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AN ANALYSIS ON BARRIERS TO VIETNAMESE MANUFACTURING ENTERPRISES IN THE CONTEXT OF INDUSTRIAL REVOLUTION 4.0

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The purpose of this paper is to analyse the potential barriers that hinder manufacturing enterprises from the perspective of Vietnam in the 4.0 industry period. The study attempts to identify the important factors and their relationships by using the Interpretive Structural Model (ISM) method. The results of the study have significant implications for researchers, managers, and policy-makers.

Keywords: *Industrial revolution 4.0, barriers, manufacturing, business.*

1. Introduction

Countries around the world have introduced their policies to promote smart manufacturing and strive to achieve the transformation and upgrade of their manufacturing industries. Vietnam, Asia's new manufacturing hub will be no exception. Since the end of the Vietnam War, economic and political reforms under, launched in 1986, the economy has grown and the incidence of poverty has been significantly reduced. Nowadays, Vietnam is one of the rapidly growing economies in Asia, attracting much foreign direct investment (FDI) in the manufacturing sector. Figures released by the General Statistics Office show that the agriculture, forestry, and fishing production sector contributed 13.96 percent to Vietnam's GDP in 2019; the industry and construction sector accounted for 34.49 percent of GDP in which the textile, electronics, and computer industries are leading ones. In the first four months of 2020, the total export turnover of the whole country reached US$ 80.86 billion, increasing by nearly 2%, equivalent to an increase of US$ 1.62 billion compared to the same period last year. Due to the effects of the Covid-19 pandemic, it was indicated that many export industries encountered negative signs of export growth in 2020. A temporary downturn in economic activity, export industries faced difficulties such as textiles and mobile phones while computers and machinery had impressive growth, have overtaken the textile and garment industry to become the second-largest export group of Vietnam ("Export turnover reached nearly US$81 billion, which industry "overcame" difficulties and which group was "in danger"?", 2020) (Figure 1). To prevent the spread of Covid-19, Vietnam locked down, various western countries' economies remained shut in a bid to halt the spread of Covid-19. Manufacturing sector is poised to be hit hard during the outbreak. The impact crisis on jobs has been much worse than expected initially, besides, businesses have to spend a pandemic medical cost, which leads to many businesses, especially undevel-

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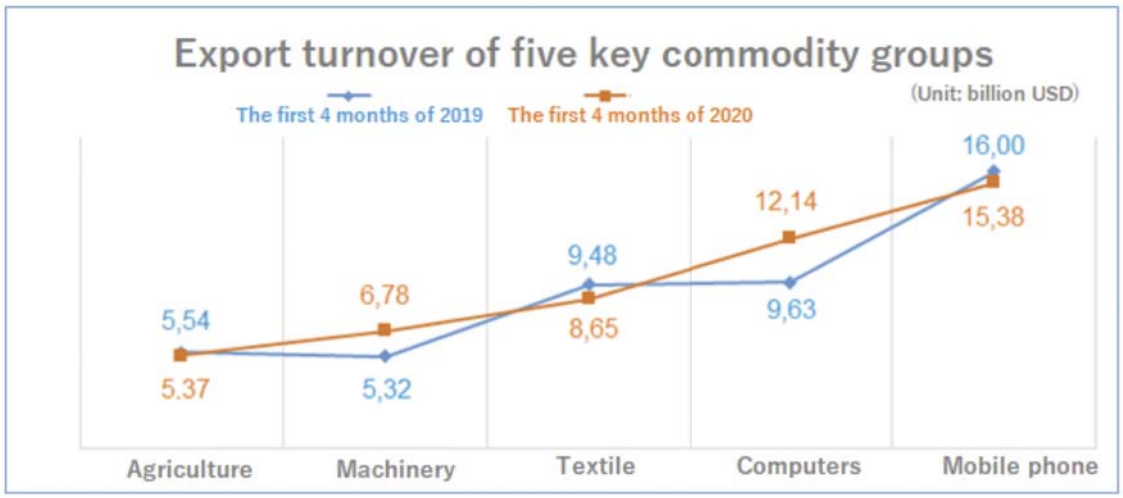
oped manufacturing enterprises that require a large amount of labour to produce goods, and it is proved that they are facing with increasing difficulties. The health and safety of workers is a top concern during the Covid-19. The characteristics of the epidemic and post-epidemic economy show that machines and robots seem to be the future of jobs, for better or worse the robots are going to replace many humans in their jobs. Hence, the outbreak is believed to be accelerating the adoption of the fourth industrial revolution.



Source: General Statistics Office

Figure 1: *Export turnover of five key commodity groups*

The term Industry 4.0 was first publicly introduced in 2011 at the world's leading industry fair in Germany as a proposal to develop a new concept of German economic policy based on high-tech strategies, and it gives the industry a panoramic view of how manufacturers are adopting digital technology to generate more output with the same level of inputs in production, but still, offer quality assurance. The fourth industrial revolution (I4.0) is likely to have a deep impact on society, across all industries and especially the manufacturing industry for decades. I4.0 - a global transformation characterized by the convergence of digital, physical, and biological technologies is just starting. Industry 4.0 comes with a whole technological revolution; many see the difficulty in the 4.0 era involves the difficulty of technology transformation. In fact, introducing technological change into an organisation presents challenges in change management (Agostini & Filippini, 2019), therefore, few studies or policies have been carried out concerning a sustainable comprehensive innovation strategy (Dean & Spoehr, 2018; Xu et al., 2018), there is still a lack of detailed analysis of the implementation processes and the related organisational requirements is missing (Orzes et al., 2020, tr. 255).

The role of Industry 4.0 becomes even more critical in the backdrop of a crisis such as Covid-19. I4.0 would be of great interest to manufacturers when I4.0 provides an automated solution for different manufacturing industries and thinking machines are replacing humans. Despite the promise, there is still uncertainty in the sphere of I4.0 implementation (Kamble et al., 2018; Nagy et al., 2018). According to the survey data of the Ministry of Industry and Trade at the I4.0 forum, at present, 61% of respondents have limited knowledge or are unclear of the

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exact impacts and 21% of respondents know of I4.0, are still passive in responding and seizing I4 [4] Fear of failure can promote procrastination in various ways, especially small and medium enterprises that are reluctant to Industry 4.0 (Veile et al., 2019). Therefore, it is necessary to investigate barriers for Industry 4.0 readiness and practice and to explore the relationships between barriers for guiding policy initiatives to promote Industry 4.0 adaptation among manufacturing enterprises.

2. Research methodology

The main aim of the article is to identify potential barriers to Vietnamese manufacturing enterprises in the context of industrial revolution 4.0; therefore, "Interpretive Structural Modelling" (ISM) method was adopted. The ISM approach is developed by Warfield and Sage, ISM has been demonstrated in supplier selection (Mandal and Deshmukh, 1994), strategic decision making (Bolaños et al., 2005), or barriers analysis (Singh and Kant, 2007).

The steps involved in developing ISM are described next.

Step 1: Selection of barriers.

Step 2: Structural self-interaction matrix.

Step 3: Reachability matrix.

Step 4: Transitivity check.

2.1. Selection of barriers

Bias can occur at any phase of research, including study design or data collection; due to the personal bias of the investigator, errors are likely to influence the results. The path to Industry 4.0 will be the same for different countries (Yadav et al., 2020), priorities that make a difference. Therefore, the research method of this article is based on the analysis of secondary data sources which strength of secondary data analysis is the approach where the work is reliably done by other researchers. The data collection was carried out as follows:

- *Database*: Scopus, it is large Elsevier's abstract and citation database of peer-reviewed literature.

- *Timing*: 12/3/2020.

- *Key term*: (TITLE (industry 4.0) OR TITLE (fourth AND industrial AND revolution) AND TITLE (challenges) OR TITLE (barrier) AND TITLE (manufacturing) OR TITLE (production).

- *Limitation:* Accepted data from Scopus as from 01/01/2015 to 12/3/2020. We excluded book chapters or articles from a conference proceeding.

The results obtained 15 articles with the following results (table 1):

We recognise that journal quality is a subjective concept, we determined to use Academic Journal Quality Guide produced by the Chartered Association of Business Schools (UK) as the point of reference to inform this exercise. According to the most recently updated edition AJG 2018, ABS defines 1* journals, these journals meet minimum scholarly standards. A large number of barriers have been discussed in previous studies, with ½ results obtained from grade 3* journals - these journals typically have good submission rates and are very selective in what they publish.

The results are summarised in Table 2. The actual results solely selected 5 articles since we omitted the papers that analysed specifically about the technology (For example Research challenges for the Internet of Things).

2.2. Structural self-interaction matrix

The ISM approach suggests the use of expert's opinion. For the purpose of the study, 4 experts working in the manufacturing industry in Vietnam of 3 different companies were placed, consisting of each expert has more than 15 years of experience working in the enterprise, at least 5 years working in Vietnam. Guest expertise is diverse, with at least 2 years of management experience in the fields of industrial engineering (IE), operations management, and IT.

Based on the barriers that we provided, the expert team conducted a meeting and agreed to eliminate the barriers: "Lack of knowledge management system" and "policy conflict" due to only one out of five consensuses (authors of journal). In addition, the experts stated that legal issues, network

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Table 1: *Summary of searchable results*

No.	DOI	Journal Title	AJG 2018 ranking
1.	10.1016/j.ijpe.2019.107546	International Journal of Production Economics	3
2	10.1007/s10845-020-01532-x	Journal of Intelligent Manufacturing	1
3	10.1016/j.procir.2019.03.262	Procedia CIRP	Not rated
4	10.1016/j.arcontrol.2019.04.002	Annual Reviews in Control	Not rated
5	10.1016/j.procir.2019.04.219	Procedia CIRP	Not rated
6	10.1287/msom.2019.0796	Manufacturing & Service Operations Management	3
7	10.1016/j.compind.2018.06.004	Computers in Industry	3
8	10.1515/mspe-2018-0034	Management Systems in Production Engineering	Not rated
9	10.1007/978-3-319-33609-1_2	Advances in Intelligent Systems and Computing	Not rated
10	10.3233/AIS-170432	Journal of Ambient Intelligence and Smart Environments	Not rated
11	https://doi.org/10.1016/j.jclepro.2020.120112	Journal of Cleaner Production	2
12	10.1108/EJIM-02-2018-0030	European Journal of Innovation Management	1
13	10.5430/ijfr.v9n2p90	International Journal of Financial Research	Not rated
14	10.1142/S1363919617400151	International Journal of Innovation Management	2
15	https://doi.org/10.1016/j.techfore.2019.05.021	Technological Forecasting and Social Change	3

security rights, connection security, or business owners are not equipped with technology knowledge should be barriers in the context of production in Vietnam when they are the problems in most developing countries. It would be advisable to add barriers: "Legal uncertainty", "Lack of technological knowledge" to be selected in the list.

In the first step towards generating a matrix, considering the contextual relationship for each variable, the existence of a relationship between any two barriers (i and j) and the associated direction of the relation is asked. The four symbols used to denote the direction of the relationship between the elements i and j are given below:

V: Barrier i will promote barrier j;
X: Barrier i and j will promote each other;
A: Barrier j will promote barrier i;
O: Barriers i and j are unrelated;
The results are shown as follows (Table 3):

2.3. Reachability matrix

In this step, SSIM is converted into a reachability matrix, which is a binary matrix. For this, V, A, X, and O are replaced either by 1 or 0 based on the relationship. The substitution of 1 and 0 are as per the following rules:

- If the (i, j) entry in the SSIM is V, the (i, j) entry in the reachability matrix becomes 1, and the (j, i) entry becomes 0.

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Table 2: *Driving barriers of Industry 4.0*

Area	Barriers	Authors				
		Alok Raj et al., 2020	Yadav et al., 2020	Agostini & Filippini, 2019	Horváth & Szabó, 2019	Kamble et al., 2018
Management	Ineffective change management	x	x		x	
	Legal uncertainty					x
	Difficulty in value chain integration/ manufacturing process redesign	x	x	x		x
	Lack of technological knowledge	x				
	Policy conflicts		x			
	Insufficient recruitment/ training		x	x	x	x
	Failure to comply with the process	x				x
Technology	High-cost investment	x	x		x	x
	Weak IT infrastructure (including network security, etc.)			x	x	x
	Lack of knowledge management system					x

- If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0, and the (j, i) entry becomes 1.

- If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1, and the (j, i) entry also becomes 1.

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Table 3: *Structural Self Interaction Matrix (SSIM)*

	i	j	1	2	3	4	5	6	7	8
1	Change management (ineffective)			O	A	V	V	V	V	O
2	(Lack of) Technological knowledge				A	A	O	A	A	V
3	(Failure to) Comply with process					V	V	O	O	V
4	(Difficulty in) Value chain integration/ manufacturing process redesign						V	V	A	V
5	(Insufficient) Recruitment/ training							V	O	V
6	Investment cost (High)								A	O
7	IT infrastructure (Weak)									O
8	Legal (uncertainty)									

- If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0, and the (j, i) entry also becomes 0.

Table 4: *Reachability Matrix*

	i	j	1	2	3	4	5	6	7	8	Total
1	Change management (ineffective)		1	0	0	1	1	1	1	0	5
2	(Lack of) Technological knowledge		0	1	0	0	0	0	0	1	2
3	(Failure to) Comply with process		1	1	1	1	1	0	0	1	6
4	(Difficulty in) Value chain integration/ manufacturing process redesign		0	1	0	1	1	1	0	1	5
5	(Insufficient) Recruitment/ training		0	0	0	0	1	1	0	1	3
6	Investment cost (High)		0	1	0	0	0	1	0	0	2
7	IT infrastructure (Weak)		0	1	0	1	0	1	1	0	4
8	Legal (uncertainty)		0	0	0	0	0	0	0	1	1

2.4. Transitivity check

The reachability set (R) consists of the factor itself and the other factor that it may impact, whereas the antecedent set (A) consists of the factor itself and the other factor that may impact it. Subsequently, the intersection of these sets is derived for all variables. Comparing the reachability set and the antecedent set, if the two sets are the same, the barriers level is given the top-level variable in the ISM hierarchy, which would not help achieve any other variable above their level. After the identification of the top-level element, it is discarded from the other remaining variables.

3. MICMAC analysis and discussion

MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement) analysis helps to analyse and classify barriers and dependen-

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Table 5: *Partitioning reachability matrix into different levels*

No.	Reachability	Antecedent	Intersection	Level
1	1,4,5,6,7	1,3	1	II
2	2	2,3,4,6,7	2	IV
3	1,2,3,4,5	3	3	I
4	2,4,5,6	1,3,4,7	4	II
5	5,6	1,3,4,5	5	III
6	2,6	1,4,5,6,7	6	IV
7	2,4,6,7	1,7	7	III
8	8	2,3,4,5,8	8	IV

cies. In this regard, the barriers are divided into four different clusters.

Group I: Contains weak barriers - often unrelated to others.

Group II: Barriers are dependent. It is unlikely to be the cause of other barriers.

Group III: Barriers are dependent and also powerful as the cause of another barrier. Any effect on a barrier belonging to one group causes an impact on another barrier and reacts to itself.

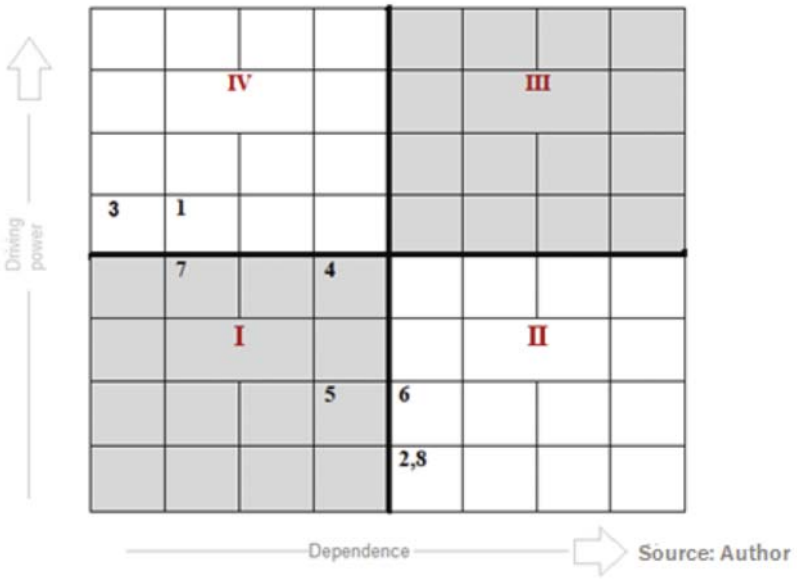
Group IV: Barriers of this group are independent or less dependent, which is the cause of other barriers.

The results shown in Table 6 indicate that:

- ***Highly developed IT infrastructure, redesigning production processes***, or ***having highly qualified personnel*** is meant to be independent; they have little impact on other barriers in the development of industrial 4.0 productions because each of these factors is autonomous. Enterprises with good IT infrastructure and reasonable production process of the group (I) but close to group (IV) mean that these two barriers are also capable of helping businesses improve their competitive advantage.

- Group (II): I***nvestment cost, knowledge of technology, and concern of solid information security legislation*** are the causes of the problem. Administrators who got these factors will facilitate the overcoming of other barriers. Domestic production enterprises are mainly small and medium enterprises, they not only lack investment capital but also have many difficulties in having management experience and possessing modern production technology. Digitalisation poses a legal barrier as the competition gets fierce. Laws on data protection, liability for artificial intelligence, standardisation must be considered while implementing digital strategy. In terms of priority, before thinking about investment finance, it is necessary to have a

Table 6: *Driving power and dominance diagram*



Source: Author

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legal system or implement ethical codes of conduct in information technology and digitalisation to attract investors, and the need to equip knowledge about technology are two of the barriers that need to be overcome first.

- ***Change management, process compliance*** is weak dependency. Figure 1 shows, non-compliance with the direct or indirect process of controlling other barriers. Understanding and complying with the 4.0 technology application process will help businesses and policymakers understand in detail the Industry 4.0 application process then overcoming hidden barriers during implementation. Furthermore, it is necessary to proactively reform activities within the enterprise to deal with competition. Any slight change in the business model also comes with many types of risks that businesses need to anticipate, no matter how small, should expect to encounter some resistance from within the organisation.

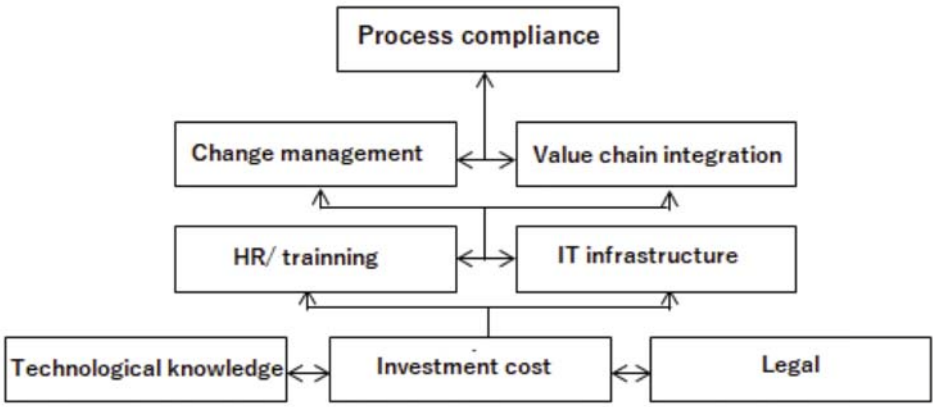

Figure 2: *ISM based model for barriers to Vietnamese Manufacturing Enterprises in the Context of Industrial Revolution 4.0*

Conclusion and future work

We analysed barriers to Vietnamese manufacturing enterprises in the context of industrial revolution 4.0. ISM-based I4.0 barrier model is a structural model that can be interpreted and analysed completely by interpreting the links, thereby making the logic more transparent. The results show that investment cost is the minimum requirement, however willing to learn new techniques and skills as current technologies become obsolete as well as building a legal framework are two issues that need to be prepared to overcome first. Upon investment cost preparation, we propose that businesses should focus on developing IT infrastructure, adjusting their production processes reasonably and effectively to gain a competitive advantage. However, no matter how well prepared we are, the failure to comply with the process and ineffective change management will break the dream of going to an "I4.0 enterprise". Besides theoretical research, in future work, it is necessary to have empirical research in enterprises by quantitative survey research. Besides, the meaning of barriers can vary from sector to sector, so it is necessary to identify specific difficulties for the specific target industry. ◆

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Summary

Mục đích của bài viết này là phân tích các rào cản tiềm năng gây cản trở các doanh nghiệp sản xuất lấy bối cảnh Việt Nam trong thời kỳ công nghiệp 4.0. Nghiên cứu cố gắng chỉ ra yếu tố quan trọng và mối liên hệ các yếu tố này bằng phương pháp Interpretive Structural Model (ISM). Kết quả nghiên cứu có ý nghĩa quan trọng đối với các nhà nghiên cứu, nhà quản lý và nhà hoạch định chính sách.

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