Readiness Model Development in the Adoption of Internet of Things (IoT) among Philippine Manufacturing SMEs Using Force Field Analysis Approach and Structural Equation Modelling

Patricia Nicole Ramos, Maryl Louise B. Enteria, & Marvin I. Norona
School of Industrial Engineering & Service Engineering and Management
Mapúa University
658 Muralla St, Intramuros, Manila, 1002, Metro Manila
pnramos@mapua.edu.ph, mlbenteria@mapua.edu.ph, minorona@mapua.edu.ph

Abstract

Internet of Things (IoT) had been one of the applications of industry 4.0 that played a vital role in changing the industrial and business processes by integrating various systems and processes independently. Thus, applying IoT help improved the manufacturing industry and helped gain a competitive advantage among our neighboring countries. This study focused on identifying the driving and restraining forces and the readiness of the Philippine manufacturing SMEs in adopting IoT. The researchers conducted a survey among Philippine manufacturing SMEs about their perception regarding IoT driving and restraining forces and their willingness to adopt IoT. The study utilized Structural Equation Modelling, Kurt Lewin's Force Field Analysis, and readiness model. The result showed that Philippine manufacturing SMEs are likely to adopt IoT, however, were neutral about applying full blast IoT technologies such as sensors for full operating conditions, and cloud systems, and big data analytics. In conclusion, ease of management and initial investment showed significance in adopting IoT. This study suggests future researchers dig deeper into how manufacturing SMEs can gain competitive advantage by applying IoT in their operations to (1) minimize cost, (2) improve quality control, and (3) minimize waste after prompting the willingness of the manufacturing SMEs in adopting IoT.

Keywords

Industry 4.0, Internet of Things, Manufacturing Industry, Philippine Manufacturing SMEs

1. Introduction

The term "Industry 4.0" was first coined at a trade fair organized in Hannover, Germany in 2011and plays a vital role in every industry by not only changing the industrial or business processes but also developing new advanced technologies and applications for different processes**.** It is characterized as the integration of manufacturing and logistics cyber-physical systems, as well as the application of the Internet of Things in industrial processes.

As technology advances and the number of smart devices continues to expand dramatically, the Internet of Things has been generated by the need for pervasive context-aware networks that enable an integrated, heterogeneous, and distributed device network. However, the incorporation and convergence of various information and research domains, covering aspects from recognition and communication to resource discovery and service integration, needs to pave the way for achieving the aforementioned goals and making the IoT paradigm more concrete. The connection between people and technology is rapidly changed by the Internet of Things (IoT). It is considered to be the next breakthrough technology, the implementation of the network through physical objects Internet access can bring many benefits to the potential prestige.

The future of IoT applications is immense, and the entire life cycle of the item can be followed by IoT techniques for better vitality management. It is shown that small and medium-sized enterprises (SMEs) have a more challenging situation taking advantage of Industry 4.0. The researchers have identified and compiled the key drivers and barriers for Industry 4.0 implementation for the manufacturing industry as shown in Fig. 1 & Fig. 2 (Fei Tao et al., 2016). Based on the Department of Trade and Industry (DTI) 2019 MSME Statistics recorded by the Philippine Statistics Authority (PSA), there are 1,000, 506 enterprises operating in the country. 995, 745 (99.5%) are MSMEs and 4,761 (0.5%) are large enterprises. 89% (891,044) of the MSMEs are micro-enterprises, 10% (99,936) are small enterprises, and 0.5% (4,765) are medium enterprises.

In countries with emerging economies (e.g. Philippines), there are economic barriers and challenges that firms and industries need to overcome to reach the new industrial stage. Furthermore, during the pandemic, issues such as environmental, social, and economical aspects are typically prioritized by various organizations to minimize their profit loss (Benitez et al., 2020). In countries where the economy is mainly composed of SMEs, investing in Industry 4.0 technologies particularly the internet of things (IoT) to further improve their manufacturing and information techniques may be a high-risk strategy. Consequently, enterprises (especially SMEs from emerging countries) struggle to adapt to IoT with its large market shifts and technologically turbulent environments.

Many studies have provided various system frameworks and positive impacts of IoT when it comes to the environmental, social, and economical aspect of the technology in a multinational company, but not so much was taken about the challenges and barriers when it comes to implementing IoT technologies on SMEs (Small and Medium Enterprises) during the COVID-19 pandemic. Although these studies show brief mention of the challenges of implementing the said technology on SMEs, there are no past studies situated in the Philippines during the pandemic.

Thus, the study the following research questions: (1) What significant factors will drive Philippine-based SMEs in the manufacturing industry to adopt IoT in their operations?, (2) What level of readiness will lead Philippine-based SMEs in the manufacturing industry to adopting IoT?, and (3) What implementation strategies can be recommended to Philippine-based SMEs in the manufacturing industry for dealing with the implementation challenges of IoT?

The study is aiming to achieve the following objectives: 1) To determine the key areas of improvement in manufacturing SMEs that can be addressed by IoT applications, 2) To identify the challenges, barriers, and key drivers for manufacturing SMEs when it comes to adopting IoT, 3) To develop and recommend IoT adoption strategies based on the level of readiness of IoT technologies in the Philippines.

The significance of the study will benefit SMEs affected by Covid in regaining operations effectiveness and achieve sustainable profitability in the long term. It will also help SMEs to contribute to the economy as a whole since SMEs comprise 10% of the total enterprises in the Philippines generating value-added products and employment. The study will serve as a reference for future research in the academe that will tackle concerns of similar interest to other industries and areas of expansion to other applications, particularly in the field of Industry 4.0. The study will be focusing on the challenges and barriers of SMEs in adopting IoT applications in their business operations. As a prelude to the study, it will employ findings based on the survey conducted by the Asian Development Bank in partnership with the Philippine Statistics Authority regarding the impact of the Covid-19 pandemic in the MSML enterprises in the Philippines. The research will identify key results areas of manufacturing SMEs in the Philippines where IoT applications are feasible and attractive in terms of addressing Covid-affected value-adding business processes.

2. Methodology

The study will focus on assessing the driving and restraining factors and determining the level of readiness of Philippine manufacturing SMEs to adopt IoT toward the new normal. Hence, the study will be utilizing the strategic planning approach of environmental scanning and Kurt Lewin's force field analysis with the end of developing a readiness model for the IoT adoption of the Philippine manufacturing SMEs. The conduct of the study will be guided by the following conceptual framework shown below:

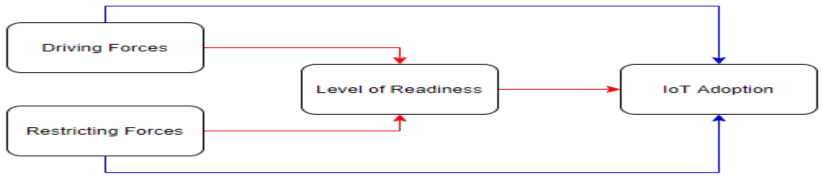

Figure 1. Conceptual Framework

Indicated above are the relationships between driving and restraining forces with the level of readiness that will in turn influence the decision to adopt IoT. The study aims to find the strength and direction of said forces in shaping up the factors that will significantly affect readiness level as well as the decision to adopt IoT. The assessment of these factors will be based on the degree of perception of management of manufacturing SMEs in the Philippines relative to the external and internal factors that affect the business operations of said SMEs.

Based on the above, the following hypotheses are posited:

$H1_0$: The driving forces have no significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.

$H1_a$: The driving forces have a significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.

$H2_0$: The restraining forces have no significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.

$H2_a$: The restraining forces have a significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.

To test the hypothesized relationships, an operational framework and definition of variables are discussed below:

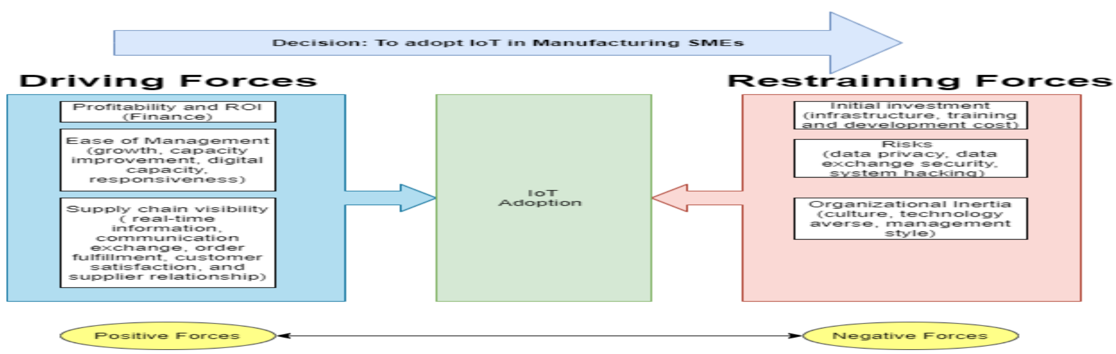

Figure 2 - Theoretical Framework

To determine the significance of each driving and restraining force in IoT adoption, the theoretical framework shown above is guided by force field analysis. The strength of each force will be measured to determine whether the goal of implementing IoT applications in Philippine manufacturing SMEs is possible or not. If the summation of the individual strength of the driving forces is greater than the summation of the individual strength of the restraining forces, it is possible to adapt to the change and the goal can be achieved. Otherwise, there will be no changes and the goal cannot be met.

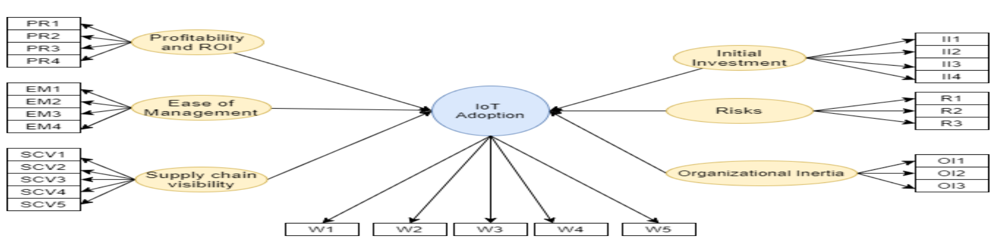

Figure 3. SEM Framework

The framework shows the complex relationship between constructs and the latent variables concerning the IoT adoption based on the conceptual framework (see Figure 1) and theoretical framework (see Figure 2). Hence, the definition of the constructs and latent variables is shown below:

Table 1. Constructs and Variables

Construct	Latent Variable	Code	Item Questions	Reference
Driving Forces	Profitability and ROI	PR1	IoT can improve gross margin and net margin index	Pappas et al (n.d), & Ghobakhloo (2020);
		PR2	IoT can improve return on equity ratio	Pappas et al (n.d), & Ghobakhloo (2020);
		PR3	IoT can increase return on asset ratio	Pappas et al (n.d) & Ghobakhloo (2020);
		PR4	IoT can have a cost-saving advantage	Ghobakhloo (2020);
	Ease of Management	EM1	IoT can gain competitive advantage	Pappas et al (n.d), & Ghobakhloo (2020);
		EM2	IoT can improve company's growth in relation to sales and market segment	Pappas et al (n.d), & Ghobakhloo (2020);
		EM3	IoT can improve capacity to meet demand	Pappas et al (n.d), & Ghobakhloo (2020);
		EM4	IoT can improve digital capacity in terms of reliability and availability of ICT support	Pappas et al (n.d), & Ghobakhloo (2020);
	Supply Chain Visibility	SCV1	IoT can provide efficient real-time information and knowledge	Pappas et al (n.d), & Ghobakhloo (2020);
		SCV2	IoT can provide real-time efficient and reliable communication exchange	Pappas et al (n.d), & Ghobakhloo (2020);
		SCV3	IoT can improve order fulfillment	Pappas et al (n.d), & Ghobakhloo (2020);
		SCV4	IoT can improve supplier coordination	Pappas et al (n.d), & Ghobakhloo (2020);
		SCV5	IoT can improve customer satisfaction	Pappas et al (n.d), & Ghobakhloo (2020);
Restraining Forces	Initial Investment	II1	Availability of credit funds/accounts for infrastructure and training and development expense	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018),
		II2	Long payback period issues	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
		II3	Impact on Debt ratio	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
		II4	High Operating and adoption cost	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
	Risks	R1	Lack of trust in data security	Chauhan et al (n.d.), Sharma et al (2020), Raj

				et al (2020), Kamble et al (2019), & Luthra et al (2018)
		R2	Lack of trust for data exchange privacy	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
		R3	Lack of trust in system security and protection in relation to unethical hacking and/or any fraudulent act	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
	Organizational Inertia	OI1	Resistance of workforce to change	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
		OI2	Technology averse	Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), & Luthra et al (2018)
		OI3	Complexity of management style to adopt IoT	Pappas et al (n.d), Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), Luthra et al (2018), & Ghobakhloo (2020);
IoT Adoption Readiness	Willingness to adopt IoT application(s)	W1	Willingness to adopt digital application without sensors	Pappas et al (n.d), Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), Luthra et al (2018), & Ghobakhloo (2020);
		W2	Willingness to adopt digital application with sensors for process control	Pappas et al (n.d), Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), Luthra et al (2018), & Ghobakhloo (2020);
		W3	Willingness to adopt remote monitoring system with production control	Pappas et al (n.d), Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al (2019), Luthra et al (2018), & Ghobakhloo (2020);
		W4	Willingness to adopt sensors for operating conditions, products etc.	Pappas et al (n.d), Chauhan et al (n.d.), Sharma et al (2020), Raj et al (2020), Kamble et al

				(2019), Luthra et al (2018), & Ghobakhloo (2020);
		W5	Willingness to adopt cloud system, big data analytics	

The study is guided by the SEM framework to test the hypotheses based on the objectives of the study about the implementation of IoT applications for the Philippine manufacturing SMEs and to develop the readiness model of the Philippine manufacturing SMEs in adopting IoT. The study will utilize quantitative data to determine the significance of each construct in relation to the variables. The significance is based on the perception of the respondents toward the IoT adaption driving forces, restraining forces, and their willingness to adopt IoT in manufacturing operations. A total of at least 250 respondents from various manufacturing SMEs in the Philippines will be considered to answer an online survey using google forms. A survey questionnaire using Likert scale will be utilized to determine the perception of the respondent on IoT adoption based on the driving and restraining forces for the force field analysis and SEM analysis and the respondent's willingness to adopt. The respondents will be composed of different high-level positions such as executives, managers, and supervisors. The stated positions are knowledgeable, decision-makers, and directly involved in the area of the study.The study will utilize Force Field analysis to determine the strength of each force to determine the significant factor(s) in relation to IoT adoption. SEM analysis will be utilized to determine the P-value, R-square, standard deviation, correlation, ANOVA, and path testing to validate and test the hypotheses in relation to the objectives of the study. SPSS Statistics and SPSS AMOS software will be utilized to determine the relationship of each construct and variables of the study based on the SEM framework (Figure 3). The readiness model based on the study of Rajnai & Kocsis (2018) will be used to develop the readiness model of the Philippine manufacturing SMEs based on the enterprise's willingness to adopt IoT in the manufacturing operations.The result of the analyses of the study will be used to develop an implementation strategy for IoT adoption in relation to the readiness of each Philippine manufacturing SMEs.

3. Results and Discussion

From the survey most of the respondents were in a managerial position which accumulated 45.6% of the data. Also, they were asked about their company line and most of the respondents were operating a Fast-moving goods (Food, Beverage, Cosmetics, and Toiletries) type of manufacturing company which accumulated to 19.2% of the data. Most of the respondents also said their company was comprised of 100-199 employees which accumulated to 42.0% of the data. The researchers assessed the respondents' perception of driving forces related to IoT adoption, 44.0% of the respondents thought that it was likely significant that IoT can improve gross margin and net margin index, 51.2% of the respondents thought that it was likely significant that IoT can improve return on equity ratio, 49.2% of the respondents thought that it was likely significant that IoT can increase return on asset ratio, 43.6% of the respondents thought that it was likely significant that IoT can have cost-saving advantage, 49.6% of the respondents thought that it was likely significant that IoT can gain competitive advantage, 48.8% of the respondents thought that it was likely significant that IoT can improve company's growth in relation to sales and market segment, 51.6% of the respondents thought that it was likely significant that IoT can improve capacity to meet demand, 43.6% of the respondents thought that it was likely significant that IoT can improve digital capacity in terms of reliability and availability of ICT support, 49.6% of the respondents thought it was likely significant that IoT can provide efficient real-time information and knowledge, 50.0% of the respondents thought that it was likely significant IoT can provide real-time efficient and reliable communication exchange, 56.4% of the respondents thought that it was likely significant that IoT can improve order fulfillment, 41.6% of the respondents thought that it was likely significant that IoT can improve supplier coordination, and lastly, 41.2% of the respondents thought that it was likely significant that IoT can improve customer satisfaction. The researchers assessed the respondents' perception of restraining forces related to IoT adoption. 42.0% of the respondents thought that it was likely significant that availability of credit funds/accounts for infrastructure and training and development expense can restrain the management from adapting IoT, 54.8% of the respondents thought that it was likely significant that long payback period issues can restrain the management from adapting IoT, 52.4% of the respondents thought that it was likely significant that IoT's impact on the company's debt ratio can restrain the management from adapting IoT, 49.6% of the respondents thought that it was likely significant that high operating and adoption cost issues can restrain the management from adapting IoT, 44.4% of the respondents thought that it was likely significant that lack of trust in data security can restrain the management from adapting IoT, 46.4% of the respondents thought that it was likely significant that lack of trust for data exchange privacy can restrain the management from adapting IoT, 50.8% of the respondents thought that it was likely significant that lack of trust in system security and protection in relation to unethical hacking and/or any fraudulent act can restrain the management from adapting IoT, 40.0% of the respondents is neutral to the possibility that resistance of workforce to change can restrain the management from adapting IoT, 33.2% of the respondents was neutral to the possibility that technology averse can restrain the management from adapting IoT, and lastly, 30.8% of the respondents is neutral to the possibility that the complexity of management style to adopt IoT can restrain the management from adapting IoT. The researchers measured the perceived willingness to adopt IoT in the Philippines which was shown in Figure 6. 45.6% of the respondents thought that the willingness of the management to adopt digital application without sensors was most significant regarding to adopting IoT, 44.0% of the respondents thought that the willingness to adopt digital application with sensors for process control was likely significant regarding to adopting IoT, 35.2% of the respondents thought that the willingness to adopt remote monitoring system with production control was likely significant regarding to adopting IoT, 27.6% of the respondents were neutral to the possibility that willingness to adopt sensors for operat8ing conditions, products, etc., and lastly, 29.6% of the respondents were neutral to the possibility that willingness to adopt cloud system and big data analytics.

Table 2. Data Statistics of indicators' Reliability

Indicators	Mean	Std. Deviation	Corrected Item – Total Correlation (CITC)	Cronbach's Alpha if Item Deleted
PR1	4.29	0.726	0.772	0.883
PR2	3.90	0.760	0.855	0.853
PR3	3.91	0.758	0.835	0.860
PR4	4.05	0.827	0.698	0.912
EM1	4.07	0.757	0.725	0.859
EM2	3.75	0.928	0.736	0.858
EM3	4.04	0.777	0.723	0.859
EM4	3.86	0.817	0.815	0.823
SCV1	3.95	0.835	0.220	0.896
SCV2	3.86	0.752	0.771	0.741
SCV3	4.11	0.714	0.747	0.751
SCV4	3.88	0.824	0.757	0.741
SCV5	4.12	0.827	0.670	0.769
II1	4.02	0.927	0.534	0.865
II2	3.91	0.752	0.750	0.754
II3	3.86	0.721	0.730	0.765
II4	4.12	0.735	0.690	0.781
R1	4.02	0.894	0.876	0.898
R2	4.00	0.862	0.907	0.872
R3	4.01	0.829	0.817	0.942
OI1	3.26	0.945	0.830	0.818
OI2	3.32	1.026	0.796	0.843
OI3	3.35	1.039	0.750	0.885
W1	4.07	1.047	0.276	0.949
W2	3.81	0.942	0.834	0.836
W3	3.60	1.068	0.872	0.821
W4	3.43	1.125	0.866	0.821
W5	3.30	1.167	0.826	0.831

The data set had given promising results (refer to table 2). Cronbach's α is 0.8388 which was well above 0.70. The CITC values of the 26 indicators were above 0.40 and of 2 indicators were below 0.40.

Table 3. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.900
Bartlett's Test of Sphericity	Approx. Chi-Square	6761.912
	Df	378
	Sig.	0.000

The KMO value was 0.900 and Barlett's test of sphericity had given a sufficiently high value at a significance level of $p<0.001$ which fulfilled the criteria of sample adequacy for factor analysis. The indicators were significantly correlated with each other since Sig. is below 0.05. To reduce the 28 indicators into a few constructs, EFA had been carried out. Eight indicators had been extracted based on the Maximum likelihood method in SPSS software. Indicators from EM1 to EM4; SCV2 to SCV5; PR1 to PR4, and OI1 to OI3 had been retained since they satisfied the goodness of fit measures of the model. To verify the results of the EFA, Confirmatory Factor Analysis (CFA) was required. The results of the CFA were presented in table 5.

Table 4. Model Fit Statistics

Goodness of fit measures of the SEM	Parameter Estimates		Minimum Cut-off	References
Absolute Fit Indices	Initial	Final		
Goodness of Fit Index (GFI)	0.607	0.804	>0.80	Gefen et al. (2000)
Adjusted Goodness of Fit Index (AGFI)	0.536	0.842	>0.80	Gefen et al. (2000)
Root Mean Square Error of Approximation (RMSEA)	0.149	0.068	<0.07	Steiger (2007)
Incremental Fit Indices				
Incremental Fit Index (IFI)	0.716	0.948	>0.90	Hair (2010)
Tucker Lewis Index (TLI)	0.686	0.924	>0.90	Hu and Bentler (1999)
Comparative Fit Index (CFI)	0.714	0.905	>0.90	Hair (2010)

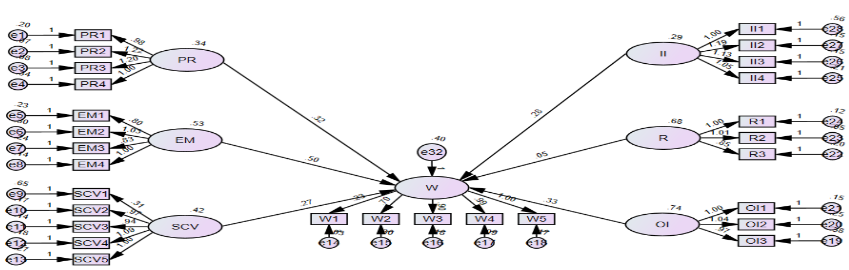

Figure 4. Initial Structural Equation Model

Structural Equation Modelling (SEM) was used to do regression analyses of the test model and evaluate the hypotheses. It presented the casual relationship among the constructs. The hypothesis was articulated to test the validity of the full structural model. Additionally, regression analyses were executed for the model.

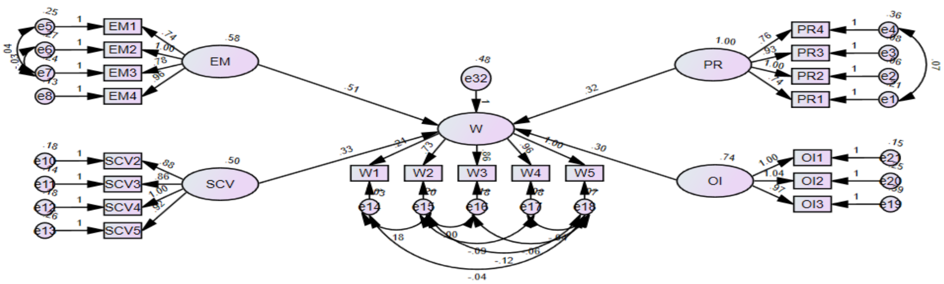

Figure 5. Final Structural Equation Modeled

The structural model presented the casual relationship among the constructs. The hypothesis was articulated to test the validity of the full structural model. The following hypotheses were stated based on conclusions obtained from the literature that dealt with the selected constructs:

$H1_0$: The driving forces have no significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.
$H1_a$: The driving forces have a significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.
$H2_0$: The restraining forces have no significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.
$H2_a$: The restraining forces have a significant relationship with the level of readiness in the adoption of IoT in Philippine manufacturing SMEs.

			Estimate	S.E.	C.R.	P	Label
W	<---	EM	.508	.068	7.521	***	par_16
W	<---	SCV	.332	.068	4.861	***	par_17
W	<---	OI	.303	.056	5.431	***	par_18
W	<---	PR	.322	.046	6.932	***	par_29
PR4	<---	PR	.757	.041	18.687	***	par_1
PR3	<---	PR	.929	.025	36.821	***	par_2
PR2	<---	PR	1.000				
PR1	<---	PR	.743	.032	23.089	***	par_3
EM4	<---	EM	.957	.064	14.848	***	par_4
EM3	<---	EM	.784	.063	12.534	***	par_5
EM2	<---	EM	1.000				
EM1	<---	EM	.738	.058	12.704	***	par_6
SCV5	<---	SCV	.919	.063	14.492	***	par_7
SCV4	<---	SCV	1.000				
SCV3	<---	SCV	.860	.053	16.301	***	par_8
SCV2	<---	SCV	.881	.056	15.658	***	par_9
W5	<---	W	1.000				
W4	<---	W	.960	.050	19.119	***	par_10
W3	<---	W	.862	.062	13.880	***	par_11
W2	<---	W	.729	.067	10.843	***	par_12
W1	<---	W	.215	.073	2.933	.003	par_13
OI1	<---	OI	1.000				
OI2	<---	OI	1.038	.058	17.768	***	par_14
OI3	<---	OI	.965	.061	15.837	***	par_15

Figure 6. Maximum Likelihood Estimates

Table 5. Direct Effect, Indirect Effect, and the Total Effect

Variables	Direct Effect	P-value	Total Effect	P-value
SCV → W	0.332	0.001	0.332	0.001
OI → W	0.303	0.001	0.303	0.001
PR → W	0.322	0.001	0.322	0.001
EM → W	0.508	0.001	0.508	0.001

The full structural model in Figure 4, latent variables SCV, OI, PR, and EM have p-value <0.001 which meant that they were significant. For the restraining forces construct, indicators under the latent variable Organizational Inertia (OI) such as resistance of workforce to change, technology averse, and complexity of management style to adopt IoT were proven significant since they had a p-value <0.01 and showed good model fit. For the driving forces construct, indicators under profitability and ROI (PR) such as IoT can improve gross margin and net margin index, IoT can improve return on equity ratio, IoT can increase return on asset ratio, and IoT can have a cost-saving advantage were proven significant since they had a p-value <0.01 and showed good model fit. Indicators under Ease of Management (EM) such as IoT can gain competitive advantage, improve company's growth in relation to sales and market segment, improve capacity to meet demand, and improve digital capacity in terms of reliability and availability of ICT support. Indicators under Supply Chain Visibility (SCV) such as IoT can provide real-time efficient and reliable communication exchange, can improve order fulfillment, can improve supplier coordination, and can improve customer satisfaction. The latent variable EM was found to be strongly correlated (β: 0.508, p = 0.001) with the willingness to adopt IoT indicating that ability to gain competitive advantage, company's growth in relation to sales and market segment, capacity to meet demand, and ability to improve digital capacity in terms of reliability and availability of ICT support were the variables, the decision makers of the company will consider the most before adopting IoT.

Table 6. Force Field Analysis Output

DRIVING FORCES	SCORE		RESTRAINING FORCES	SCORE
IoT can improve gross margin and net margin index	4	**IoT Adoption**	Availability of credit funds/accounts for infrastructure and training and development expense	4
IoT can improve the return on equity ratio	4		Long payback period issues	4
IoT can increase return on asset ratio	4		Impact on Debt ratio	4
IoT can have cost-saving advantage	4		High Operating and adoption cost	4
IoT can gain competitive advantage	4		Lack of trust in data security	4
IoT can improve company's growth in relation to sales and market segment	4		Lack of trust for data exchange privacy	4
IoT can improve capacity to meet demand	4		Lack of trust in system security and protection in relation to unethical hacking and/or any fraudulent act	4
IoT can improve digital capacity in terms of reliability and availability of ICT support	4		Resistance of workforce to change	3
IoT can provide efficient real-time information and knowledge	4		Technology averse	3
IoT can provide real-time efficient and reliable communication exchange	4		Complexity of management style to adopt IoT	3
IoT can improve order fulfillment	4			
IoT can improve supplier coordination	4			
IoT can improve customer satisfaction	4			
TOTAL	**52**		**TOTAL**	**37**

The scoring method in Force Field Analysis as shown in table 6, was based on the survey questionnaire in 5-point Likert scale model: 1 being the lowest and 5 being the highest. Respondents were asked about their perception on the driving and restraining forces and their willingness to adopt IoT. The scale with the greatest number of respondents in each indicator were reflected on the score table 6. Indicators under driving forces were all given the score of 4 (likely significant) and had a total score of 52. Indicators under restraining forces were also given the score of 4 (likely significant) however, there 3 indicators such as resistance of workforce to change, technology averse, and complexity of management style to adopt IoT were given a score of 3 (neutral). Hence, the restraining forces have a total score of

37. Thus, the decision to adopt IoT was possible. Philippine manufacturing SMEs were willing to adopt digital applications without sensors, digital applications with sensors for process control, a remote monitoring system with production control. As reported in Business World by (Balinbin,2021), the Philippines was ranked 59th out of 79 countries in the 2020 Global connectivity index (GCI) according to Huawei Technologies Co., Ltd. which suggest that the Philippines remained a starter in terms of digital transformation using Rajnai & Kocsis (2018) readiness assessment model, the strategy for the new entrant in digital transformation must prompt a willing attitude. Moreover, according to the study of Grufman et al (2020), beginners should do studies towards industry 4.0 and have systems that are compatible with industry 4.0 technologies and should have a little competence in its organization and IT security.

4. Theoretical and Practical Implications

In this study, researchers focused on profitability and ROI, and initial investments for the financial factor of adopting IoT, ease of management, supply chain visibility, risks, and organizational inertia for the organizational factors in adopting IoT and willingness for digitalization readiness factor. However, the researchers failed to describe some indicators in much detailed or much measurable form. Also, the researchers only had limited willing respondents in manufacturing SMEs from different manufacturing segments which the researchers believed it affected the focus of the study. For the future researchers, the researchers suggest studying a manufacturing segment focused and/or top 3 manufacturing segment focus to come up with a more accurate plan in adopting IoT in Philippine manufacturing SMEs. There was a possibility that the Philippine manufacturing SMEs can adopt IoT in their operations. The key was that the decision-makers must have a willingness in adopting IoT and must focus on the driving forces such as profitability and ROI, ease of management, supply chain visibility and organizational inertia for the restraining forces. Using force field analysis helped determine the strength of each force internally in order to determine the likelihood of adopting IoT. Using SEM analysis helps to determine the relationship of each factor externally.

6. Conclusion

This study analyzed the significant factors that drive the Philippine manufacturing SMEs in adopting IoT in their operations using structural equation modeling (SEM) and Force Field Analysis. The use of SEM indicates that Profitability and ROI (PR), Ease of Management (EM), Supply Chain Visibility (SCV), and Organizational Inertia (OI) had significance in adopting IoT in manufacturing SMEs in the Philippines. Also, willingness to adopt IoT had a significance in determining the IoT adoption. Using force field analysis indicates that Philippine manufacturing SMEs can likely adopt IoT in their operations. However, as for the willingness, they remained neutral for adopting sensors for operating conditions, and cloud systems, and big data analytics. This study suggests future researchers dig deeper into how manufacturing SMEs can gain competitive advantage by applying IoT in their operations to (1) minimize cost, (2) improve quality control, and (3) minimize waste after prompting the willingness of the manufacturing SMEs in adopting IoT. The current findings can be used to guide the focus of the Philippine manufacturing SMEs in adopting IoT in their operations.

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Biographies

Patricia Nicole Ramos is a graduate of Mapua University with a degree in BS Service Engineering and Management. She has successfully completed her yellow belt certification in Six Sigma along with multiple certifications, gearing up for her next Six Sigma certification. Currently, she is working at a financial business process outsourcing company, Payreto as a Reports Analyst and a Marketing Intern. Apart from research and data analysis, she is into project management, inventory management, and digital marketing.

Maryl Louise Enteria is a Service Engineering and Management student of Mapua University. Her interest and research projects are on digitalization and new technology for effective management.

Marvin I. Noroña is a faculty member of the Mapua University School of Industrial Engineering & Engineering Management and School of Graduate Studies. He earned his BSIE and MBA degrees from University of the Philippines and is completing his dissertation for a Doctor in Business Administration degree at the De La Salle University. Apart from research and teaching, he is into management consulting and training in the areas of sustainability, supply & operations management, production & service systems improvement, strategic planning and management, lean six sigma, and design thinking.