Asian Social Science; Vol. 16, No. 9; 2020
ISSN 1911-2017 E-ISSN 1911-2025
Published by Canadian Center of Science and Education

Is the Maturity Model applicable in Vietnam?

Vu Thi Tuyet Mai[1], & Nguyen Thi Phuong Thu[2]

[1] Planning and Development Department, National Economics University, Viet Nam

Correspondence: Vu Thi Tuyet Mai, Planning and Development Department, National Economics University, A1 Building, 207 Giai Phong Street, Hai Ba Trung District, Ha Noi, Viet Nam. E-mail: maivu@neu.edu.vn.

Received: April 2, 2020 Accepted: July 7, 2020 Online Published: August 31, 2020

doi:10.5539/ass.v16n9p11 URL: https://doi.org/10.5539/ass.v16n9p11

Abstract

Manufacturing enterprises are currently facing many challenges of industrial revolution 4.0 when beginning to change the production model, working with embedded systems which can collect and transmit specific data. The application of maturity models to the Industry 4.0 may help organizations to address the challenges regarding the concept of Industry 4.0 and the diversification methodology. This research is going to examine the application of a maturity model for assessing Industry 4.0 created by Schumacher et al. (2016). The Maturity model of Schumacher et al. (2016) was built to assess the maturity and to infiltrate of the enterprises manufacturing into the Industry 4.0. The purpose of this paper is examining the applicable of using the Maturity model in evaluating the maturity of industrial enterprises in Vietnam toward industry 4.0. The issues will be addressed in this paper: i) The nature of Industry 4.0 and challenges for the manufacturing enterprises; ii) The Maturity model for manufacturing enterprises towards Industry 4.0; iii) The process of applying Maturity model in assessing the manufacturing enterprise towards Industry 4.0; iv) Some initial recommendations for Vietnamese manufacturing enterprises and v) Conclusion.

Keywords: manufacturing enterprises, maturity model, industrial revolution 4.0

1. Introduction

Global manufacturing businesses are facing economic challenges due to increasing technology development, falling natural resources, rising energy, increasing employee age and market globalization. In addition, customers increasingly demand to improve product services, product diversity, increase quality standards, support services and satisfaction. The phrase of “The Fourth Industrial Revolution” was first mentioned in the Strategic Action Plan on high technologies of German Government in 2012 and now is widely used. It indicates the Network development and dynamic processes using large amounts of data to control intelligent machines (Sirkin et al., 2015b). "Revolution" refers to a mutational and thoroughly change in world history. Many revolutions have taken place when new technologies and new methods perceive that the world is creating a profound changes in economic systems and social structures.

The first industrial revolution, which lasted from 1760s to 1840s, began with the construction of railroads and the invention of the steam engine, opened a new era in human history - mechanical production era. Next, the second industrial revolution took place in the late 19th century and early 20th century with the advent of electricity and assembly lines to help to develop mass production. The third industrial revolution began in the 1960s, commonly called the computer revolution or the digital revolution because it was catalysed by the development of semiconductors, supercomputers, personal computers and Internet. The world is now in early forth industrial revolution built on the digital revolution as the Internet increasingly popular and mobilizing with tiny and robust sensors with lower price and artificial intelligence. The forth industrial revolution refers to the emergence and dissemination of a wide range of new digital technology (Rzigmann et al., 2015) with embedded sensors helping more intelligent products and devices communicate and interact with each other (Internet of Things - IoT); help to collect and assess data in real time to optimize production costs and quality (Big Data and Analysis - BDA); develop more autonomous and flexible robots and advanced production techniques. Many digital technology become more feasible and it can be deployed industrial applications due to cost reduction and reliability. However, it can take 15 to 20 years to fully implement (Baum & Wee, 2015). Industry 4.0 has the potential to bring the change from manufacturing operations into a separate automated, optimized and fully integrated products in data flow among the worldwide value chain. In this process, IoT impacts on transforming all industries and services, and affect all businesses in general and manufacturing enterprises in particular.

Manufacturing enterprises are currently facing many big challenges from Industry 4.0. It has difficulty in improving organizational capabilities, absorbing new production technology and building suitable strategic development because of increasing complexity across all corporation levels. That is the reason why the production enterprises need to update, improve the capacity and skills towards Industry 4.0. It also should improve the development performance and innovation management strategy to diversify new production fields. Some manufacturing enterprises have realized the importance of integrating the vision and understanding of the Industry 4.0 into the organizational culture of the business. The Maturity model of Schumacher et al. (2016) was built to assess the maturity and to infiltrate of the enterprises manufacturing into the Industry 4.0. The model give 9 factors to assess the maturity of the manufacturing enterprises towards Industry 4.0 that includes: Products, Customers, Operation, Technology, Strategy, Leadership, Governance, Culture, and Human. In some studies, the Maturity model has been transformed into a practical tool and tested in some businesses. The researchers said that this model is transparent, easy to use and has potential application in the real production environment.

The model gives 9 factors to assess the maturity of the manufacturing enterprises towards Industry 4.0 that includes: Products, Customers, Operation, Technology, Strategy, Leadership, Governance, Culture, and Human. The research using qualitative method explores barriers and suggests conditions in applying the model to manufacturing enterprises and the Vietnamese Government to accelerate the maturation process of Vietnamese manufacturing enterprises towards to meet the requirements of Industrial Revolution 4.0. This research focuses on solving the following main issues: i) The nature of Industry 4.0 and challenges for the manufacturing enterprises; ii) The Maturity model for manufacturing enterprises towards Industry 4.0; iii) The process of applying Maturity model in assessing the manufacturing enterprise towards Industry 4.0; iv) Some initial recommendations for Vietnamese manufacturing enterprises and v) Conclusion.

2. Method

This paper is undertaken by using the combined the methodology of quantitative correlative research and qualitative research. The data obtained from a case-study with a Vietnamese manufacturing enterprise with around 400 employees in textiles industry are presented similarly with the UNDP research conclusion. The company received a questionnaire per e-mail to allow for reflected assessment of their internal situation on their own time. The questionnaire criteria included a closed question for each factor. Each question requires answers according to the Likert scale ranging from 1 - "no difference" to 5 - "very different". For example, for the criterion of "Implementation of industrial 4.0 Roadmap" in "Strategy" factor.

The qualitative interivews, with working tools being in-depth interviews, was conducted after the quantitative survey. In the context of the qualitative survey, in-depth interviews were conducted by experts. Another important aspect of in-depth interviews was to collect business proposals and recommendations on solutions to help Vietnam’s business sector accelerate the model toward the Industry 4.0. For this purpose, a targeted questionnaire was prepared and used by the research team for in-depth interviews. Other information, such as the overall score and scores in each field obtained from quantitative analysis results as well as from general information about enterprises on web pages, was prepared and thoroughly examined before direct interviews were conducted.

3. Results

3.1 Nature of Industry 4.0 and Challenges for Manufacturing Enterprises

The Industry 4.0 calls for the application of high technology into the operation of the manufacturing enterprises in order to ensure the sustainable development in the future, addressing the challenges related to resource and energy efficiency, urban production and demographic change that help to increase productivity and using resources efficiently (Kagermann, 2015). A major technology push manufacturing enterprises towards Industry 4.0 based on the Internet and internet services, help to develop computational power, lead to cloud computing service. These technologies have the potential to create a new generation of industrial systems based on services residing on devices and on the cloud. In order to develop and apply these technologies successfully, they need the talented human resources, the perfect IT infrastructure, the economic strength and good awareness of the manufacturing enterprise leaders (Karnouskos et al., 2014).

Kagermann et al. (2013a) describes Industry 4.0 with seven concepts: (1) smart factory, (2) cyber systems, (3) self-organization, (4) new systems in distribution and procurement, (5) new system in developing products and services, (6) adaption to the needs of people and (7) social responsibility of enterprises. In particular, the Internet and assistive technologies act as the backbone to integrate physical objects, agents, people, smart machines, production chain and production processes across the organized range to make an intelligent system of machines, fast and flexible network value chain.

Hermann et al. (2014) said that the characteristics of manufacturing enterprises in Industry 4.0 is the ability to foresee the future products to meet the variety and complexity demand with low cost and low environmental impact. Industry 4.0 is understood as a new level of organization, can control the entire value chain in the lifecycle of the product, and require the model changes in business operations instead of improving the production ability based on technology. The manufacturing companies tend to focus more on the aspects of technology towards 4.0 to achieve short-term market advantage. Industry 4.0 will change the design, manufacture, operation and service of products and production systems. Connection and interaction between parts, machines, and people will make the production system 30% faster and 25% more efficient. Therefore, production will experience a major transition from the individual to the whole and complete integration, the elements are connected flexibly and quickly and the result is the production system with higher quality.

Global manufacturing businesses are facing economic challenges due to increasing technology development, falling natural resources, rising energy, increasing employee age and market globalization. In addition, customers increasingly demand to improve product services, product diversity, increase quality standards, support services and satisfaction. Therefore, there are many challenges for manufacturing enterprises towards Industry 4.0 as *requiring new skills of the labor force, data security* and *investment needs*.

Technology is changing rapidly with robots, big data, artificial intelligence and connected objects, which brings new possibilities and new challenges for the enterprise production and manufacturing industries. Manufacturing enterprises must train and test new *skills of the labor force* to transform towards Industry 4.0 successfully. The most sought-after industrial skills in 4.0 are Data Management, Data security, Interaction between people and machines, Interface design, Software Development, Programming, Scientific data, and Analysis (Lee et al., 2014). The big challenge for manufacturing enterprises is employee training and recruitment of new human resources, finding the most suitable approach to fix the value chain, maintaining or building on the competitive advantage of the business. Studies conducted in Germany and the United States indicated that the vast majority of industrial employees do not have the skills needed for Industry 4.0.

Data security is a concern for all manufacturing enterprises in Industry 4.0. The rapid proliferation of data systems in businesses highlights the importance of computer security. When technology is connected to the internal network and concentrated in the same building, ensuring everything work securely becomes easier. However, at present numerous objects that are connected can be moved and accessed over the Internet. It makes pressure on the management of network security (Schmidt et al., 2015). Therefore, it is necessary to integrate network security factors in the deployment of the IT infrastructure of enterprise production.

New technologies are related intimately to *the investment needs* because Industry 4.0 requires a special change in manufacturing enterprises and also requires big funding. The majority of the new technologies are very expensive and the manufacturing enterprises mostly lack a large amount of money to carry out the production towards Industry 4.0.

To deal with these challenges, manufacturing enterprises must have the ability to manage the entire value chain of the enterprise fast and properly. Manufacturing enterprises need virtual structures and networking to enable the increase of collaboration, quick adaptation throughout the entire product lifecycle, strong innovation in production and distribution. Many manufacturing enterprises can forecast market growth in the future but do not know how to create opportunities for new growth or even do not know how to overcome challenges when facing Industry 4.0 in the specific situation of the business. Now many manufacturing enterprises realize that the comprehensive approach in management and diversification of the system are necessary but difficult to implement because prerequisite condition of the diversification of the system (awareness, knowledge, processes, techniques, tools, etc.) does not exist in manufacturing enterprises, most of whom are SMEs.

However, in fact only by implementing production towards Industry 4.0 can help the manufacturing enterprises to increase productivity and grow in a sustainable way. Therefore, the application of evaluation on manufacturing enterprises under the Maturity model towards Industry 4.0 and action program for manufacturing enterprises are needed to be studied and applied.

3.2 The Maturity Model for Manufacturing Enterprises Towards Industry 4.0

The term of "maturity" refers to a state of being completed, perfect, or ready. It implies the development progress in a system. Accordingly, the mature system (i.e. biological, organizational or technological) has the ability of increase over time, related to the desire of some subjects in the future. Maturity can be assessed qualitatively or quantitatively, either sporadically or continuously (Kohlegger, 2009).

The maturity of a manufacturing enterprise toward Industry 4.0 is the progress status of the conditions of inside

and outside support such as the vertical and horizontal integration of the production system or the digital integration of the entire value chain. Maturity models are often used as a tool to conceptualize and measure the maturity of an organization, a business, or a process by assessing the status of certain goals. The Maturity model aims to capture the starting point and enable the creation of Industry 4.0 development process.

The maturity model proposed in the manufacturing sector recently includes: energy management and utilities (Chair et al., 2013), eco-design manufacturing (Pigosso, 2013) and the lean production (Maasouman, 2015) towards Industry 4.0. Table 1 is a summary of the models, tools and methods used to assess the readiness or maturity of enterprises moving towards industry 4.0:

Table 1. The models are ready and mature businesses Industry 4.0

Model name	Organization / Source	Evaluation methods
Impact - Readiness Industry 4.0 (2015)	VDMA, RWTH Aachen, IW Consult	Assessment by 6 criteria including 18 points and 5 level of readiness; identifying the barriers to the progress and suggesting how to fix them.
Empowerment and Implementation of Strategy for Industry 4.0 (2016)	Lanza, et al	Evaluation of Industry 4.0 maturity by checking and applying model; analysing gaps and toolbox to overcome the barriers to the intended maturity; no details of measurement and proposal of the development process
Industry 4.0 / Assessment of Digital Operation (2016)	Price water - house Coopers	Online self-assessment by 6 criteria; focus on maturity technologies at 4 levels; application of consulting tools such as assessment fees, requirement of achieving 3 out of 6 criteria; no details of measurement and proposal of the development process .
Model Maturity of enterprises connected (2014)	Rockwell Automation	The maturity model is similar to the five-stage approach to Industry 4.0; The assessment model focuses on 4 criteria; no details of measurement and proposal of the development process
Reifegrad model (2015)	FH - Oberösterreich	Assessment of maturity by 3 criteria including 13 scales of maturity; maturity is assessed at 10 levels; no details of scales and proposal of the development process

Source: Schumacher et al. (2016)

In the above model, the Impact–Readiness Industry 4.0 is based on science with the transparent structure and results. The maturity model of Industry 4.0 has been expanded and focused more on organizational aspects by Schumacher, A. et al. (2016). The research transferred the abstract concepts of smart manufacturing into these criteria that are measurable in the environment of the actual production. Besides, the study also provides detailed information on model structure and methods of evaluation to ensure transparency of application for businesses.

The study by Schumacher et al. (2016) proposed a model that includes a total of 62 maturity criteria grouped into 9 factors from enterprises, created conditions for different analyses of maturity of Industry 4.0. Table 2 provides an overview of the factors and measurement criteria.

Table 2. Elements of the Maturity model towards Industry 4.0

Factor	Criteria for measuring maturity
Strategy	Roadmap for implementing Industry 4.0, Resources available for implementation; Applying business models, ...
Leadership	The readiness of leadership, capacity and methods of management, Coordination for the Industry 4.0.
Customers	Using customer data, Digitizing activities of sales/services, capacity of digital media of customers, ...
Products	Personalizing products, Digitizing products, Integrating products into other systems, ...
Operation	Decentralization process, Modelling and simulation, interdisciplinary training, interdisciplinary collaboration, ...
Cultural	Sharing knowledge, open innovation and collaboration between companies, value of IT in the company, ...
Human	IT capacity of the staffs, the openness of staffs with new technology, the activeness of staffs, …
Governance	Labor regulations for Industry 4.0, The conformity of industry standards, protection of intellectual right
Technology	Modern IT, using applications of mobile devices, using communication through machines, ...

Source: Schumacher et al. (2016)

Each criterion has five maturity levels in which the level 1 describes the lack of the concept of Industry 4.0 and the level 5 represents the state complete the required attributes. The goal of the model is to guide and train manufacturing enterprises, identify new opportunities to diversify the areas of activities towards 4.0 Industry.

The manufacturing enterprises which are level-one “mature” can identify business goals, recognize and understand operational issues that managers are constantly facing in production. However, at this level, managers and workers have ineffective quality of operation, high costs, few resources or inefficient use of resources, and provide no solutions/products to customers.

The manufacturing enterprises which are level-two “mature” implements the plan of "maturity" prototype test with small budget. Prototype includes devices and sensors, brings innovation in four areas: product innovation, process innovation, organizational innovation and market innovation. In particular, (1) Product innovation includes developing new products to significantly improve new products or services, to maintain or increase market share, expand product lines, increase competitiveness and competitive advantage for businesses. (2) Process innovation includes the application of new manufacturing processes or new distribution methods, refining existing processes or methods, purchasing new production equipment to reduce production time and costs, and create a competitive advantage for businesses. (3) Organizational innovation reviews the workplace organization, changes supply chains, restructures operations, reviews knowledge management, and engages in new alliances or partnerships to encourage a culture of innovation, better use of employee skills, improve business productivity and increase competitiveness. (4) Market innovation includes the application or significant change of product marketing methods, the use of new advertising media or techniques, changes in the way products are placed and promoted more effectively, brings products to new markets, lengthens the product life cycle, responds more quickly and comprehensively to customer needs.

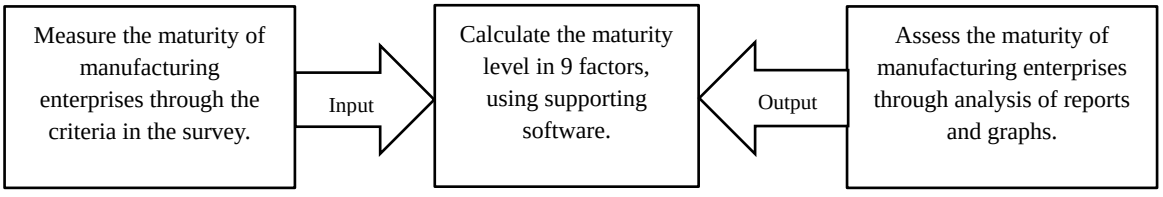
The manufacturing enterprises which are level-three “mature” knows how to measure and validate data to support management. Data is collected by sensors from devices which can identify ineffective factors or areas. The manufacturing enterprises can use this information to improve processes to reduce waste, save costs of waste treatment. These process improvements can be applied at the factory allowing additional data collection. Then these enterprises perform the comprehensive assessment of the situation and the new situation compared to previous activities. The main factors serving the production processes such as energy costs, manpower costs, the necessary production volume, productivity can be calculated and analysed by using data management software.

The manufacturing enterprises which are level-four “mature” can confirm information about the creative smart manufacture for the testing devices and sensors, continue to expand activities to supplemented chains and machines. The enterprises can process complex data with the goal of extending and implementing new methods step by step so that the processes are not disturbed. Increasing the number of data points, related machines and sensors is the increasing exchange of data so that they need to use cloud computing to increase storage capacity and calculate according to the new needs. The proliferation of data in servers located in the centre requires enterprises to have the security measures to safeguard information in order to ensure that all data can be accessed easily for employees who are given rights and prevent unauthorized system access.

The manufacturing enterprises which are level-five “mature” can link with external industry 4.0 to create a larger ecosystem. Manufacturing enterprises can disseminate data and access to information to partners in the supply chain and customers. It can help the production and business activities combine more effectively.

3.3 Process of Applying the Maturity Model to Assess Manufacturing Enterprises Towards Industry 4.0

The Maturity model develops the process into stages to guide the manufacturing enterprises building Industry 4.0 strategy in the vision of the business. The measurement and identification of criteria representing the maturity of manufacturing enterprises follow the three-step process as shown in Figure 1 below, integrated in an easily-handled software support tool.



Source: Schumacher et al. (2016)

Figure 1. Three-step process for assessing maturity towards Industry 4.0

Step 1: Measure the maturity of manufacturing enterprises. Assessment of the maturity of an enterprise through the criteria is performed by using the questionnaire criteria included a closed question for each factor. Each question requires answers according to the Likert scale ranging from 1 - "no difference" to 5 - "very different". For example, for the criterion of "Implementation of industrial 4.0 Roadmap" in "Strategy" factor and the question is proposed in Table 3 as below:

Table 3. Sample questions to measure a maturity criterion

Question	1	2	3	4	5
Does the enterprise use maps to plan Industry 4.0 activities?	❒	❒	❒	❒	❒

1 ... Not implemented, 5 ... Fully implemented Source: Schumacher et al. (2016)

It is important to stress that the questionnaire was answered correctly, and all the responder have an understanding of the basic concept of Industry 4.0. In addition, advisory members may increase the representativeness of the questions and the accuracy of the maturity model. That answers are then used as data input for software tools to calculate and assess the maturity level.

Step 2: Calculate the maturity level of manufacturing enterprises. It can be seen that not all factors have the same importance in assessing enterprise maturity towards Industry 4.0. For example, in technology, the criterion of "the existence of the modern information technology system" has different contributions to the growth of the Industry 4.0 compared to the criterion of "using benefits of mobile devices". Therefore, the expert method should be used to rank factors when developing the process of assessing the maturity of manufacturing enterprises.

The Maturity model tend to fail if they are too complex. After the survey was completed (i.e. survey integrated into a web page), the answer is processed in software, the result is calculated and summarized in a report of maturity automatically. The first pages of the report contain a summary of the maturity factors, describing the maturity level of the nine factors, followed by the decision and definition of maturity level and their characteristics. Finally, the detailed results of the nine measurement criteria including Products, Customers, Operation, Technology, Strategy, Leadership, Governance, Culture, and Human are aggregated as a base to serve for strategic decision making and to develop specific projects and programs.

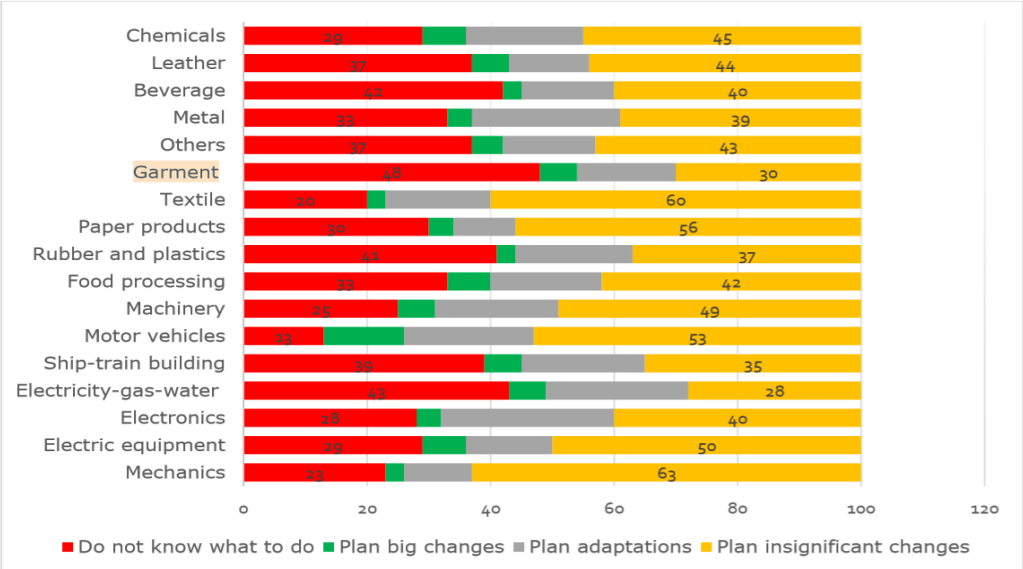
Step 3: Assess the maturity of manufacturing enterprises. The Maturity model towards Industry 4.0 divides manufacturing enterprises into five maturity levels in a three-stage process. Maturity level 1 is the Initial level in which the enterprises at this level do not have the vision towards industry 4.0; Maturity level 2 is the Management level in which the enterprises at this level have a sound strategy in Industry 4.0; Maturity Level 3 is the Identifying level, the enterprises at this level have customer segment, string value and key resources. Maturity level 4 is the Conversion level, the enterprises at this level have made strategic transformation into specific projects. Maturity level 5 is the Detail level, the enterprises at this level have transformed their business model towards industry 4.0.

The manufacturing enterprises have not accepted the philosophy of Industry 4.0 and it can progress through the maturity level by applying the target practice was identified in the processes of each level. Manufacturing enterprises can be "mature" and reach higher levels by gradually changing to achieve each of the 9 factors of the maturity model towards Industry 4.0.

4. Discussion: Is the Model Applicable in Vietnam?

The Industrial Revolution 4.0 will bring profound changes to society through significant digital changes in the manufacturing sector. To survive, the manufacturing enterprises must rely on training and people who master the technology, and incorporate new technology, robotics and automation. In order to penetrate into Industry 4.0, even before the competitors, manufacturing enterprises need to improve their competitiveness, work more effectively, perform digital transformation to renovate their business processes, provide products with high added value, reduce time and cost of production, maximize the skills of staff and extend the life cycle of the products.

However, according to Mr. Nguyen Quan, Chairman of the Vietnam Automation Association, up to 80% of Vietnamese manufacturing enterprises are neither interested in digital transformation nor prepare highly qualified human resources for this process. (ictnews, 2019). Vietnam just approached the 3rd revolution and has been forced to switch to Industrial Revolution 4.0. Currently, Vietnam's labor productivity is low compared to other countries in the region besides low technology level, old-generation machines. Only 30% of human resources are trained workers, which causes the lack of experts in high-tech fields. Therefore, manufacturing industries are under great pressure and must change to adapt to new trends.



Source: Calculation of UNDP, 2019

Figure 2. Responses of enterprises to Industry Revolution 4.0

Figure 2 show that the readiness rate toward industry revolutions is 48% in garments, 41% in rubber and plastics 29% in chemicals, but less than 30% in mechanical engineering, electronics, electrical equipment, machinery and multi-disciplinary enterprises. (UNDP, 2019).

The data shows that most companies at the time do not possess the required knowledge about Industry 4.0 to self-assess the maturity of their own company. In the Figure 2 the maturity level in nine dimensions is visualized. A radar chart is used to depict the overall result at-a-glance.

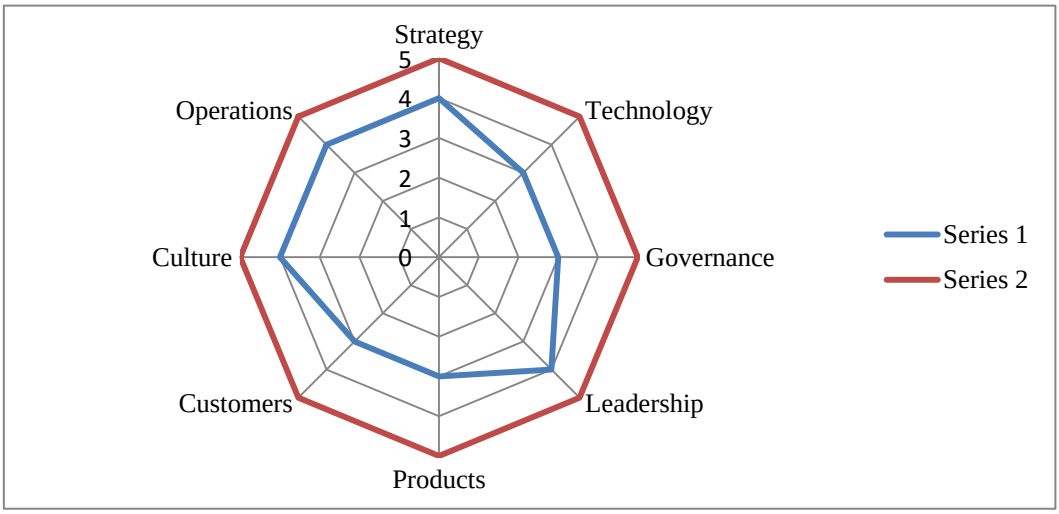


Figure 3. Visualizing Industry 4.0 maturity in nine dimensions.

The relatively lowest maturity level in the dimension ‘Technology’ (see Figure 3) is justifiable, as the manufactured textile company show low mature characteristics in regard to Industry 4.0. The typical Industry 4.0 readiness technologies are still in limited use at the company, it is about 13.2% (UNDP, 2019).

The company has planned for making significant adjustments in the context of Industry 4.0. However, the company does not know how to change the way of governance, interact with customers and how to change technology to be "more mature" in Industry 4.0. The qualitative data demonstrate the 9 dimensions as the following:

1. Strategy and Leadership

In the context of Industry 4.0, the commercialization of innovation is part of the process of researching and developing enterprises. Manufacturing enterprises need to expand their research and development departments beyond the enterprise's value-added network as the scale of available knowledge is rapidly expanding, making research and development field complex. The product life cycle becomes short. Therefore, manufacturing enterprises need to develop innovation strategies to test ideas and integrate them into the innovation process of enterprises.

In the medium term, the business model of rigid, inflexible production enterprises will react slower and can lag the post when competing in the new conditions. To prevent this, existing business models must move comprehensively towards digital transformation. In manufacturing businesses, identifying things that need to change, recognizing industry convergence and identifying breakthrough technology is difficult. Therefore, it is necessary first to transform core competencies into similar business models such as restructuring value chains, seeking appropriate cooperation and controlling operational goals. Thus, the new value-added model of manufacturing enterprises begins to be shaped.

However, followed by the share of “outsiders” (and “beginners”) having reached 83% (17%) in Strategy and Organization according to enterprise survey results of UNDP, 2019. To implement the new model, the production enterprises should have core competencies in solving new problems rather than the production of specific products. The changes in the operating environment requires leaders in the manufacturing enterprises have to change to become the actual leader of production technology. Automated manufacturing processes interacting with intelligent machines use support systems as part of a fundamental change in the industry 4.0 era. Therefore, leaders require certain information technology knowledge, coordination and management skills.

2. Customers and Products

Customers in Industry 4.0 will require more product consumption, so that digitizing sales and managing customer data to serve after-sales customers is necessary. Smart Products achieved the lowest readiness level, with 93% assessed at “outsider” level (3% at “beginner”) according to enterprise survey results of UNDP (2019). Therefore, the application of information technology helps manufacturing enterprises guarantee the product quality through the data records during the process of products. The monitoring device is remotely controlled to ensure the basic standard of the products. The products also need to be digitized, even raw materials need to be digitized for data management.

3. Operation

Manufacturing enterprises towards Industry 4.0 need to invest in modern production lines which can operate effectively without much human intervention with higher production standards. The question here is how the enterprises can mature in operation with the percentage of "adequate capacity" responses between 55.3% and 63%, varying by field of operation (Figure 3-10). Only 26.429.0% of enterprises found they needed support. The remaining 10.2-16.2% of respondents said they could not do anything or found no relevance (UNDP, 2019). As we know, the modern production technologies do not completely replace people but lead people to higher challenges in new roles requiring new skills, which are not only focused on production. It must also focus on research and development of hi-tech products, services and warranties.

4. Culture and Human

Similar to the current information technology system, the smart production system is vulnerable to attacks by hackers, system failures and other risks because these risks increase the probability of appearing in the 4.0 era. The most important methods to protect your system from the risks are training information technology to the staff and workers and investing in modern security software.

The continuity, flexibility and speed of staff training can be the key to the success of the company in the future. Manufacturing enterprises need to focus on continuing education for employees and workers to ensure professional level. Increasing the proportion of high technology human resources in the enterprises is easy to implement and cost savings and can take immediately to begin the process of transition to Industry 4.0. Manufacturing enterprises need to carry out the method of hand-held work, the people with good skills and experience will be the ones who directly train young employees and workers with limited skills.

5. Governance

The management in manufacturing enterprises towards Industry 4.0 needs to apply to communication activities between people but also additional regulations that focus on interaction between humans and machines

supplemented by sensors, chips and mobile devices. The low readiness score in this pillar and the relatively high percentage (71%) of "outsider" enterprises was due to the impact of 58% of enterprises failing to control equipment and 70% of firms' facilities not being upgradeable to connect equipment (UNDP, 2019). That the reason why the management in manufacturing enterprises towards Industry 4.0 needs to be changed due to the change in production model, labor regulations.

6. Technology

Shorter investment cycles and meet the demand for flexible manufacturing platform have increased the demands for product life-cycle management of integrated value added. The investment planning should ensure safety and higher quality to take advantage of opportunities and benefit from Industry 4.0. The financial plan should integrate with the profit and loss account, the balance sheet and cash flow statement as the sub-plan in the sales plan, human resource plan and investment plan. Implementing these measures helps manufacturing enterprises increase plan quality and reduce planning costs. Besides, production processes need to be developed from the technology depth to the appropriate costs to help expand production quickly with diverse materials.

5. Conclusion

In order for Vietnamese manufacturing enterprises to mature towards Industry 4.0, the innovation and digital transformation in manufacturing enterprises is not enough. It requires digital transformation and transformation in all management agencies instead. The "maturity" progress of the manufacturing enterprises Vietnam is in need of support from the government in terms of legislation, administrative procedures, legal policies of the State (tax policy, customs, and incentives for businesses or newly promulgated technical standards). The government management must also be changed to suit the "maturity" of enterprises by implementing government projects well as electronic government, electronic tax refund and promote the implementation of automatic data management model.

Under the impact of Industry 4.0, the connection between the Local Government with the related parties should also be done in the more efficient way, so that it should enhance digital services, promote interaction and calculation transparency in the activities of the authorities at all levels. The Government accelerates the approval process and makes faster decision will contribute to reduce administration cost for businesses in general and in particular manufacturing enterprises.

References

Baum, C., & Wee, D. (2015). *Manufacturing's Next Act*. McKinsey & Company.

Duy Vũ. (2019). "80% doanh nghiệp sản xuất tại Việt Nam chưa chuẩn bị nguồn lực cho chuyển đổi số". *ICTnews.* Retrieved October 18, 2019, from https://ictnews.vn/cntt/80-doanh-nghiep-san-xuat-tai-viet-nam-chua-chuan-bi-nguon-luc-cho-chuyen-doi-so-191138.ict

Erol, S., Schumacher, A., & Sihn, W. (2016). *Strategic guidance towards Industry 4.0 – a three-stage process model.* Proc. of Interna-tional Conference on Competitive Manufacturing 2016 (COMA16), Stellenbosch, South Africa.

Ganzarain et al. (2016). Three stage maturity model in SME's toward industry 4.0. *Journal of Industrial Engineering and Management (JIEM), 9*(5), 1119-1128.

Hermann, C. et al. (2014). Sustainability in Manufacturing and Factories of the Future. *International Journal of precision engineering and manufacturing-green technology, 1,* 283-292. https:/doi.org/10.1007/s40684-014-0034-z

Kagermann, H. (2015). Change Through Digitazation-Value creation in the Age of the Industry 4.0. In H. Albach, H. Meffert, A. Pinkwart, & R. Reichwald (Eds.), *Management of Permanent Change* (pp. 23-45). New York: Springer.

Kohlegger, M. et al. (2009). *Understanding Maturity Models Results of a structured Content Analysis.* IKNOW '09 and I-SEMANTICS '09, Graz, Austria.

Maasouman, M. A., & Demirli, K. (2015). Assessment of Lean Maturity Level in Manufacturing Cells. *IFAC-PapersOnLine, 48*(3), 1876-1881.

Ngai, E. W. et al. (2013). Energy and utility management maturity model for sustainable manufacturing process. *International Journal of Production Economics, 146*(2), 453-464.

Pigosso, D. C. A. et al. (2013). Ecodesign maturi-ty model: a management framework to support ecodesign implementation into manufacturing companies. *Journal of Cleaner Production, 59,* 160-173.

Rzigmann, M. et al. (2015). *Industry 4.0: the Future of Productivity and Growth in Manufacturing Industries*. Boston Consulting Group, Boston, MA.

Sirkin, H. L. et al. (2015b). *Why Advanced Manufacturing Will Boost Productivity*. Boston Consulting Group, Boston, MA.

Schumacher, A. et al. (2016). A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. Science Direct. *Procedia CIRP, 52,* 161-166

UNDP. (2019). *Industry 4.0 Readiness of industry enterprises in Vietnam.* Report in Hanoi February, 2019.