A TAXONOMY OF STRATEGIES FOR INDUSTRY 4.0 IMPLEMENTATION IN INDONESIA

Budhi Sholeh Wibowo
Departemen Teknik Mesin dan Industri
Universitas Gadjah Mada
Jl. Grafika 2 Yogyakarta
budhi.sholehwibowo@ugm.ac.id

Abstract

Industry 4.0 tidak hanya membawa peluang besar namun juga berpotensi membawa imbas negatif bagi perkembangan industri di Indonesia. Makalah ini bertujuan untuk membangun taksonomi strategi penerapan Industry 4.0 melalui pemetaan 33 sektor manufaktur di Indonesia. Penelitian dilakukan berdasarkan statistik kinerja sektor industri besar yang diukur berdasarkan tujuh variabel yaitu: jumlah perusahaan, input, output, nilai tambah, biaya tenaga kerja, dan perubahan modal. Menggunakan analisis klaster, didapatkan bahwa penerapan Industry 4.0 di Indonesia dapat dikelompokkan dalam 4 strategi, yaitu: automasi, kolaborasi, biasa, dan bisnis model baru. Taksonomi ini relevan bagi perencana kebijakan publik dan pelaku industri untuk menentukan strategi penerapan Industry 4.0 di Indonesia.

Keyword:*industry 4.0; analisis klaster; taksonomi; manajemen strategi; manufaktur.*

1. Introduction

Digital economic growth in Indonesia continues to show a positive trend. Along with the growth of internet and smartphone users, Indonesia has advanced to become the fastest and the largest growing digital economy in Southeast Asia. Based on reports from Google Temasek [1], the market value of the digital economy in Indonesia has reached IDR 391 trillion in 2018 or increased by 30% from last year. Google Temasek projected that, in 2025, the digital economy in Indonesia has potential to reach IDR.1,450 trillion or three folds from the current value, where online travel, e-commerce, and online transportation are estimated to be the prime sector in the future.

The world is currently experiencing massive changes. Manufacturing and mining companies which once dominated the economy ten years ago now has been replaced by digital companies such as Apple, Microsoft, and Alphabet. Innovation in information technology has allowed many new business models to emerge and disrupt the business order in ways that have never been imagined before. For example, Airbnb, the world’s largest accommodation provider, owns no real estate. Alibaba, the world's largest retail business, does not have a shop; and Go-Jek, the largest transportation service provider in Indonesia, does not even have a transportation fleet at all. These digital startups are growing very fast. They not only substitute the old business models but also significantly change the way human work and behave.

Based on the latest social and economic development trends, practitioners and academics argue that the world is currently facing a new wave of industrial revolution. This new era was marked by the advance of artificial intelligence, internet of things and cloud computing. These technologies allow a computer to automatically retrieve information, make decisions, and control physical objects from anywhere through the internet. This work system is known as the Cyber-Physical System (CPS). CPS combines virtual and physical dimensions to perform specific functions through digital networks. The existence of the CPS has revolutionized the way industry works which was once dominated by humans, now is more dominated by algorithms or artificial intelligence.

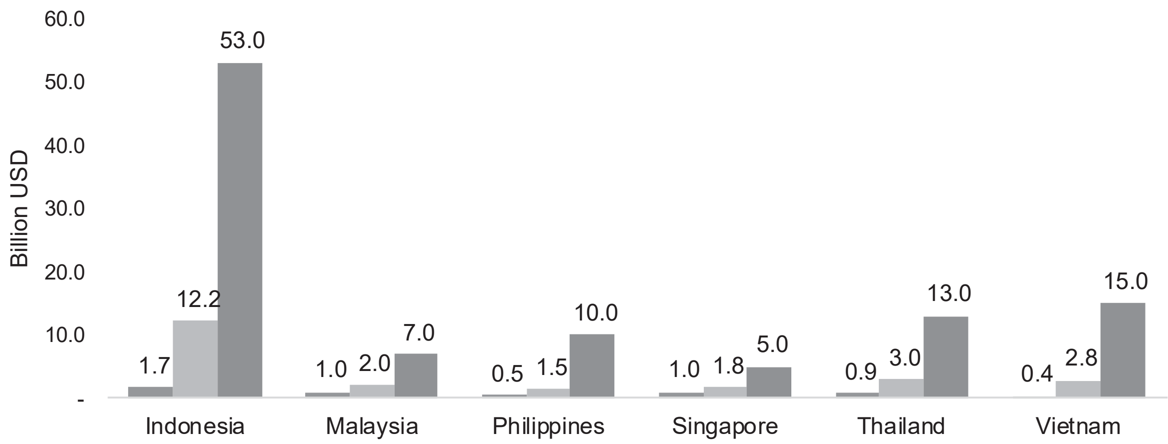

Figure 1. e-Commerce market share in Southeast Asia (adapted from [4]).

The term Industry 4.0 first emerged from the name of a government project in Germany to promote computerization, digitalization and automation in the manufacturing sector [2]. The term became famous when the Industry 4.0 working group, led by Siegfried Dais (Robert Bosch GmBH) and Henning Kagermann (German Academy of Science Engineering) presented their final report at the Hannover Fair in 2013, which contained a set of recommendations for the implementation of Industry 4.0 in Germany [3]. The term Industrial 4.0 itself originally refers to an intelligent network between machines in a production system with the help of information and communication technology [3]. However, the term of Industry 4.0 now has expanded. It does not only refer to machine connectivity and production systems but also refers to an integrated system between the physical and digital world which enables the development of a new and revolutionary business model [4].

With 255 million inhabitants, Indonesia is the fourth largest population in the world where more than 54% of its population is living in urban areas. Indonesia is also the largest economic power in ASEAN with annual economic growth reaching 6%. The manufacturing sector accounts for 20% of Indonesia's total GDP with a workforce of more than 25 million people. The implementation of Industry 4.0 in Indonesia is expected to boost national competitiveness and national productivity in various sector.

However, according to Schwab [4], the positive impact of the fourth industrial revolution was mostly on the demand side. Consumers will be increasingly spoiled by various conveniences of life with little costs ranging from access to education, ordering taxis, shopping for products, watching movies, to long-distance communication. Nevertheless, the biggest challenge of Industry 4.0 is more on the supply side, where the social gap is likely to intensify. In recent years, labor contribution to GDP in many developed countries has decreased significantly. Companies are more interested in substituting labor with capital [4]. If this trend continuous, it could result in massive unemployment in the future. Various jobs which involve manual and repetitive work, such as concierge, couriers, and shop keepers, would have a high risk to be replaced by robots and automation. Moreover, with the rapid growth of computing power and artificial intelligence, many more complex professions such as drivers, lawyers, doctors, and financial analysts will also be affected by automation, sooner or later [5].

Although the fourth industrial revolution may intensify unemployment, it also has the potential to bring new professions that have never been imagined before. Reflecting on previous industrial revolutions, the loss of jobs has always been followed by the emergence of new jobs in different forms. Many scholars believe that with appropriate training and reorganization, the workforce who previously were marginalized can return with a new role [4]. Moreover, along with the emergence of new business models and expanding access to global market, Industry 4.0 will also create new demand for goods and services. Hence, in the long run, it is also expected to create new jobs and increase the employment rate. The study from McKinsey [6] estimated that in 2030 there will be more jobs created than destroyed due to the impact of automation. For example, in India, McKinsey [6] projected that about 57% of current jobs will be destroyed in 20130. However, new job categories will also rise for about 212% which offset the number of the job lost.

Therefore, the role of the government is crucial to lead the revolution, especially in developing countries, such as Indonesia, which is dominated by a large number of low-skilled labors with low capital. The government should minimize the negative externalities from the implementation of Industry 4.0, while maximizing its benefits with regards to the conditions and situations in Indonesia. Yet, the biggest challenge to implement Industry 4.0 in Indonesia is to maintain labor welfare while minimizing social inequality. Many sectors in Indonesia such as food, textile, rubber, and tobacco industries are labor-intensive industries. These sectors absorb more than 50% of Indonesia's workforce. Besides, the majority of Indonesian workers also have lower skills and productivity compared to the neighboring countries. Therefore, a rash implementation of Industry 4.0 may lead to massive unemployment and a decline in social welfare.

This study aims to provide a taxonomy of strategies Industry 4.0 implementation in Indonesia. Taxonomy refers to a categorization of objects used to distinguish groups based on several dimensions or quality traits. A taxonomy of strategies is vital for public policy because it is more efficient for the government to offer technical and management supports to a group of sectors with similar traits instead of developing unique strategies for each manufacturing sector. The specific objectives of our study are two folds: (1) to develop different groups for manufacturing sectors in Indonesia; and (2) to examine effective strategies to implement Industry 4.0 in each group. This study is based on the statistics of large manufacturers in Indonesia. Our hypothesis is that the manufacturing sectors can be clustered into a number of strategic groups based on their quality treats. The grouping mechanism serves as the basis to develop effective strategies to adopt Industry 4.0.

The remainder of this paper is structured as follows. Section 2 describes the data and methods used in this study. Section 3 is dedicated to the discussion on the research findings. Lastly, the conclusions of this study is provided in Section 4.

2. Data and Methods

This study is based on the performance of 33 manufacturing sectors in Indonesia as reported by Statistics Indonesia in 2016 [7]. The statistics evaluate the performance of 26,332 large manufacturers in Indonesia which is aggregated into 33 sectors, from food, beverages, to metal and automotive. Seven variables are considered in the study, namely: number of enterprises, industry input, industry output, value added, labor cost, and capital change. Industry input is all costs incurred in the production process which consist of raw material, fuel, electricity and gas, building rent, machinery and tools, and services that are not related to the production process. Industry output is the output value generated from the industrial activity process which consists of: goods produced, electric power sold, industrial services received from other parties, margin from intermediate goods, and other revenues from non-industrial services. Value added is the difference between the input and the output. A cluster analysis is employed to classify the manufacturing sectors based on their performance and characteristics. The classification provides a taxonomy which will be the basis to formulate strategies to implement Industry 4.0 in Indonesia.

Cluster analysis is a multivariate technique which aims to classify objects based on their characteristics so that each object that has similar properties will be grouped within the same cluster. Reasonably, good clusters are clusters that have high homogeneity between members within the same cluster and high heterogeneity between different clusters. This method starts grouping with two or more objects that have the closest similarity. Then the process is forwarded to another object that has a second closeness and so on so the cluster will form a kind of "tree," where there is a clear hierarchy between objects, from the most similar to at least similar. Logically all objects will eventually form a cluster. The similarity in cluster analysis can be measured based on a Euclidian distance. Therefore, if there are p parameter, the distance between two objects can be measured by using the following equation:

$$d_{ij} = \sqrt{\sum_{k=1}^{p} \left(x_{ik} - y_{jk}\right)^2} \qquad 1)$$

where d_{ij} is the distance between object i and object j, *and* x_{ik} is the value of dimension k for object i while y_{jk} is the value of dimension k for object j.

As the variables have different ranges, it is crucial to standardize the values so that the range for each variable are equal. The objective is to avoid weight differences between the variable due to the range variances. The standardization process is done based on the following equation:

$$z_{ik} = \frac{x_{ik} - \mu_{xk}}{\sigma_{xk}} \qquad 2)$$

where z_{ik} is the standardized value of parameter k for object i, x_{ik} is the value of parameter k for object i, μ_{xk} is the mean, and σ_{xk} is the standard deviation of parameter k.

The cluster is determined based on a function which aims to minimize the distance between objects in the same group and maximize the total distance between objects in different groups. This study employs a hierarchical clustering method with the aid of Orange software version 3.2.

The optimal number of clusters is determined based on the Silhouette Score. Silhouette Score is a degree which measures how similar an object is to its cluster. The score ranges from -1 to +1, where a high value indicates that the objects have a high similarity to its cluster and low similarity to the other clusters, and vice versa. Let us define $a(i)$ as the mean distance of object (i) to all other objects in the same clusters. Let us also define $b(i)$ as the mean distance of the object (i) as to all other objects in the neighboring clusters. Therefore, the silhouette score $s(i)$ can be defined as the following:

$$s(i) = \frac{b(i) - a(i)}{max\{a(i), b(i)\}} \tag{3}$$

The mean of $s\ (i)$ is a measure of how cohesive all the objects in the cluster. Thus, the mean over all objects measures how properly the data have been clustered.

3. Results and Discussion

To determine the strategy for implementing Industry 4.0, the manufacturing industry in Indonesia is mapped into 5 clusters based on seven variables i.e., number of enterprises, input, output, value added, labor cost, and capital change. The profile of the cluster is shown in Table 1.

Table 1. Cluster Average Performance

Cluster ID	Average Number of Companies	Average Total Labors	Average Input per labor (IDR)	Average Output per labor (IDR)	Average Value Added per labor (IDR)	Average Labor Cost (IDR)	Average Capital Change (IDR)
C1	606	136,682	**1,170**	**2,468**	**1,206**	**70**	243
C2	**2,140**	**446,447**	*273*	*476*	*219*	*25*	*66*
C3	*487*	*79,096*	550	841	469	48	66
C4	1,166	230,292	328	631	266	38	**382**

3.1 Cluster 1: Automation

The industries in the first cluster are characterized by high productivity, high labor cost, and low employment. This cluster includes automotive, chemical, and basic metal industry. They represent the top manufacturing sectors in Indonesia which generates the highest value-added and business surplus. The workers employed by these companies are highly paid which also indicates that they are high-skilled workers. Therefore, automation will have a low impact on the workers in this cluster. By having a substantial capital and high-skilled workforce, companies in the first cluster are potentials to adopt industry 4.0 and maximizing its benefits with minimum risk. They may adopt advanced technologies such as automation and robotics to support higher efficiency. Automation mechanizes unexciting, time-consuming, and repeatable tasks for high-skilled workers, allowing them to spend their time performing a more valuable task. By adopting Industry 4.0, these companies would achieve higher profitability with minimum risk.

3.2 Cluster 2: Collaboration

The second cluster represents companies that have low value-added but high employment. They include food, tobacco, leather, wood, textile, and apparel industry. Nearly 50% of Indonesian labors depend on these sectors to live and work. Nevertheless, this cluster is dominated by workers with low skills. So that direct implementation of Industry 4.0 such as automation to this cluster would lead to massive labor unemployment. Therefore, the focus in this cluster is not in the operational efficiency but more in the market expansion through the use of internet and digital marketing.

However, due to the low skills of labors and limited capital, the companies in this cluster also cannot initiate digital marketing by themselves. Therefore, they need to collaborate with other parties who have digital skills and good access to capital in order to increase their revenues. Several forms of collaboration between these industry players and the owners of digital platforms have been carried out in Indonesia as performed by Bukalapak, Tokopedia, and Go-Jek. Collaboration like this can encourage positive social impacts in the era of Industry 4.0. The government can help accelerate this collaboration by establishing a business center for innovation and incubation in several regions with an orientation to social impact. The center for innovation and business incubation can also be used as a training center to improve digital skills for old workers to be able to access new work roles in the Industry 4.0 era.

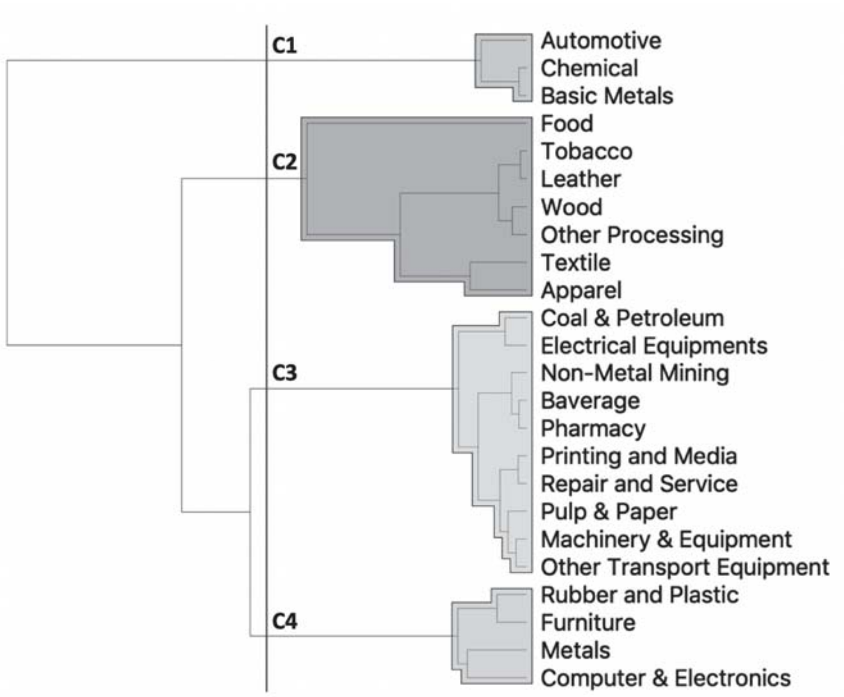

Figure 2. Dendrogram of the Clusters.

3.3 Cluster 3: Business As Usual

This cluster represents a small portion in Indonesian manufacturing landscapes which have average value added but low employment. Therefore the implementation of Industry 4.0

may not have a significant impact on national productivity. These sectors may continue their business as usual.

3.4 Cluster 4: Innovative Business Models

The third cluster is industries that have medium employment, low value-added, yet receive the highest surge in the capital. This cluster represents furniture, computer, electronics, and metal industry. The surge in capital indicates a confident outlook for the industry to grow. Therefore, the focus for this industry is to use the capital to investigate new business models who can bring higher value added to the industry.

4. Conclusions

This study proposed a taxonomy of strategy to implement Industry 4.0 based on statistics of 33 manufacturing sectors in Indonesia. The clusters are developed based on seven variables namely: number of enterprises, industry input, industry output, value added, labor cost, and capital change. The results suggests that the manufacturing sectors can be grouped into four clusters. Cluster 1 represents a group of sectors that have high value-added and high workforce skills. Cluster 2 embodies a group of sectors with high employment but low value-added. Cluster 3 denotes a group of enterprises with low employment and low in the number of companies. Lastly, Cluster 4 represents growing manufacturers that have a surge in the capital. The clustering result also implies that each cluster has a unique problem which requires a unique solution. Based on the clustering result, a taxonomy of strategies to implement industry 4.0 in manufacturing sectors is developed. The strategies are unique, ranging from automation to collaboration, depending on the cluster characteristics.

The Government of Indonesia may also use this taxonomy to build priority sectors for the adoption of Industry 4.0. For example, a manufacturer which is identified with high value-added and high labor skills as in Cluster 1 may be enforced to adopt automation strategy for increasing operational efficiency. While manufacturers with low value-added but high employment as in Cluster 2 may be imposed on partnership and collaboration to expand market penetration. Manufacturers in Cluster 3 may continue their business as usual and the manufacturers in Cluster 4 can focus more on research and development to build new business model.

There are also some limitation in this study. Firstly, the dataset is based on the Statistics in 2016 which may not capture the historical trend of manufacturing sectors in Indonesia. Secondly, the clusters are developed based on the statistics in aggregate level. Although being helpful for simplification, aggregate statistics may oversight the details and dynamics in enterprises level. Future studies may overcome this limitation by providing empirical case studies in enterprises level to validate the appropriateness of the proposed strategy from this study.

References

[1] Google Temasek (2018) e-Conomy SEA 2018, Southeast Asia's internet economy hits an inflection point

[2] BMBF-Internetredaktion (2016) "Zukunftsprojekt Industrie 4.0 – BMBF". Bmbf.de. https://www.bmbf.de/de/zukunftsprojekt-industrie-4-0-848.html. Accessed on 4 March 2018.

[3] Industrie 4.0 Plattform. (2018) Diakses pada 20 December 2018. https://www.plattform-i40.de/I40/Navigation/DE/Home/home.html. Accessed on 4 March 2018.

[4] Schwab, P. (2018), The Fourth Industrial Revolution. World Economic Forum.

[5] World Economic Forum (2018) The Future of Jobs. World Economic Forum.

[6] Manyika J., et al. (2017) Jobs Lost, Job gained: Workforce Transition in a Time of Automation. McKinsey Global Institute.

[7] BPS (2016). Statistik Industri Besar Indonesia. https://www.bps.go.id/subject/9/industri-besar-dan-sedang.html. Accessed on 4 March 2018.