The Development of the Maturity Model to evaluate the Smart SMEs 4.0 Readiness

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Abstract

The first industrial 4.0 revolution was an announcement by Germany in 2013. That the advanced technology has applied in the industrial sectors such as the Internet of thing, Cyber-Physical System, Big Data and Cloud Computing. Especially in the field of Small and Medium Enterprise (SMEs) size, which is the mainstay of the economic development. However, SMEs are still lacking the knowledge and understanding to adopt the technology properly into the smart SMEs. In this research was defined the maturity model to assess the Smart SMEs readiness. First, the paper was reviewed and discussed the exit of assessment and maturity model. Then defined the importance of the dimension of the concept of Industry 4.0. The survey based on a case study was validated by the model. Overall the paper was present the 5 Dimension and 43 Sub-Dimension. The main important dimension is Manufacturing and Operations, People Capability, Technology Driven Process, Digital Support and the last important is Business and Organization Strategy. After that, the Maturity Model of Dimension in the Industry 4.0 transformation was tested by the real company aspects into the measuring. The result shows the Model was clear, easy to understands and can improve the organization by individual case.

Keywords
Industry 4.0, Smart SMEs, Maturity Model, Evaluation, Readiness

1. Introduction

In the 21st Century, technology has applied in many industrial sectors. That can adopt technology to increase operational efficiency and create value in their business. Technology was used in the industry to increase opportunities and productivity as well as reducing costs, reduce resources and costs. As a result, today's technology is progressing and contributing to more efficient use. Technology is the key component to applying and helps to improve the production. That from the past of industrial revolution, the first invention introduced mechanical engineering to replace human labor. Watt's steam engine was used in the fabrication of the Textile Industry which are the main industry and expanded to other industries. The second industrial revolution are become the use of conveyor belts for mass production systems and economies of scale. The third industrial as known as industrial era. It is the electronic and computer system, IT system and automation. (Ahmad et al .2017). In the next future, the world is about to enter the industrial era of the fourth industry revolution which is the introduction of Automation technology to work with the Internet to integrate work with robots or Cyber to Cyber or Cyber-Physical System. (A.C. Pereira 2017)

Especially, in the Small and medium-sized enterprises (SMEs), are the fundamentals of production and there are the main drivers of the country's growth and development. Therefore, SMEs should be developed in terms of technology to optimize their operations with the integration and application in the concept of the fourth industry. It is an important development to drive SMEs to enter into the era of innovation and technology as known as Smart SMEs, which is to use technology to integrate from upstream to downstream, such as raw material supply, production, delivery, the data collection, inventory management, to respond demand and reach customers quickly, and the operation must be linked to all component for competitive in the market sustainable. (Erik et al. 2017) (Gregory Clark 2013).

However, the importance of using technology to increase efficiency in the organization is the main problems. First, there is a lack of knowledge and understanding in the term the development and improvement of technology in the business. Second, the SMEs don't know the source that they can find the technology. The last, they don't awareness to applied advanced technology in the production and can't evaluation their business to find the gap of the technology to adapt in their organization. In the research will develop the maturity model that affect factors in Small and Medium Enterprises (SMEs) for implements the Smart SMEs because SMEs are the main driving force of the economy. (Arash et al, 2012) SMEs will improve their business by adapted technology to sustainability.

The research is structured as follows. In section 2 was discuss the background and the assessment of Industry 4.0 that is the main domain and research contribution. Next, in section 3 was the conclusion the concept and developed the maturity industry 4.0 model for assessing the Smart SMEs reediness. In section 4 was tested the model by the real company and shown the result. Finally, section 5 concluded the main dimension, limitation of the research and the suggestion for future research.

2. The background and the assessment of Industry 4.0

In this sector is a review of the literature about the concept of industry 4.0 and the readiness model. The first part is related to research in the field of the exit of the assessment of Industry 4.0 and the readiness model. Next, the research will define the importance of the dimension in the advanced technology concept by the review of the important key concept that can toward traditional SMEs to Smart SMEs.

2.1. The Exit of the Assessment of Industry 4.0

The research is presented in the field of an evaluation model for the assess industrial readiness 4.0. The Maturity Model is often used as a tool to assess the organization by the conceptual framework. The maturity is preferring a “Ready” that the implementation of the process before the entering a new process. (J. A. et al. 1989). It contains 4 level in the structure of the model. There are the Level 1 is the Beginner. Level 2 is the Intermediate. Level 3 is the Expert and Level 4 is the Expert System level.

From the table 1 The exit of the assessment and maturity model of Industry 4.0 was shown the paper was publication in the year 2014-2018 that developed the model to assess the state of the organization to implement the Industry 4.0 content. The first paper is from Patti et al in 2015 were developed the framework for developing business intelligence maturity model in 5 Dimension. Next paper, Andreas et al. was developed a maturity model for assessing Industry 4.0 readiness in 2016. The framework has 9 Dimensions and 62 items for 5 level of the maturity model.in the same year, Christian et al. have to integration Maturity Model in term of the Industry 4.0. It 4 consists of 5 stages of the main concept allows a company to assess itself such as Automation in the state 1 has no automation technology in their technology and the last is the stage 5 the organization has the advance of the Automation technology. In 2017, Dr. Zsolt et al. reviewed the Maturity Model in a content of Industry 4.0. They have to develop the assessment by showed 11 Dimension of the personalized and non-comparative Industry 4.0. Ebru et al. was developed the model of Industry 4.0, it includes the 5 level of Capability Dimensions of Industry and the last model is a framework to evaluate and guide Industries 4.0 from capability maturity model from Ahmad et al. in 2018.

Table 1. The Exit of the Assessment and Maturity Model of Industry 4.0

AUTHOR(S)	AREA/ ISSUE	APPROACH
ONUR AGCA ET AL (2015)	An Industry 4 readiness assessment tool.	The readiness assessment for Industry 4.0 have 4 level for 5 Dimensions and 37 Sub-Dimension
PATTI ET AL (2015)	Acframework for developing business intelligence maturity model	Critical success factors for BI implementation in 5 Dimension
IMPULS (2015)	Industrie 4.0 Reediness	The Assessment has 6 dimensions and 18 Sub-Dimension to measurement readiness in 5 levels
ANDREAS ET AL. (2016)	A maturity model for assessing Industry 4.0 readiness.	The assessment for Industry 4.0 has 9 Dimensions 62 Sub-Dimension for 5 level of the maturity model.
CHRISTIAN ET AL. (2016)	Integration Maturity Model Industry 4.0	Integration Maturity Model Industry 4.0 consists of 5 stages of allows a company to assess itself
DR. ZSOLT ET AL. (2017)	Industry 4.0 Readiness	The assessment showed 11 Dimension of the personalized and non-comparative Industry 4.0
EBRU ET AL. (2017)	Assessment Model for Industry 4.0	The model of Industry 4.0, it includes the 5 level of Capability Dimensions of Industry
AHMAD ET AL. (2018)	Industrie 4.0 roadmap	A framework to evaluate and guide Industrie 4.0 from capability maturity model

The popular model was public by IMPULS in 2015, the Industry 4.0. The Industrie 4.0 Reediness been introduced to identifying the key factors for preparing for entry into the 4.0 era. The Assessment has 6 dimensions and 18 Sub-Dimension to measurement readiness in the 5 levels of maturity model. For the example of the dimension is the Autonomous Processes, Cloud System, Data Analytics, Data-driven Service, Employee skill sets, ICT add-on Functionalities, Infrastructure and Equipment, IT System, IT Security etc. In the same year the one of the popular of the reediness from Onur Agca et al and The University of Warwick, they show the readiness assessment for Industry 4.0 have the model contains 4 level for 5 Dimensions and 37 Sub-Dimension. the example of the components is automation, automation, workflow, automation, business model, cloud, data-driven service, and data-driven decision making.

In the next section have to review about the importance of the concept of industry 4.0 and the key component to improving and develop the model to assess the Smart SMEs readiness.

2.2. The Key Concept transformation toward Industry 4.0

This part is the literature review of the concept of industry 4.0 and the key components that can transformation toward Industry 4.0. The first paper is the research has highlighted the importance of the industry 4.0 research topic that for

the organization need to transformation toward Industry 4.0. The most important topic there is the collaborative network, the virtualization process chain, Mass customization, the Simulation and Modeling of products and process and etc. T. Stock and G. Seliger in 2016 was shown the Business Model, Value Creation Network, Equipment, Human, Organization, Process and Product is the opportunity factor for sustainable manufacturing in Industry 4.0. In 2017, A.C. Pereira and F. Romero present the Smart Factory, Smart Product, Business Models, and Customer is the main concept to implications of the Industry 4.0. Then, Feng et al was shown the vision for smart and optimal manufacturing in the process industry. There are Automation, Cyber physical System and the Intelligent System. Next, Ray et al. was concluding the future perspective of the industry 4.0 in the framework is about the Smart Design, Smart machine, Smart monitoring, Smart Control and Smart scheduling. At the same time Uwe et al. talking about the characteristics of the Industry 4.o there are Flexibility, digitalization, self-optimization, Internet of thing, big data, real-time data and etc. Then, Yang Lu was Presents an overview of the content and scope of Industry 4.0 and Erik Hofmann and Marco Rusch present the conceptual of Industry 4. research in the context of logistics management in the same year. The last research is Hajar et al. in 2018 was developed the Theoretical operationalization framework of Industry 4.0 (Malte et al. 2014) (see table 2)

Table 2. The Key Concept transformation toward Industry 4.0

AUTHOR(S)	AREA/ ISSUE	APPROACH
MALTE ET AL (2014)	An Industry 4.0 Perspective	The Industry 4.0 research topic that for the organization need to transformation toward Industry 4.0
T. STOCK AND G. SELIGER (2016)	The state-of-the-art review of Industry 4.0	The opportunity Factor for sustainable manufacturing in Industry 4.0
A.C. PEREIRA AND F. ROMERO (2017)	The meanings and the implications of the Industry 4.0	Industry 4.0 concept and contributes.
FENG ET AL. (2017)	Fundamental Theories for Smart Manufacturing	Key Technologies for Smart and Optimal Manufacturing
RAY ET AL. (2017)	Intelligent Manufacturing in the Context of Industry 4.0	A review key technology of Industry 4.0
UWE ET AL. (2017)	Industrie 4.0 and Lean Production Systems	Shows the analyzed and structured Industrie 4.0 elements for the lean sustainable
YANG LU (2017)	Industry 4.0 and presents an overview of the content	Presents an overview of the content and scope of Industry 4.0
ERIK HOFMANN AND MARCO RUSCH (2017)	The opportunities of Industry 4.0	The conceptual of Industry 4. research in the context of logistics management
HAJAR ET AL. (2018)	A critical of Industry 4.0 in manufacturing	Theoretical operationalization framework of Industry 4.0

Industry 4.0 has the concept of technology as important as Digital, Network Communication, Computer, and Automation. It contains the Complex Technology there are Cyber-Physical System, Internet of Things, Internet of Service, Robotic, Big Data, Cloud Manufacturing, and Argument Reality. Technology to push to the Industry 4.0 must have the components of the Device, Machine, Production modules and Products that can be connected and transmitted

to each other, Business Model and Customers. First, Smart Factory is an enterprise capable of flexible working. Their systems can be linked in all parts of the work with the reliable data transmission. Smart Products is the value chain of products that are passed on at every stage of production that can monitor workflow and data time to markets. Business Model must have cooperation and access environment by self-organization. Last, Customer, that business will reach the customers quickly, efficient and most demanding.

When the organization ness to transformation toward Smart Manufacturing, the key element of the organization's entry into smart technology and applications must be the Smart Machine is a machine or a tool to operate a business with the high potential to have the ability to order production. It can improve and report the results of production and the period of self-optimization. Next, Smart Products is a product designed to be able to be tracking the data of production, and raw material. Then, the Digital Threads are all parts of the data that are linked to each other in the organization and production. When the Analytics is an analysis of information from a variety of sources, such as machines, systems, and human operations that can analyze the results of the investigation and solve the problem. Finally, Cyber Security is a very important part of Smart Manufacturing. It is a combination of technology and data that can collaboration which is to protect all data. Include the protection of information to the public or competing organizations.

In the next section was to develop the Industry 4.0 Maturity model to evaluate the Smart SMEs readiness because the problem with Industry 4.0 is that most organizations are not aware of the use of these technologies. The understanding and knowledge of the concepts and goals of the application. (Malte Brettel. 2014)

3. Industry 4.0 Maturity Model

In the review about the exit of the assessment of Industry 4.0 and the concept transformation toward Industry 4.0. This research was defined as the maturity model overall the 5 Dimension and 43 Sub-Dimension. The main important dimension is Manufacturing and Operations, People Capability, Technology Driven Process, Digital Support and the last important is Business and Organization Strategy. (see table 3)

Table 3. The Dimension and Sub-dimension of the Industry 4.0 Maturity Model

DIMENSION	SUB-DIMENSION
BUSINESS AND ORGANIZATION STRATEGY	Business Model, Company culture, Collaboration Network, Environment, Finance and Investments, Infrastructure and Equipment, Information Sharing, Innovation management, Partnership, Road-Map, Strategy, Supply chain integration, Supply chain visibility, and Supply chain flexibility...
MANUFACTURING AND OPERATIONS	Automation, Autonomous Processes (M2M), Flexible Manufacturing System, Human-machine Integration, Lead time, Product Customization, Risk...
TECHNOLOGY DRIVEN PROCESS	Cloud System, CPS, Data Connected (Information Flow, Data collection, Data usage, Distribution Control, IT System (IoT, IoS), Product and Process integration system, Real-time data analytic and management, Self-optimization and Tracking (Product and Process) ...
DIGITAL SUPPORT	Big Data Analytics, Data-driven service, Data-driven Decision Making, Digital Product, Digital Modeling (Transformation), ICT add-on Functionalities, IT Security, Integration marketing channels...
PEOPLE CAPABILITY	Employee skill sets, Leadership and Skill acquisition...

The evaluation is contained about the 3 part of questions; first part is the rating of the priority to the main dimension (Ordinal Scale) (see table 4). The second pert is the rating of the priority to each sub-dimension (Ordinal Scale).

Table 4. The Example of the question in part 3.

Dimension	Put the important Number
Business and Organization Strategy	*3*
Manufacturing and Operations	*1*
Technology Driven Process	*2*

* Number 1 is the most important…, respectively

The last part put the score of each sub-dimension by Linkert scale. (see table 5). The level 0 is shown the dimension is not relevant in their organization. The level 1, the key dimension is relevant but not implemented in the organization. The level 2, the dimension was implemented in some area of the organization. The level 3, the dimension was implemented in the most area of the organization and Level 4 was full implementation.

Table 5. The Example of the question in part 3.

Dimension	0	1	2	3	4
	Manufacturing and Operations				
Automation	Irrelevant	○	○	○	○
Machine Integration	Irrelevant	○	○	○	○
Cloud system	Irrelevant	○	○	○	○

* Number 0 is irrelevant, 1 not implement and 4 fully implement…, respectively

In the last step is the Normalization of the most important dimension score. The formula of the total weight is the rating score of the n dimension divide by the sum of all the i dimension by the equation 1.

$$\textbf{weight score} = \frac{1/r_n}{\sum 1/r_i} \qquad (1)$$

where r = rating at the n
n = dimension n

i = dimension 1,2,3….

In the next section is the tested the model by the real company. There are shown the result to confirm that the Model was clear, easy to understands and can improve the organization by individual case.

4. Case-Study SMEs

In this research have to survey based on a case study from a plastic company in Thailand. The organization is a small enterprise size, there are 20 workers in, with the total income of 20 million baths a year. The researcher was sending the questionnaire to the manager by e-mail. In finally, the Score of the survey shows the most important of dimension is Manufacturing and Operations, People capability, Technology driven process, Digital support and the last important is Business and organization strategy, respectively. (see Table 6)

Table 6: The final weighting Score of Main Dimension

DIMENSION	WEIGHT
MANUFACTURING AND OPERATIONS	0.438
PEOPLE CAPABILITY	0.219
TECHNOLOGY DRIVEN PROCESS	0.146
DIGITAL SUPPORT	0.109
BUSINESS AND ORGANIZATION STRATEGY	0.088

The result from the sub-dimension showed in Figure 1. The result shows that the organization has some implemented of the in-risk operation, Automation, and Lead time in the most of area that is the level 3 is the expert level. The level 2 is the Intermediate level, the Autonomous process and Human-machine integration was some implementation. The Product customization and Flexible manufacturing system are not implemented in the organization. (see figure 1)

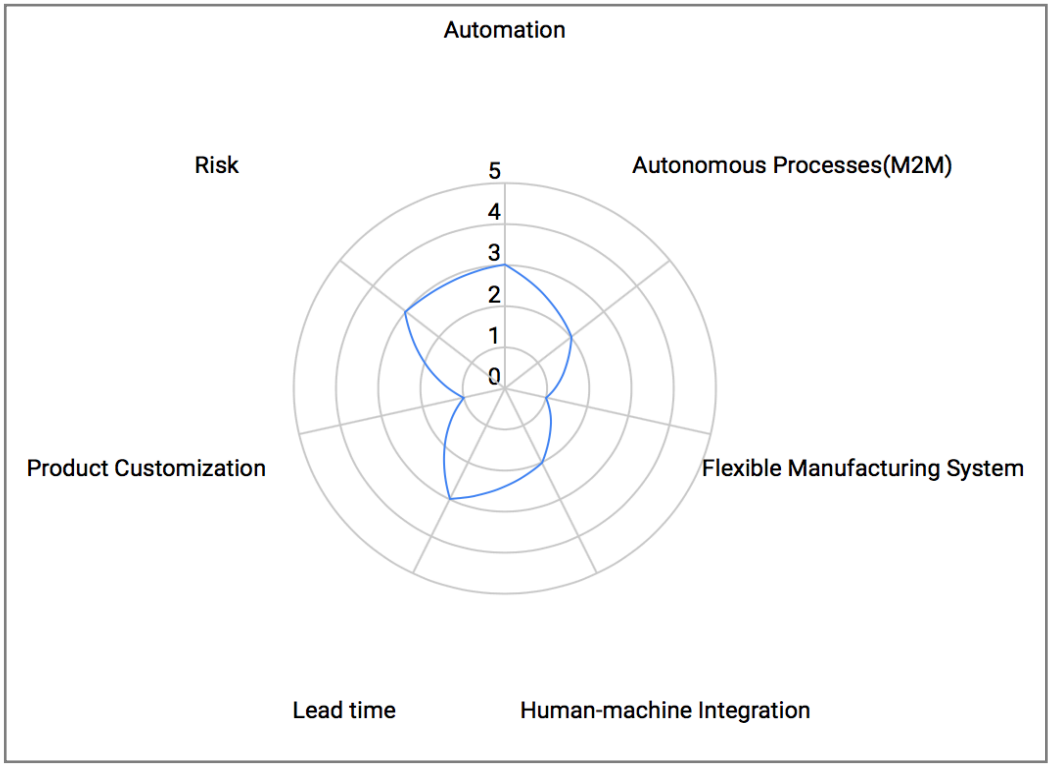

Figure 1. The Example Result of the Business and Organization Strategy

In the Sub-Dimension from the total weighing score found the most important there are Flexible manufacturing System, Employee skill sets, Product Customization, Leadership, Automation, Autonomous processes, Skill acquisition, Collaboration network, Data Connected (Information flow), Human-machine Integration, Lead time, Finance and investment, Risk, IT Security, Integration marketing channels, Infrastructure and equipment, Real-time data management, Environment, Information sharing, Data-driven services, Partnership, Digital modeling (Transformation), Company culture, Product and process integration system, Cloud system, Strategy, Real-time data analytic and management, Supply chain visibility, Supply chain flexibility, Self-optimization, Distribution control, Innovation management, Supply chain integration, Tracking, Data collection, Digital product, Big data Analytics, ICT add-on functionalities and Data-driven Decision making, respectively

In the next section is the last section. It concluded the main dimension, limitation of the research and the suggestion for future research.

5. Conclusion

In this research is about the developed the maturity model to evaluate the SMEs who want to enhance Smart SMEs. Although the traditional SMEs have the problem with Industry 4.0 because the most organizations are not aware of the use of these technologies. The understanding and knowledge of the concepts and goals of the application. The model was developed from the relevant model and added the dimension that the important from the key concept in Industry 4.0. Then the final model was containing the 5 dimensions and 43 sub-dimensions.

Then the research was teste the model by using the case study and the result shown that the important od dimension there are Business and Organization strategy, Manufacturing and operations, Technology driven Process, Digital support, and People capability and the most important of the sub-dimensions are Flexible Manufacturing System, Employee skill sets, Product customization, Leadership, Automation, Autonomous processes, Skill acquisition, Collaboration network, respectively.

The limitation of this research is a many the dimension supported on the production manufacturing. It has a some of the dimension to support the other kinds of the industry. For the organization does not select the optimal dimension in their business because the result of the model shows only the status of the organization.

In the future research will added more of the dimension and sub-dimension to support the other kind of the industry sector and the result can show the optimal dimension and sub-dimension to implantation in each organization.

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