of things is considered the next generation internet connected fixed (ICT) system that will be used to integrate supply chain and logistics process. Studies [15] that develop the concept of Internet of things (IOT) capability related to defining improvement and sustainability performance of firm and industry. For this type of study theoretical evidences draws a theory dependent upon organizational capability [16]. Therefore, this theory was developed further considering an empirical model which depends on the effect of IOT sustainability and capabilities on multiple dimensions of supply chain process integration. IOT focuses on the practices and function of organizational performance and supply chain performance. Organizational capability theory (OCT) enables integration [17] processing of customer-service, supply chain orientation and firm performance. Internet of things shows advancement in technology, it also enhances the effect of IOT on innovation while connecting it through different objects, devices and networks. Basic function of IOT is to communicate the data through internet connection but this type of connection is considered one of the advanced form of platform that easily facilitates 'things' which can further be sensed, identified and located on the global platform. It is one of the ways through which firm and business can effectively progress in communicating through transferring information with the help of advanced and latest technology (ICT). ICT is supposed to be a well-developed network of organizations depending upon real-time basis. IOT is also defined as a digital working network which connects convenient objects for the connectivity of data that added capabilities to its functionality. Evidence of IOT application is given by conventional means of communication such as purchasing, transportation, storage and distribution of data with other smart devices that coins IOT umbrella of related technologies. However, studies [18] believe that IOT functions collaborate with potential supply chain integration to increase the sustainability performance. OC theory helps business performance

capabilities and integrated capabilities to distribute the data in a proper network of organizations.

### **1) IOT Capability relationship with Sustainability Performance**

According to various studies [19] that deals with developing a connection between IOT capabilities with the sustainability performance while using OC theory. OC theory studies about the development of ICT that enables supply chain management along with supply chain performance and supply chain integration, which will however produce a positive impact on the sustainability performance (SP) with the use of IOT connecting network. Integration is regarded as bringing improvement in the performances that are documented through empirical evidences of the studies, yet it highlights the concept of IOT capabilities along with its orientation with SP. Through introducing integration and innovation in business orientation which will eventually generate greater customer value by offering superior inter or intra-organizational services. SP also refers to the flow of products, goods and services to strengthen the supply chain management which will perhaps increase the IOT network capabilities. A collaborative mechanism that depends on the function of network wide spread the IOT capabilities which enhances the performance of sustainability orientation in firm business. Thus, the following hypothesis is proposed that:

**H1:** IOT capabilities has a significant impact on sustainability performance

### **2) Mediating Role of Supply Chain Integration between IOT capability and Sustainability Performance**

As per studies [20] supply chain integration acts as a mediating role between IOT capability and SP, therefore SCI is also known as a device which bridges a gap between two variables that are connected through a strong and influential network. OC theory draws evidence regarding the function and liability of IOT performance and its orientation which fits in a scenario of network-based competitions, which develops and further determines the strength of supply chain performance along with supply chain integration. In the current dynamic and competitive business environment supply chain integration compete with individual organizations that perhaps increases supply chain performance and supply chain orientation for achieving sustainable competitive

advantages. Supply chain integration molds a performance mechanism in such a way that it is further used for improving supply chain performance. Supply chain management literature largely focuses on the application regarding digital connection of business processes within the organization and between organizations involving upstream suppliers and downstream customers. IOT help in an organization building with the help of its capabilities, sources and capability theory perspective. Literature joins these three variables in such a way that when one variant increases other also increases, such as when SCI influences IOT capability than SP is also influenced by SCI and IOT network for the purpose of having significant and positive impact over each other. Therefore, IOT is an object that enhances the capability to integrate the suppliers, retailers, customers, managers and intro-organizational logistic procession capability is an element that bridges the gap between physical and digital world, but yet more and more improvement and advancement has to be done in the logistic process of SCI and IOT network condition to positively affect SP. Thus, the following hypothesis is proposed that:

**H2:** Supply chain integration has a significant mediating role between the relationship of IOT capability and Sustainability Performance.

### **3) Mediating Role of Internal integration between IOT capability and sustainability performance**

Researchers [21] suggest the view point of the mediating role which is carried out by internal integration IT between two diverse variants like IOT capability and SP. Internal integration depends upon the internal function, practices, orientation and performance of form and business capabilities that enhances the capacity of SP along with IOT performance. Internal integration relies on the category based on intra-organizational logistics process which further elaborates the phenomenon of developing internal competitiveness that is also responsible for bridging a gap between physical and digital world of information, accessibility and communication with the use of new generation network. Supply chain integration is embedded with technology and performances that provides identification and sensing facility. However, due to networking processing internal integration produces a positive impact on the orientation of IOT capability

which further positively influences the sustainability performance to increase productivity performance as well as service improvement performance. OC theory develops a connection between the variables and the use of mediating role of internal integration that is supposed to be primary demand driven that develops intense internal digital connectivity. IOT paradigm with the help of internal integration plays a significant role in the retail industry to manage supply networks according to the supply chain management [22] to give positive response to the customer demands. However yet, IOT application is considered broadly technical, informative and oratory to focus on the function of internal integration performance which will produce its impact on IOT capability and SP that will somehow configure the idea of technological adoption for creating reliable data transparency and visibility to achieve supply chain process integration at internal level. Thus, the following hypothesis is proposed that:

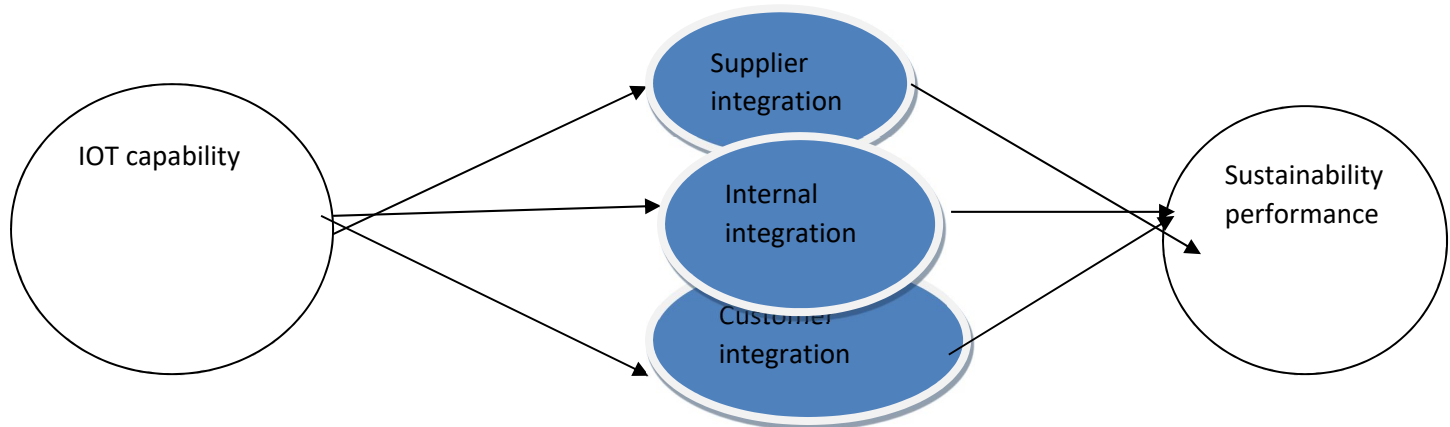
**H3:** Internal integration has a significant mediating role between the relationship of IOT capability and Sustainability performance

#### **4) Mediating Role of customer integration between IOT capability and Sustainability performance**

OC theory enhances the role of customer integration services (CIS) for the purpose to connect IOT capability with SP. Emerging list of technologies can benefits various ideas and concepts regarding IOT capabilities and SP which can further facilitate external (suppliers and customers) and internal (cross-functional process) which might help to deliver effective and efficient supply chain performance [14] as well as orientation and form orientation and performance. Firm performances enhance the affectivity of productivity which can easily influence sustainability performance of firm and business at large level. IOT capability develops a certain conceptual framework regarding supply chain management and supply chain performance which will integrates a role of customer orientation within an organization that may add value to the additional capability to the current configuration of ICT capability. Sharing of information communication with the use of large developed network, however also positively influence the customer integration and IOT capability. ICT act as a backbone for the building of IOT construction capability which will

run smoothly into the mainstream business running on the legacy of ICT orientation. Inter and intra-organizational communication and information underpin various research studies which is related to resource based view theory, however firm should develop its own resources and capabilities which is necessary for performance improvement. This improvement in performance positively affects the performance of customer integration which acts as a mediating role between IOT capability and sustainability performance. Therefore, integration related to internal, customer, supply chain or organizational capability that depicts higher order process capability that can directly influence IOT performance or orientation along with sustainability performance. External and internal integration represents firm's external processes integration for the development of customer integration value and orientation. Thus, the following hypothesis is proposed that:

**H4:** Customer integration has a significant mediating role between the relationship of IOT capability and SP.

**Model:****Figure 2:** Model**3. Research Methodology****3.1. Population and Sample Selection**

The target population for this research study is manufacturing sector of Thailand, researcher observed the impact of internet of things capability and IoT enabled supply chain integration on the sustainability performance of manufacturing industries. Researcher has been selected textile, electronic and automotive industries of Thailand as sample because these industries incorporate internet of things capability in supply chain and IoT enabled supply chain integration ultimately improved the sustainability performance of these industries. Managerial employees of these manufacturing industries have been selected as respondents because they have knowledge about the internet of things and they know how to incorporate the IoT in the supply chain. In the next step of sampling, researcher has to select the sample size of the research study. For the sample size selection idea of (Klein, 2015) has been used, according to which researcher used the formula such as number of questions\*10 for the calculation of sample size. On the bases of this calculation, sample size has been selected is 350, questionnaire has been distributed among 350 respondents but the after-data collection and after discarding the missing values and invalid responses only 310 responses considered valid.

**3.2. Data Collection and Procedures**

In order to collect the data from managerial employees of Thailand companies, data collection method researcher has been used is questionnaire.

Before finalizing the questionnaire, researcher has to undertake two steps such as content validity of scale has been confirmed by industries practitioner and academics prior to data collection in order to avoid repetition and ambiguity in questionnaire items and language should be Thai for understanding of employees of Thailand. Moreover, online and self-administered questionnaire techniques have been used for data collection.

**3.3. Reliability, Validity and Common Bias**

Reliability and validity have been assessed in this research study through SPSS and AMOS respectfully. Reliability has been assessed by SPSS and examined by criteria which states that Cronbach's  $\alpha$  must has to exceed specified limit 0.70. As far as the validity is concerned, convergent validity has been assessed by SPSS and criteria to examined it are (1) items loading ( $\lambda$ ) and its threshold range is greater than 0.70, (2) composite constructs reliability must has to exceed the specific limit 0.70, CCR values were strong at 0.75 or at above and (3) average variance extracted has to be greater than 0.50. Coming towards discriminant validity between constructs, it has been assessed by criteria which entails that square root of AVE has to be greater when compared with all other constructs .

Further, common bias method has been observed in research study when respondent used the same measures provided by common rater. for exploratory and dependent variable in different study. As the set of variables are different for every study that's why set of variables for this study includes internet of things capability, IoT enabled supply chain

integration and improving sustainability performance. To evaluate these variables researcher has to use measures carefully. Moreover, Harman's single factor test has been used by researcher in order to control the risk of common bias, which include two type of analysis exploratory factor analysis and confirmatory factor analysis. In EFA approach, researcher checked whether all constructs interpreted by single factor or not. Results reported that no single but different factors used for interpretation of all the constructs. Almost 80% of total variance accounted for by factor solution and 28% of variance accounted for by single factor. On the other hand, CFA approach has been used in order to confirm the absence of common bias method.

### 3.4. Hypothesis Testing

Structure equation modeling has been used for hypothesis testing, which has been runs on AMOS. Path analysis has been performed under SEM for testing the hypothesized path of structural path model. Hypotheses which has been tested in this study are impact internet of things capability on sustainability performance in mediating role of IoT enabled supply chain integration. Direct, indirect and total effect has been used while assessing the acceptance or rejection status of hypothesis. Moreover, significance of relationship has also been considered in order to accept or reject the hypotheses.

### 3.5. Measures

IOTC was measured with the scale developed by Lorenzo (2000), with the help of five items that were taken on a five-point Likert scale. Then SI was assessed by the scale developed by the researcher [29] and here four items were taken on a five-point Likert scale and were assessed. II and CI were measured by a scale developed by [28], four items

were taken and measured on a five-point Likert scale. Finally, SP was measured by the scale developed by [29] and five items were taken which were measured on a five-point Likert scale.

## 4. Analysis and Results

The current research was about the analysis of the impact of IOT capability on the sustainability performance along with the mediating role of internal integration (II), customer integration (CI) and supplier integration (SI). The current study received 310 appropriate responses which could be considered for analysis after screening of missing and blank responses. The demographic analysis of the current data revealed that most of the respondents in the current study were females because 59.6 percent responses were accounted by females while 40.4 percent responses were accounted by male respondents. The age of most of the respondents was ranging from 21 to 30 years (i.e. 83.4 percent) while 13.2% respondents were having age between 31 and 40 years. There were least number of respondents in the sample who reported their age more than 50 years. However, 2.8 percent respondents were of age ranging from 41 to 50 years. As far as the education of respondents is concerned, it has been found through demographic analysis that educational level of 50.2 percent respondents was "post-graduation" and the educational level of 39.5 percent respondents was "Masters" while the 7.2 percent respondents reported their education level as "Graduation". Remaining respondents were having other educational backgrounds.

The current data has been checked in terms of its normality and acceptability through descriptive statistics, the results of which have been provided in table 1.

**Table 1.** Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
SI	319	1.00	4.90	3.5044	1.07618	-.851	.137
II	319	1.00	5.00	3.4204	1.10311	-.702	.137
CI	319	1.00	5.00	3.4873	1.06526	-.726	.137
SP	319	1.00	5.00	3.4487	1.08385	-.674	.137
IOT	319	1.00	5.00	3.4441	1.10428	-.617	.137

The mean value, standard deviation, and skewness of all variables i.e. CI, SI, II, IOT, and SP are giving acceptable values. It can be seen that there is no

extreme value in the data of any of them and there is appropriate variation in their data. Furthermore, the value of skewness between -1 and +1 for all of them

is also confirming the normality of their data so, the further analysis can be proceeded on this data due to its adequacy and normality.

The current data was also analyzed to see its internal consistency and multicollinearity for which the

discriminant validity and convergent validity of the data were assessed in AMOS. Table 2 depicts the results of convergent and discriminant validity.

**Table 2.** Convergent and discriminant validity

	CR	AVE	MSV	CI	IOT	SI	II	SP
<b>CI</b>	0.943	0.646	0.328	<b>0.804</b>				
<b>IOT</b>	0.976	0.775	0.230	0.442	<b>0.880</b>			
<b>SI</b>	0.954	0.678	0.316	0.489	0.480	<b>0.824</b>		
<b>II</b>	0.954	0.673	0.328	0.573	0.330	0.562	<b>0.820</b>	
<b>SP</b>	0.922	0.629	0.311	0.413	0.432	0.558	0.554	<b>0.793</b>

The results of table 2 are indicating that CR for all variables is more than 0.7 thus confirming the reliability of scales and the data. The AVE for all current variables more than 50 percent is indicating that variation of each variable has a good explanation in the current data while the MSV less than AVE is confirming the convergent validity of the data. The highest correlation of each variable with itself in

comparison to other variables is further confirming the convergent validity of the data.

The test of CFA was applied on the data to check the model fitness in which the major indicators named as "CMIN/DF, GFI, IFI, CFI and RMSEA" were considered to decide the model fitness. Table 3 provides the summary of model fitness.

**Table 3.** Model Fitness

Indicators	Threshold range	Current values
CMIN/DF	Less or equal 3	1.921
GFI	Equal or greater .80	.801
CFI	Equal or greater .90	.943
IFI	Equal or greater .90	.943
RMSEA	Less or equal .08	.054



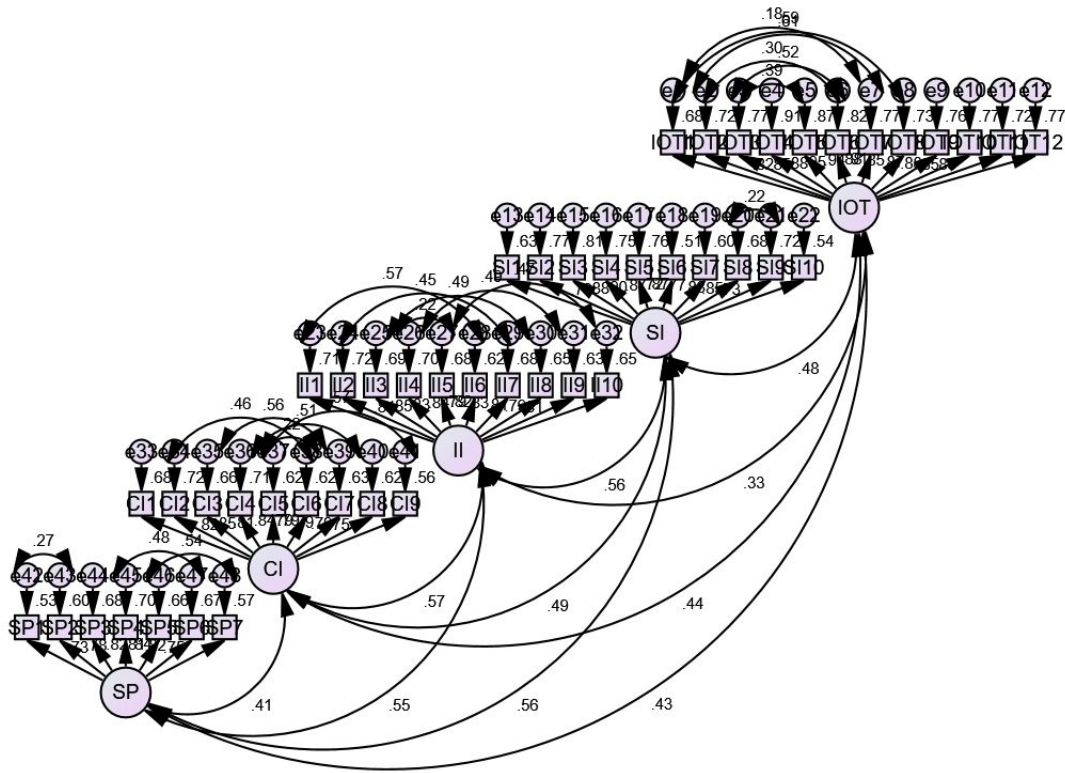


Figure 1. CFA

The value of CMIN/DF is 1.921 which is less than 3 and the value of GFI is more than 0.8 so, both these values are acceptable. Furthermore, the value of CFI and IFI both are 0.943 that are more than 0.90 and the value of RMSEA is less than 0.08 (i.e. 0.054) so, the good model fitness is proved through these results. It means that the current model containing the SP as dependent variable and IOT as independent variable

along with three mediators (SI, II, CI) has the good fitness. The screenshot of CFA taken from AMOS has been presented in figure 1.

Structural equation modelling was performed for the hypotheses testing in order to check the total, direct as well as indirect effects of IOT on sustainability performance. SEM provided following results.

Table 4. Structural equation modelling

Total Effects				
	IOT	CI	SI	II
CI	.419***	.000	.000	.000
SI	.457***	.000	.000	.000
II	.313***	.000	.000	.000
SP	.422***	.023	.282***	.301***
Direct Effects				
	IOT	CI	SI	II
CI	.419***	.000	.000	.000
SI	.457***	.000	.000	.000
II	.313***	.000	.000	.000

Total Effects				
	IOT	CI	SI	II
SP	.189**	.023	.282***	.301***
Indirect Effects				
	IOT	CI	SI	II
CI	.000	.000	.000	.000
SI	.000	.000	.000	.000
II	.000	.000	.000	.000
SP	.233***	.000	.000	.000

Note: \*\* indicates p-value<0.05 and \*\*\* indicates the p-value <0.01.

SEM revealed that IOT has significant and positive impact on SP (p-value <0.01). The impact of IOT on SP is 0.422 which means that one unit increase in IOT will cause 42.2 percent increase in SP. However, this is the total impact of IOT on SP which is divided in its direct and indirect effects on SP. The direct impact of IOT on SP is 0.189 only while the remaining effect is caused through mediators. The

results of direct and indirect effects are indicating that SI and II are significant mediators in the relationship between IOT and SP however, CI does not significantly mediate the relationship between IOT and SP because the p-value against its effect on SP is more than 0.05. Figure 2 indicates the screenshot of SEM taken from AMOS.

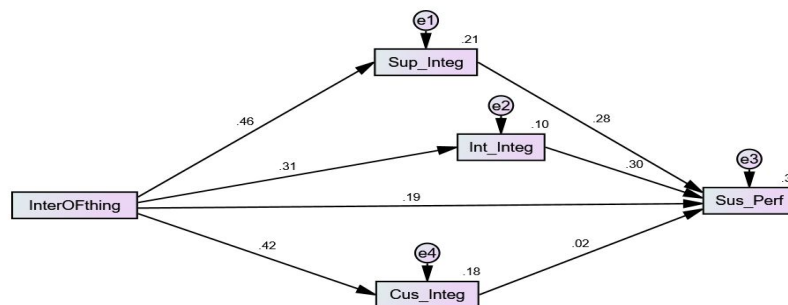


Figure 2. SEM

## 5. Discussion and Conclusion

### 5.1. Discussion

The study was aimed to know about the affiliation between the internet of things capability (IOTC) and sustainability performances (SP). (IOCT) comprises of supplier integration (SI), internal integration (II) and customer integration (CI). The purpose of this study was also to get knowledge about the meditating role of SI, II, and CI between (IOCT) and (SP). This study suggested some hypothesis, the first hypothesis

recommended that “There is a significant impact of IOTC on SP” [23]. This hypothesis was accepted. The main reason for the acceptance of the hypothesis is that the researchers explained that there is a significant and helpful impact of IOTC on SP as per the study of Muhammad Bin Daya, he proposed that (IOTC) helps the independent companies to improve their supply chain management and through this company can grow and sustain for long-run. The next hypothesis recommended that “SI has a positive

meditating role between IOTC and SP" [24]. This hypothesis was also got accepted. as per the suggested hypothesis, according to Antonio K. W. Lau (who is a researcher) the use of internet resulted in long term benefits and improved relations with the supplier and enhance the sustainability performance. Hypothesis number three suggested that "II has a positive and significant deliberating role between IOTC and SP" [25]. This hypothesis was also accepted. Researchers stated the reason of the significant role of II on IOTC and SP is just the better use of internet things. Hypothesis number four suggested that "There is a significant role of CI between IOTC and SP". This hypothesis was also accepted. Reviewers mentioned that due to the significant use of internet there is positive and balanced integration between IOTC and SP.

## 5.2 Conclusion

The main persistence of this research was to know about the IOTC of an organization. The main features of IOTC are SI, II and CI. The aim was also to have a deep insight on the meditating role of these aspects on IOTC and SP. This research was conducted in Thailand and this research was purely related to the manufacturing sector. This study targeted 350 people as a sample in Thailand and 310 responses were considerable. The data were gathered through questionnaires. Research concluded that there is a significant impact of IOTC on SP and the mediating role of mediating variables of this study was also positive.

## 5.3. Implications

Our research enhanced the literature material. Our research is a great addition in the literature. Our research will provide relevant knowledge to the students who want to study the problems about, IOTC, SP and mediating role of SI, II, CI. The other manufacturer which were not understudy in this research, they can get useful and productive information about the relevant problems and can improve their organization's sustainability performance. Government of Thailand should keenly observe this study and they can make policies regarding this problem effectively. With the help of accurate data, concerned authorities can make strategies for the better system. This study can be applied outside Thailand in order to enhance

sustainability performance because the countries like Thailand also facing the same situation and issues about sustainability performance.

## 5.4. Limitations and future research indications

In this research, the sample size which is taken for research purpose was 350 people from manufacturing companies of Thailand. The future researchers can study the huge sample size and they can get more accurate and reasonable data than this. The research tool for this study was only questionnaire. The future students and use more than one data collection tool for their research like, interviews, questionnaire, telephonic inquiries or internet. This research is only conducted in Thailand the future researcher can go beyond one country and conduct research globally regarding the same problem. Future researchers can take IOTC as a mediator between SI, II, CI and SP.

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