Industry 4.0 Readiness: Drivers, Barriers and its Potential Impact on the Organizational Performance of Selected Small and Medium Enterprises in Metro Manila

Emilina R. Sarreal*
De La Salle University

Carmela Vaine N. Cardinez
De La Salle University

Mark Justine L Madriaga
De La Salle University

Jan Ellaine Joyce U. Sy
De La Salle University

ABSTRACT

This study investigates the factors influencing Industry 4.0 adoption among Philippine SMEs. Despite the government's efforts to promote Industry 4.0 through the Inclusive Innovation Industrial Strategy (I3S), the Philippines remains at a low level of readiness. This study aims to identify the perceived drivers and barriers that influence SME adoption of Industry 4.0 technologies. Through a quantitative research design, the study surveyed 200 SMEs in the National Capital Region (NCR). The analysis focused on factors like organization type, age, perceived drivers, barriers, and their impact on organizational performance. The findings reveal that while perceived drivers positively influence I4.0 readiness, barriers such as lack of knowledge and resources hinder adoption. The study also highlights the mediating role of I4.0 readiness in influencing organizational performance. Recommendations include leveraging drivers, addressing barriers, strengthening government support, and fostering a digital mindset within organizations. Additionally, investing in employee training, collaborating with academia, and implementing comprehensive policies are crucial for successful Industry 4.0 adoption in the Philippines.

Keywords: Industry 4.0, SMEs, Philippines, adoption, drivers, barriers, organizational performance, readiness, sustainable production and consumption.

Received 17 April 2024 | Revised 13 October 2024 | Accepted 28 December 2024.

1. INTRODUCTION

Industry 4.0, a technological revolution originated in Germany in 2011, is reshaping industries globally. It is not merely an industry or a nation but a global force affecting communities at all developmental stages. While its influence is widespread, countries with weak ICT infrastructure, abundant labor, large rural populations, or extensive informal economies may face challenges in adopting Industry 4.0.

The COVID-19 pandemic has accelerated Industry 4.0 adoption as businesses seek to reduce labor costs through automation and AI. Micro, small, and medium enterprises (MSMEs),

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

crucial to ASEAN's economy, recognize the potential of digital integration but often struggle to fully leverage it.

The Philippines' Inclusive Innovation Industrial Strategy (I3S) aims to enhance the competitiveness of its manufacturing, agricultural, and service sectors. However, the country faces challenges in Industry 4.0 readiness due to institutional weaknesses, human capital shortages, and insufficient technology platforms.

Statement of the Problem

Despite the I3S, the Philippines remains at a low level of Industry 4.0 readiness. This study aims to identify the drivers and barriers that influence the adoption of Industry 4.0 technologies among selected SMEs in the National Capital Region (NCR).

Research Questions

- To what extent do perceived drivers like legislation, strategy, and public advisor systems promote Industry 4.0 readiness?
- How do perceived barriers like legislation, management, and workforce hinder Industry 4.0 readiness?
- How do organization type and age affect Industry 4.0 readiness?
- How do perceived drivers and barriers, mediated by Industry 4.0 readiness, impact organizational performance (profitability, cost, sales, efficiency, effectiveness, quality, and productivity)?

Research Objectives

- Determine the effect of Industry 4.0 readiness on the relationship between perceived drivers and organizational performance.
- Determine the effect of Industry 4.0 readiness on the relationship between perceived barriers and organizational performance.

2. REVIEW OF LITERATURE

Perceived Drivers for I4.0 Readiness

Perceived drivers for I4.0 readiness among companies include customer requirements, competitors, cost reduction, improved time-to-market, legal requirements, strategy, and public advisor system support. These drivers influence the use of I4.0 technologies directly and indirectly.

Direct effects occur when companies immediately adapt to meet new customer needs or regulations using specific I4.0 technologies**. Indirect effects** involve proactive investment in knowledge and skills to prepare for future competition.

Perceived Barriers for I4.0 Readiness

Perceived barriers to I4.0 readiness include lack of knowledge and understanding, standards, company focus, data protection, employee qualification, education, financial and human resources. These barriers can directly prevent investment in new technology or indirectly hinder organizational preparation for future developments, delaying I4.0 readiness and technology adoption.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Influence of Organization Type on I4.0 Readiness

Soomro et al. (2021) found that large manufacturing organizations are more advanced in I4.0 adoption than service technology organizations due to the alignment of I4.0 technologies with manufacturing processes.

Influence of Organization Age on I4.0 Readiness

Soomro et al. (2021) also found that older organizations (over 10 years) have a better approach to I4.0 readiness and implementation, using I4.0 technologies more effectively. This suggests that older organizations are more resilient in adapting to technological advancements like I4.0.

3. OPERATIONAL FRAMEWORK

As noted by AMERIAL (2022), I4.0 concepts may be unfamiliar to many Philippine organizations. To address this, a practical operational framework has been developed to assess the readiness of Philippine SMEs for I4.0 and identify the factors influencing their adoption.

Independent Variables:

- **Drivers:** Based on Stentoft et al. (2021) and supported by Soomro et al. (2021), these include customer requirements, competitors, cost reduction, improved time-to-market, legal requirements, strategy, and public advisor system support.
- **Barriers:** Also identified by Stentoft et al. (2021), these include lack of knowledge and understanding, standards, company focus, data protection, employee qualification, education, financial and human resources.

Mediating Variable:

- **I4.0 Readiness:** Defined as an organization's ability to benefit from I4.0 technology components (Stentoft et al., 2021). Types of I4.0 technologies include:
- **Cyber-Physical Systems (CPS):** Integrate robots and sensors with production lines to automate tasks and optimize processes.
- **Internet of Things (IoT):** Connects physical objects to the internet, allowing them to collect and share data.
- **Big Data Analytics:** Analyzes large datasets to extract insights, improve decision-making, and predict future outcomes.
- **Cloud Computing:** Provides on-demand access to computing resources, offering scalability and cost-efficiency.
- **Robotics:** Utilizes robots for repetitive tasks, enhancing productivity and reducing human error.
- **3D Printing:** Creates 3D objects layer-by-layer, enabling rapid prototyping and customized manufacturing.
- **Augmented Reality (AR):** Superimposes digital information onto the real world, improving training and maintenance efficiency.
- **Horizontal Integration:** Connects different companies in a value chain for seamless collaboration.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

- **Vertical Integration:** Integrates intelligent machines into a system, increasing production visibility and flexibility.
- **Cyber Security:** Protects Industry 4.0 systems from cyberattacks that can disrupt operations and steal data.
- **Mobile Technologies:** Leverage mobile devices and apps for real-time data access and process automation.
- **Artificial Intelligence (AI):** Enables machines to learn and make decisions, optimizing supply chains, design, and maintenance.
- **Radio Frequency Identification (RFID):** Tracks materials and products throughout the manufacturing process, improving efficiency and traceability.

Dependent Variable:

- **Organizational Performance:** Measured using criteria similar to Ali and Xie (2021) and performance metrics from Duman and Akdemir (2021), Ali and Xie (2021), and Szasz et al. (2020).

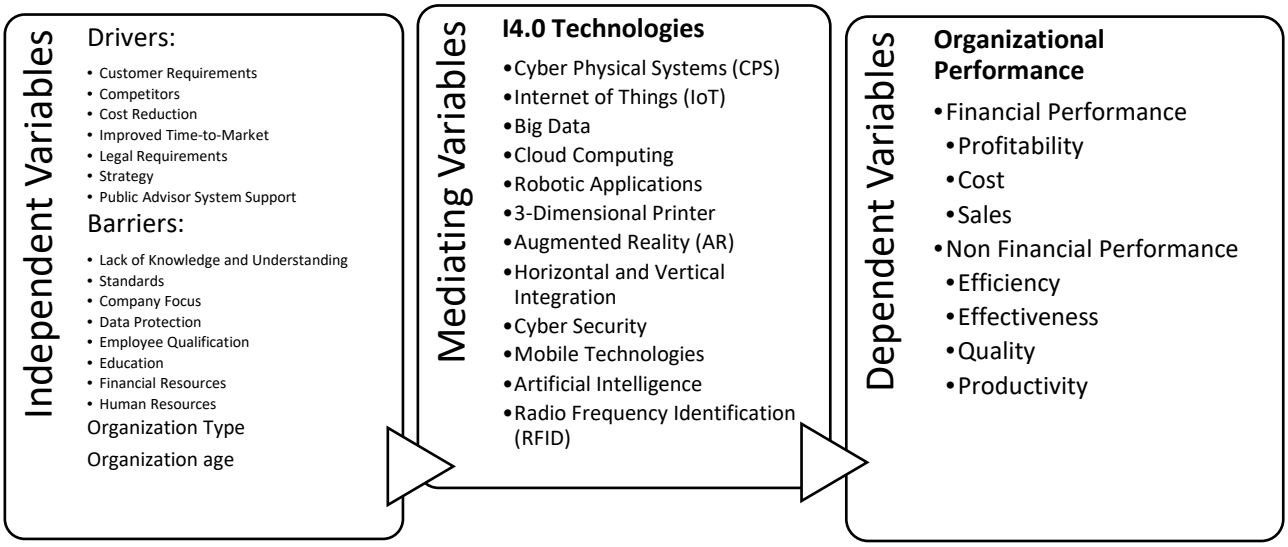

Figure 1. Operational Framework on the mediating effect of I4.0 Technologies between Perceived Barriers and Drivers of Adoption and Organization Performance

In the context of the Philippines, only two studies have identified the drivers and barriers for I4.0 deployment: AMERIAL (2022) and the World Economic Forum (2018) report. Organization age and type are frequently cited as crucial factors in I4.0 literature, enabling comparisons between older and younger companies, as well as manufacturing and service organizations (Chimay; Azab et al.; Ertan, as cited by Soomro et al., 2021). While numerous studies have examined the impact of I4.0 on the manufacturing industry (Frank et al., 2019), there is a dearth of research on its role in the service industry. Moreover, no studies have investigated how I4.0 may affect the organizational performance of the retail sector in emerging nations.

4. METHODOLOGY

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Population, Sample size and Respondent Qualifications

The target population of the study are the small and medium enterprises (SMEs) operating in NCR that are engaged in (1) wholesale and retail trade; repair of motor vehicles and motorcycles, (2) accommodation and food service activities, and (3) manufacturing. According to the DTI, the number of SMEs in NCR has reached a total of 28,506 during the year 2021. The researchers utilized the Slovin's formula in calculating and determining the total sample size per organization type which were then surveyed. With this, a total of 28,506 SMEs in NCR was used as the population size (N) (DTI, 2021). Moreover, in order to determine the percentage share per organization type, the researchers divided the total SMEs per organization type over the total SMEs in the Philippines.

The (1) owners, (2) top-level managers, (3) IT department heads, or (4) business development managers of SMEs of various organization types in NCR are the chosen respondents for this study. By having these selected organizational positions answer the survey, the data collected ensures that it is comprehensive and representative of the whole organization, as these positions are knowledgeable of the development and future technological applications of the organization. Additionally, the respondents had the option to select one or more job positions on the survey questionnaire as they may take on several job responsibilities for their respective organizations. Furthermore, only one respondent per organization would suffice as long as they qualify for the positions required. Snowball sampling was applied to expand the reach of the researchers. With this method, the researchers asked respondents to refer or nominate another individual to participate in the study (McGraw-Hill, 2017; Dudovskiy, 2022).

The survey questionnaire had 5 parts composed of 1) The introduction of the survey and the informed consent for respondents to provide demographic and company profile information which was cleared by the ethics committee composed of the thesis adviser, panelists and department chairperson; 2) The willingness of the organization to use specific I4.0 technology components in the future; 3) The degree of readiness of the organization through the statements adopted from the study of Stentoft et al (2020) provided and measured in the form of a 5-point Likert scale with the following indications, 1= at very low degree, 2 = at low degree, 3 = at moderate degree, 4 = at high degree, and 5 = at very high degree; 4) perceived drivers and barriers of I4.0 readiness of the organizations statements from the study of Stentoft et al. (2020) utilizing a 5-point Likert scale (1= strongly disagree to 5 = strong agree); 5) The potential impacts of I4.0 readiness on organizational performance for both non-financial and financial impacts to gauge awareness of the respondents' benefits that the I4.0 technology components may bring once utilized by the organizations with a 5-point Likert scale adopted from Duman and Akdemir (2021).

5. DISCUSSION OF RESULTS

Descriptive Analysis

Based on organization type, of the 200 respondents, 83 were small and 35 were medium-sized in the wholesale and retail trade; repair of motor vehicles (WRT/RMV) category. In the accommodation and food service activities (AFS) category, there were 46 small and 16 medium-sized organizations. Finally, in the manufacturing (M) category, 13 were small and 7 were medium-sized.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

In terms of organization age, 31 were under 1 to 5 years, 104 were under 6 to 10 years, and 65 were over 10 years. Regarding organizational position, 125 were business owners, 51 were top-level managers, 13 were business development managers, and 11 were employees with multiple tasks.

As shown in Table 1, the wholesale and retail trade; repair of motor vehicles category accounted for 59% of the respondents with a total of 118 out of 200 respondents. Of the 118 respondents in this category, 83 were small-sized organizations with an asset size of PHP 3,000,001 to PHP 15,000,000 and employing 10 to 99 individuals. The remaining 35 respondents were medium-sized, with an asset size of PHP 15,000,001 to PHP 100,000,000 and employing 100 to 199 individuals.

The accommodation and food service activities category comprised 31% of the participants. This category included 46 small-sized and 16 medium-sized organizations.

The remaining 10% of the respondents were from the manufacturing sector. Thirteen of these respondents were small-sized, while 7 were medium-sized organizations. The low proportion of respondents from the manufacturing sector can be attributed to the fact that most manufacturing companies are classified as large-scale businesses, which do not meet the criteria for inclusion in the study, which focuses specifically on Small and Medium-sized Enterprises (SMEs).

Most respondents are business owners or organization owners, totaling 125. The next most frequent organizational position is top-level manager, with 51 respondents. As observed in the table, some categories have multiple positions. This is entirely valid as an employee may hold multiple roles within their organization, taking on two or more, or even all, of the roles provided by the researchers.

In relation to perceived drivers and barriers, factors such as customer requirements, competitors, cost-reduction, improved time-to-market, legal requirements, public advisory systems, and conscious strategy were considered moderate drivers. In contrast, factors like knowledge, standards, focus, data protection, qualified workers, employee education, importance, interplay, financial, and human resources were deemed as moderate barriers.

Among the drivers, cost-reduction benefits had the highest mean score, indicating its significance in promoting Industry 4.0 readiness. Table 2 presents the mean scores for each perceived driver, illustrating their relative importance. All factors were considered moderate drivers, with cost-reduction benefits leading the way. Improved time-to-market, organizational strategy, customer requirements, and competitors using new technologies also received high mean scores. Legal requirements and the public advisory system had slightly lower mean scores.

Table 3 shows the mean scores for perceived barriers. Similar to the drivers, all factors were considered moderate barriers. Lack of understanding, knowledge, and a different focus emerged as significant barriers. Other factors such as lack of qualified employees, required continued employee education, limited financial resources, and understanding of the interplay between human and technology also posed moderate challenges.

Results also indicate that the I4.0 readiness of the SMEs operating in the National Capital Region (NCR) of the Philippines. The 200 respondents were considered organizations with

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

an above-average degree of I4.0 readiness. Overall, the survey responses emphasize the importance of horizontal and vertical integration in diversifying products, ensuring quality control, improving efficiency, reducing costs, optimizing supply chain management, enhancing communication, and seizing business expansion opportunities. Integration technologies play a crucial role in streamlining operations, increasing profitability, and promoting growth for organizations.

Table 1. Company profile of respondents

	Organization type		Organization size by asset size	
			Small-size	Medium-size
Wholesale and Retail Trade; Repair of Motor and Motor Vehicles	Count	118	83	35
	% of Total	59%	58%	60%
Accommodation and Food Service Activities	Count	62	46	16
	% of Total	31%	32%	28%
Manufacturing	Count	20	13	7
	% of Total	10%	9%	12%
Total		**200**	**142**	**58**

Organization age	Count	% to total
1 to 5 Years	31	16%
6 to 10 Years	104	52%
More than 10 Years	65	33%
Total	**200**	**100%**

Job position of respondents	Count	% of Total
Business Owner	125	62.50%
Top-level Manager	51	25.50%
Information Technology Head	0	0%
Business Development Manager	13	6.50%
Business Owner/Top-level Manager	7	3.50%
Information Technology Head/Business Development Manager	2	1%
Business Owner/Top-level Manager/Business Development Manager	1	0.50%

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Business Owner/Top-level Manager/Information Technology Head/Business Development Manager	1	0.50%
Total	**200**	**100%**

Multiple linear regression Analysis

Multiple regression modeling was used to analyze the relationships between the independent variables (IVs) and the mediating variable (medV).

Based on Table 4, the combined set of independent variables (drivers, barriers, organization type, and organization age) can explain 31.7% of the variance in I4 readiness when jointly affecting the mediating variable. Table 4 also shows that all independent variables, except for organization age, significantly influence I4 readiness at a p-value of 0.05. Barriers to I4 readiness have a significant negative effect, while drivers and organization type have a significant positive influence.

These results led to the **rejection of hypotheses Ho1, Ho2, and Ho3** due to significant p-values (<0.05). However, **hypothesis Ho4 could not be rejected** as the study lacked sufficient evidence to prove the effect of organization age.

Direct Effect of Independent Variables and Mediating Variable on Dependent Variables

The researchers used Kenny's (2023) mediated regression approach to assess the direct effects of independent variables and the mediating variable on dependent variables. Both sets of variables were used as predictors in separate regression models. As noted by Kenny (2023), using only the mediating variable as a predictor is insufficient due to potential correlations between independent variables and the mediating variable.

Table 5 presents the adjusted R^2 values for the joint independent variables and mediating variable in predicting each dependent variable. Only the relationships between the independent and mediating variables and effectiveness and cost had explanatory power exceeding 10%, at 21.8% and 11.2%, respectively. The remaining relationships had significantly lower explanatory power. The corresponding p-values indicate the significance of each relationship. The effects of both independent and mediating variables on profit, cost, effectiveness, quality, and productivity are all significant due to p-values lower than 0.05**.**

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Table 2: Mean for Perceived Drivers of Industry 4.0 Readiness of Organizations

		1 = Strongly Disagree	2 = Disagree	3 = Unsure	4 = Agree	5 = Strongly Agree	Mean	Verbal Interpretation
Customer Requirement	Count	6	14	35	99	46	3.83	Customer requirements are perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	3%	7%	17.5%	49.5%	23%		
Competitors	Count	3	16	54	68	59	3.82	Competitors using new technologies are perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	1.5%	8%	27%	34%	29.5%		
Cost Reduction	Count	1	8	36	88	67	4.06	Cost reduction benefits are perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	0.5%	4%	18%	44%	33.5%		
Improved Time-to-Market	Count	2	9	44	92	53	3.92	Improved time-to-market is perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	1%	4.5%	22%	46%	26.5%		
Legal Requirement	Count	12	13	48	76	51	3.71	Legal requirements are perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	6%	6.5%	24%	38%	25.5%		

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Public Advisory System	Count	9	17	45	87	42	3.68	Public Advisor System feedbacks are perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	4.5%	8.5%	22.5%	43.5%	21%		
Conscious Strategy	Count	2	15	46	82	55	3.87	Organizational strategy is perceived by the organization as a moderate driver of I4.0 readiness.
	% of Total	1%	7.5%	23%	41%	27.5%		

Table 3: Mean for Perceived Barriers for Industry 4.0 Readiness of Organizations

		1 = Strongly Disagree	**2 = Disagree**	**3 = Unsure**	**4 = Agree**	**5 = Strongly Agree**	**Mean**	**Verbal Interpretation**
Knowledge	Count	3	15	30	100	52	3.92	Lack of knowledge is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	1.5%	7.5%	15%	50%	26%		
Standards	Count	5	10	64	71	50	3.75	Lack of standards is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	2.5%	5%	32%	35.5%	25%		
Focus	Count	3	7	39	99	52	3.95	Different focus is perceived by the organization as a moderate barrier of I4.0
	% of Total	1.5%	3.5%	19.5%	49.5%	26%		

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

								readiness.
Data Protection	Count	9	18	43	91	39	3.67	Lack of data protection is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	4.5%	9%	21.5%	45.5%	19.5%		
Qualified Workers	Count	3	19	41	76	61	3.87	Lack of qualified employees is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	1.5%	9.5%	20.5%	38%	30.5%		
Employee Education	Count	4	16	48	74	58	3.83	Required continued employee education is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	2%	8%	24%	37%	29%		
Importance	Count	3	10	41	88	58	3.94	Lack of understanding of the strategic importance is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	1.5%	5%	20.5%	44%	29%		
Interplay	Count	3	10	52	94	41	3.80	Lack of understanding between the interplay between human and technology is perceived by the organization as a
	% of Total	1.5%	5%	26%	47%	20.5%		

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

								moderate barrier of I4.0 readiness.
Financial	Count	4	18	40	84	54	3.83	Having few financial resources is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	2%	9%	20%	42%	27%		
Human Resource	Count	7	22	37	82	52	3.75	Having few human resources is perceived by the organization as a moderate barrier of I4.0 readiness.
	% of Total	3.5%	11%	18.5%	41%	26%		

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Table 4. Multiple Linear Regression - Model Coefficient Results (Degree of I4.0 Readiness as the Dependent Variable)

Dependent Variable	R	R^2	Adjusted R^2	F	p
Degree of I4.0 Readiness	0.575	0.331	0.317	24.136	< 0.001

Independent Variables	Estimate	Coefficients Std. Error	p-value
Drivers of I4.0 Readiness	0.561	0.059	< 0.001
Barriers of I4.0 Readiness	-0.254	0.067	< 0.001
Organization Type	0.083	0.032	0.009
Organization Age	0.027	0.067	0.683

Table 5: Multiple Linear Regression - Model Fit Results (Perceived Drivers and Barriers of I4.0 Readiness, and Organization Type and Age, and Degree of I4.0 Readiness as the Independent Variables)

				Overall Model Test	
Dependent Variables	R	R^2	Adjusted R^2	F	p
Profit (F1)	0.323	0.104	0.0812	4.52	< 0.001
Cost (F2)	0.366	0.134	0.112	6.00	< 0.001
Sales (F3)	0.217	0.0469	0.0223	1.91	0.094
Efficiency (NF1)	0.233	0.0542	0.0298	2.22	0.053
Effectiveness (NF2)	0.488	0.238	0.218	12.1	< 0.001
Quality (NF3)	0.259	0.0673	0.0432	2.80	0.018
Productivity (NF4)	0.268	0.0719	0.0480	3.01	0.012

Indirect Effect of Independent Variables to Dependent Variables through Mediating Variable

As observed in Tables 6 and 7, there are seven significant indirect effects. These are the indirect effects of (1) perceived drivers of Industry 4.0 readiness on cost through the degree of Industry 4.0 readiness, (2) perceived drivers of Industry 4.0 readiness on effectiveness

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

through the degree of Industry 4.0 readiness, (3) perceived drivers of Industry 4.0 readiness on productivity through the degree of Industry 4.0 readiness, (4) perceived barriers of Industry 4.0 readiness on effectiveness through the degree of Industry 4.0 readiness, (5) perceived barriers of Industry 4.0 readiness on productivity through the degree of Industry 4.0 readiness, (6) organization type on effectiveness through the degree of Industry 4.0 readiness, and (7) organization type on productivity through the degree of Industry 4.0 readiness. Additionally, the direct effects of perceived barriers of Industry 4.0 readiness on effectiveness and organization type on effectiveness were significant.

Based on these significant indirect and direct effects, the researchers conclude that the degree of Industry 4.0 readiness fully mediates the relationships between (1) perceived drivers of Industry 4.0 readiness and cost, (2) perceived drivers of Industry 4.0 readiness and effectiveness, (3) perceived drivers of Industry 4.0 readiness and productivity, (4) perceived barriers of Industry 4.0 readiness and productivity, and (5) organization type and productivity. However, the degree of Industry 4.0 readiness partially mediates the relationships between (1) perceived barriers of Industry 4.0 readiness and effectiveness, and (2) organization type and effectiveness.

Given these significant indirect and direct effects, we conclude that the degree of I4.0 readiness **fully mediates** the relationships between:

1. Perceived drivers of I4.0 readiness on cost
2. Perceived drivers of I4.0 readiness on effectiveness
3. Perceived drivers of I4.0 readiness on productivity
4. Perceived barriers of I4.0 readiness on productivity
5. Organization type on productivity

Meanwhile, the degree of I4.0 readiness **partially mediates** the relationships between:

1. Perceived barriers of I4.0 readiness on effectiveness
2. Organization type on effectiveness

Significant indirect effects were observed only in the relationships listed above, indicating the mediating role of the degree of I4.0 readiness in these instances.

6. CONCLUSION

Despite limitations in rejecting all null hypotheses, this study yielded valuable insights. The degree of I4.0 readiness fully mediated relationships between perceived drivers and barriers, organization type, and organizational performance in terms of cost, effectiveness, and productivity. Partial mediation was observed between perceived barriers and effectiveness, as well as organization type and effectiveness.

The study's findings regarding the significant effects of perceived drivers and barriers on I4.0 readiness align with Stentoft et al. (2021), while the findings on organization type's influence align with Soomro et al. (2021).

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Table 6. Mediation Results with Financial Performance as Dependent Variable

Dependent Variables		Independent Variables							
		Drivers of I4.0 Readiness		Barriers of I4.0 Readiness		Organization Type		Organization Age	
	Effect	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Profit (F1)	Indirect	0.03406	0.571	-0.01545	0.575	0.00506	0.579	0.00166	0.738
	Direct	**0.34074**	**0.001**	-0.02460	0.812	-0.04584	0.340	-0.12570	0.210
	Total	0.37480	< 0.001	-0.04004	0.689	-0.04078	0.389	-0.12403	0.217
Cost (F2)	Indirect	**-0.12611**	**0.037**	0.05719	0.062	-0.01875	0.095	-0.00616	0.685
	Direct	-0.05396	0.607	**0.33078**	**0.001**	**0.15159**	**0.001**	0.03170	0.748
	Total	-0.18006	0.040	0.38797	< 0.001	0.13284	0.005	0.02554	0.798
Sales (F3)	Indirect	0.04462	0.472	-0.02024	0.479	0.00663	0.487	0.00218	0.720
	Direct	**0.22379**	**0.042**	-0.04513	0.672	0.00322	0.948	-0.03474	0.737
	Total	0.26841	0.003	-0.06537	0.527	0.00986	0.840	-0.03256	0.754

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Table 7. Mediation Results with Non - Financial Performance as Dependent Variable

Dependent Variables		Independent Variables							
		Drivers of I4.0 Readiness		Barriers of I4.0 Readiness		Organization Type		Organization Age	
	Effect	Estimate	p-value	Estimate	p-value	Estimate	p-value	Estimate	p-value
Efficiency (NF1)	Indirect	0.05398	0.169	-0.02448	0.191	0.00803	0.218	0.00264	0.692
	Direct	0.07796	0.258	0.07119	0.287	0.02636	0.396	0.01270	0.845
	Total	0.13194	0.022	0.04671	0.472	0.03439	0.264	0.01534	0.814
Effectiveness (NF2)	Indirect	**0.15965**	**< 0.001**	**-0.07240**	**0.006**	**0.02374**	**0.028**	0.00780	0.681
	Direct	0.11017	0.133	**0.21527**	**0.002**	**0.08156**	**0.014**	-0.04447	0.519
	Total	0.26982	< 0.001	0.14287	0.045	0.10530	0.002	-0.03667	0.609
Quality (NF3)	Indirect	0.04606	0.298	-0.02089	0.313	0.00685	0.330	0.00225	0.700
	Direct	0.09620	0.218	0.14133	0.062	0.03306	0.348	-0.00164	0.982
	Total	0.14226	0.028	0.12044	0.101	0.03991	0.251	6.11e-4	0.993
Productivity (NF4)	Indirect	**0.14508**	**0.003**	**-0.06580**	**0.015**	**0.02157**	**0.041**	0.00709	0.682
	Direct	-0.06355	0.437	0.03827	0.629	0.03369	0.360	0.10931	0.155
	Total	0.08153	0.240	-0.02753	0.726	0.05527	0.137	0.11639	0.140

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

7. KEY RECOMMENDATIONS

Business owners and managers can gain a competitive edge by leveraging drivers contributing to I4.0 readiness and proactively addressing identified barriers. Government standards and regulations should be closely monitored, even in the absence of specific digital technology laws. Engaging with initiatives like the I3S can bolster I4.0 readiness and facilitate strategic deployment of I4.0 technologies.

Fostering a digital mindset within the organization's culture and executing strategic planning is recommended. Investing in comprehensive employee training equips the workforce with skills to strategically utilize I4.0 technologies in alignment with overarching business objectives. Public feedback, collected through surveys, is essential for refining products and customer service while monitoring social media interactions to maintain competitiveness. Establishing an in-house digital technology team ensures organizations remain abreast of emerging trends and foster innovation. Continuous employee training further improves I4.0 readiness, enabling proficient integration of technologies for heightened efficiency and customer satisfaction.

To address legislative concerns, organizations can engage external digital technology consultants to standardize technologies according to their needs, enhancing I4.0 readiness. Regarding management barriers, balancing operational efficiency with strategic development, prioritizing data protection, and fostering digital understanding would enhance I4.0 readiness. An in-house digital team can aid in strategic development, data protection, and technology understanding, optimizing resource allocation and maximizing potential with limited resources. Workforce issues are addressed through investing in employee training and education, elevating knowledge, skills, and understanding of I4.0 technology components and their integration with human aspects.

Government collaboration between the Department of Trade and Industry (DTI) and the Department of Science and Technology (DOST) is crucial for creating comprehensive policies with incentives for integrating I4.0 technologies. The government could establish a reliable information-sharing platform through a dedicated website, workshops, or seminars to empower organizations to adopt I4.0 technologies.

This study provides valuable insights for academia and future researchers to delve deeper into drivers, barriers, and other relevant factors. Exploring readiness across industries and identifying perceived drivers and barriers is beneficial, alongside leveraging these technologies. Amidst the country's I4.0 adoption, academia can incorporate study data into courses like Business, ICT, and Management. Encouraging industry-academia partnerships through internships, research, and I4.0-focused curricula bridges the gap between theory and practical skills.

ACKNOWLEDGEMENTS

The research team acknowledges the thesis panelists' comments which made the paper better and more robust. The researchers would also like to extend their profound gratitude to the anonymous paper reviewer for his/her helpful comments and suggestions.

REFERENCES

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[1] Ali, S., & Xie, Y. (2021). The impact of Industry 4.0 on organizational performance: the case of Pakistan's retail industry. European Journal of Management Studies, 26 (2/3), 63-86. https://www.emerald.com/insight/content/doi/ 10.1108/EJMS-01-2021-0009/full/pdf
[2] AMERIAL. (2022). Digital Transformation: The Way Forward Industry 4.0 Readiness of Philippine MSMEs. https://mirdc.dost.gov.ph/images/AMERIALWHITE- PAPER-2022_FINAL.pdf
[3] Ayentimi, D. T., & Burgess, J. (2018). Is the fourth industrial revolution relevant to sub-Sahara Africa? Technology Analysis & Strategic Management, 31(6), 641-652. https://doi.org/10.1080/09537325.2018.15421
[4] Bain & Company (2018). Advancing towards ASEAN Digital Integration. bdnews24.com, Uber Taxi Services in Dhaka Illegal: BRTA. Retrieved from https://bdnews24.com/bangladesh/2016/11/25/ uber-taxi-servicesin-dhaka-illegal-brta
[5] Craig, W. (2019). Ten Ways Using MobileTechnology Can Benefit Businesses. https://denmarkbusinesssolutions.com/2019/05/01/benefits-of-mobile-technology-for-business/
[6] DTI. (2021). Inclusive Innovation Industrial Strategy. https://innovate.dti.gov.ph/resources/I 3s-strategy/inclusive-innovation-industrial-strategy/
[7] Duman, M. C., & Akdemir, B. (2021). A study to determine the effects of industry 4.0 technology components on organizational performance. Technological Forecasting and Social Change, 167, 120615. https://doi.org/10.1016/j.techfore.2021.120615
[8] Frank, A.G., Dalenogare, L.S., & Ayala, N.F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. International Journal of Production Economics, 15-26. https://doi.org/10.1016/j.ijpe.2019.01.004
[9] Kenny, D. (2023). Mediation. https://davidakenny.net/cm/mediate.htm#BK
[10] Kuo, Y., Wu, Y., and Liu, Y. (2022). Identifying Key Factors for Sustainable
[11] Manufacturing and Development. Review of Integrative Business and Economics Research. Vol. 11, Issue 1, pp. 30-50 retrieved from https://buscompress.com/uploads/3/4/9/8/34980536/riber_11-1_02_m20-905_30-50.pdf
[12] Maplesden, P. (2022). 7 benefits of RFID in supply chain management and logistics.
[13] https://www.techtarget.com/searcherp/tip/7-be nefits-of-RFID-in-supply-chain-management-and-logistics
[14] Micklitsch, J. (2023). What Impact will Artificial Intelligence have on Productivity
[15] and the Economy?https://ancora.net/what-impact-willartificial- intelligence-have-on-productivity-an d-the-economy/#:~:text=Artificial%20intellige nce%20(AI)%20has%20the,overall%20efficiency%20and%20increase%20output
[16] Schuldenfrei, M. (2019). Horizontal and Vertical Integration in Industry 4.0.
[17] Manufacturing Business Technology. https://www.mbtmag.com/business-intelligence/article/13251083/horizontal-and-vertical-integration-in-industry-40
[18] Soomro, M. A., Hizam-Hanafiah, M., Abdullah, N. L., Ali, M. H., & Jusoh, M. S.
[19] (2021). Embracing Industry 4.0: Empirical Insights from Malaysia. Informatics, MDPI. https://doi.org/10.3390/informatics8020030
[20] Stentoft, J., Wickstrøm, K.A., Philipsen, K., and Haug, A. (2021). Drivers and barriers for Industry 4.0 readiness and practice: empirical evidence from small and medium-sized manufacturers. Production Planning & Control, 32 (10), 811-828 https://doi.org/10.1080/09537287.2020.17683
[21] Sugandini, D., Ghofar, A., Suardi, Ambarwati, S., and Arundati, R. (2024). Limitations of Application of Open Innovation for increasing the Performance of Craft SMEs in

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Sleman, Indonesia, Review of Integrative Business and Economics Research. Vol. 13, Issue 2, pp.478-484 retrieved from https://buscompress.com/uploads/3/4/9/8/34980536/riber_13-2_32_s23-204_485-496.pdf

[22] Szász, L., Demeter, K., Rácz, B.-G,. and Losonci, D. (2021). Industry 4.0: a review and analysis of contingency and performance effects. Journal of Manufacturing Technology Management, 32 (3), 667-694. https://doi.org/10.1108/JMTM-10-2019-0371

[23] Tunggal, A. T. (2023). Why is Cybersecurity Important?https://www.upguard.com/blog/cybersecurity-important

[24] World Economic Forum and A. T. Kearney. (2018). Readiness for the Future of Production Report 2018. http://www3.weforum.org/docs/FOP_Readiness_Report_2018.pdf.

[25] Yu, F., & Schweisfurth, T. (2020). Industry 4.0 technology implementation in SMEs – A survey in the Danish-German border region. International Journal of Innovation Studies, 4,76–84.https://doi.org/10.1016/j.ijis.2020.05. 001

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)