WALAILAK JOURNAL
http://wjst.wu.ac.th Applied Sciences

Impacts of the 4th Industrial Revolution on Industries

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Received: 5 August 2019, Revised: 18 December 2019, Accepted: 30 December 2019

Abstract

The leap of technology has led to a paradigm shift called the "industrial revolution". Industry 4.0 is the fourth industrial revolution which implemented the philosophy of cyber-physical systems, internet and future-oriented technologies, and smart systems with promoted human-machine interaction paradigms. The emergence of Industry 4.0 was introduced to the world as a new trend to improve working surroundings in industries and solve the problems faced by the industries. There is a limited information about Industry 4.0 and not every person understands the real meaning of Industry 4.0. Thus, the objective of this review paper is to identify the possible impacts of Industry 4.0 on manufacturing industries which will encourage more organizations to adopt Industry 4.0.

Keywords: Industry 4.0, Industrial revolution, Impacts, Manufacturing industry

Introduction

Manufacturing is a process that transforms inputs (such as raw materials, energy and information) into outputs (finish goods) adding value satisfying human needs [1]. High-tech products are produced by the industry to realize the scale effects in value chain and personalization and to meet heterogeneous customer's demands [2]. The social challenges of the 21st century have become more complex, which require structured technology management methods [3]. There are specific manufacturing solutions that may solve the disadvantages of the manufacturing lines in traditional ways; for instance, agile manufacturing and flexible manufacturing before smart manufacturing in Industry 4.0 [4]. The Industry 4.0 has been paid attention for its importance, over the German-speaking. In fact, it has become the vital theme on the 2016 World Economic Forum's agenda [5].

A company will face the challenges in introducing new products or services, business models and innovations when it cannot overcome the technology challenges [6]. Industry 4.0 is a famous word but there is still not enough of the basic academic knowledge for this word [7]. Some companies usually do not have enough manpower to look forward. They reject to enter new into areas since they lack the opportunities to invest in emerging technology considering that they may suffer losses due to a misfocusing on wrong technology [8]. The objective of this review is to identify the possible impacts of Industry 4.0 on manufacturing industries.

Literature review

Industrial revolution

Industry plays a vital role in the economy as it produces highly mechanized and automated material products [9]. The leap of technology has led to a paradigm shift called the "industrial revolution". The industrial revolution is a fundamentally technological revolution which focuses on the sources of invention to understand [10]. Manufacturing has always been one of the key drivers of technological development and social change which shapes the world around us [11].

The first 3 industrial revolutions (the steam engine, the age of science and mass production) have transformed our modern society and changed the world around us fundamentally [12]. Now there have been 4 industrial revolutions which are industrial revolution (focus on mechanization), industrial revolution (focus on electricity and mass production), industrial revolution (focus on automation by using electronics and IT) and industrial revolution (focus on cyber-physical systems or CPS).

First industrial revolution

The first industrial revolution began around 1760s through the advent of steam engine that powered the manufacturing sectors in relation to agriculture and textile. Allen (2009) argued that first industrial revolution in Britain took place due to its unique price and wage structure. However, Mokyr conceptualizes the first revolution as, "the set of events placing technology as the main engine for economic change". First industrial revolution witnessed slow pace and required an emergence of mechanization with industry as the foundation of the economy. New energy type was created with the mass extraction of coal together with the discovery of steam engine that revolutionized economy, human and material exchanges.

Second industrial revolution

During second industrial revolution, technological improvement in production of steel and iron as well as light bulb was invented as a new source of energy [11]. Moreover, the second industrial revolution happened on 1870 to 1969, which focused on the mass production, electrical energy utilization, and labour division [13]. Furthermore, there have been exponential demands for new resources based on new organization models and further development in transportation cause the beginning of mass consumption [11]. The second industrial revolution focused on applying electricity which allows the utilization of the conveyor belt and assembly line [15]. Cincinnati's meat packaging lines in 1870 had inspired Henry Ford to introduce the principles of assembly line into automotive kingdom which is still used in the manufacturing of motor cars.

Third industrial revolution

In 1969, third industrial revolution occurred. Modicon introduced the primary programmable logic controller to support digital programming of automation systems [16]. The digital programming manages the advance automation system engineering today and brings a highly flexible and efficient in automation system. The third industrial revolution led to the automation of the production process by using extensive electronics and information and communication technologies (ICT) [15]. In addition, computers networks and IT systems in the third industrial revolution from 1969 to 2015 were used [13]. The automation in production and intelligent control robots as well as other integration gave the breakthrough [17]. Third industrial revolution started in the centre of 20th century, developing of microcontrollers to digitize the factory as well as introducing automation and microelectronics technology into manufacturing [11]. Computer Integrated Manufacturing (CIM) controlled the whole production process by integrating computers into planning and production processes [11].

Forth industrial revolution

Based on DLG-Expert report 5/2015, in the 2011 Hannover Messe trade fair, a German term "Industries 4.0" was first applied that refers to the achievement of innovation, developments, and processes in manufacturing industry including new technologies in the growing market. Since the first publication, many European manufacturing research institutes and companies have conducted research on this topic, emphasizing Industry 4.0, including exchange of information, controlled machines and production line which are autonomously and intelligently operated in manufacturing [18]. The representative example of Industry 4.0 is one of the innovations that enables to build new virtual world to forecast the faults and activate maintenance processes automatically or self-organized the operation of logistics such as unexpected and abnormal changes [19]. The fourth industrial revolution also implemented in administrative process and services except physical production systems and factories [13].

The emergence of Industry 4.0 happened because of the development of cyber technique, combined with digital ecosystems in industry value chain [15]. Despite being created in Germany, the concept of Industry 4.0 shares a lot with the development of other European countries where different labels such as Smart Factories, Smart Industry, Advanced Manufacturing or Industrial Internet of Things (IIoT) have emerged [20]. Industry 4.0 is the fourth industrial revolution which implemented the philosophy of CPS, internet and future-oriented technologies and smart systems with promoted human-machine interaction (HMI) paradigms [9].

There are 9 technology advances that were implemented in manufacturing as foundation for Industry 4.0. They transfer the production to become isolated, optimized cells will integrate fully, automated, and optimized production flow which affect the relationships of the traditional production among customers, providers, and producers and between human beings and machines [21].

Impacts of industrial revolution

Industrial revolution changed the lifestyle in different aspects; for instance, in transportation (from horse-carriages, sailboats to railways, steamboats and trucks), communication (telephony and telegraph) and in urban centres (sanitation, health, water and electricity) [22]. Based on Khan academy, the population of the people was 670 million before using fossil fuels widely in 1700, then it increased to 6.7 billion people in 2011 which is a 10-fold almost 300 years. Besides, the world's economy increased 14-fold, income per capita increased mere 4-fold, and the application of fossil fuels grew at least 13-fold.

Components of industry 4.0

The nine pillars in Industry 4.0 include the big data and analytics, autonomous robots, simulation, horizontal and vertical system integration, the industrial Internet of Things (IIoT), cybersecurity, the cloud, additive manufacturing and augmented reality [21].

Big data analytics

Big data is a set of technology that require new type of integration to discover huge hidden values in huge datasets which are multiple, complex and huge scope [23]. Big data analytics images as these data are too large, too irregular and very quick to be conducted by traditional modes [24]. Big data analytics can be dealt with unstructured information from call records, transactions in mobile banking, online user generated content such as images blog posts and tweets as well as online searches that change into precious business through computing technology to reveal trends and patterns between data sets [24]. All types of companies are making a bet on big data analytics to assist them to better comprehend the buyer, compete in market, find insights more quickly, accelerate products and services, and improve profits [25]. Big data analytics can also provide users with various statistical results for monitoring and adjusting the system configuration through on-site or remote terminals [26].

Autonomous robots

Autonomous robots are usually considered as a system that integrates perception and action in a dynamic environment. Most vital is the deliberation ability with minimal human supervision [27]. The application of robots in autonomous production method will give more accurate work since they are able to work in a restricted work station [28]. Autonomous robots are designed to fulfill high level missions or very narrow external controls on their own [29]. Manufacturers in numerous industries have utilized robots for long terms to handle complex missions. This demand for robots is growing to gain bigger utility and become autonomous, flexible and cooperative [21].

Simulation

Simulation includes a set of technical instruments and ways necessary for the successful application of digital manufacturing. It allows experimentation and verification of product, activities and system layout and configuration [30]. Through simulation, the operator can experiment and optimize the machine settings for the coming product in the virtual world. Previous physical conversion, accordingly make the machine set-up time shorter; thus, raising its quality [21]. Simulation saves time and resources by setting up an evidence of idea before building a physical setup for prototyping [31]. The simulation model output can provide a reliable estimate for the performance of the system considered by the decision maker before establishing the physical system [31]. This include the creation of 2D and 3D simulations in virtual commissioning and simulation cycle times, energy consumption or ergonomic field of production facility [28]. The simulation system could gather data from physical shop floor by the manufacturing execution system (MES) and MES will implement a shop floor control plan that will be solved by the simulation system [32].

Horizontal and vertical system integration

To achieve the targets of this dual CPS plan, the subsequent characteristics of Industry 4.0 is implemented which are horizontal integration through value networks, end-to-end digital integration of engineering across the entire value chain and vertical integration and networked manufacturing systems [33]. Horizontal integration through value networks enables local and globally dispersed value chain partners to collaborate by integrating their information and communication (ICT) systems, processes and data streams [34]. End-to-end digital integration of engineering across the whole value chain is throughout the product of the life cycles that draw a clever cross-linking and digitization at all stages, from raw material procurement to manufacturing systems, product utilize and end of product life cycle [35]. Vertical integration is merging of planning and development with production [36]. Vertical integration and networked manufacturing systems is integrating internal IT systems, activities and data flows from product development to manufacturing, logistics and sales to enable cross-functional collaboration and to form an intelligent manufacturing environment [37].

The industrial internet of things

The industrial Internet of Things (IIoT) can be verified in the 3 main field from its orientation things, internet, and schematic [38]. IoT is an advance technology that can link to system, physical objects, and service to make the communication work for object-to-object as well as data sharing [39]. IoT allows the wireless devices to give a greater information level to end users and assist further integration of technology into daily life [40]. Nowadays, IoT is implemented in global supply chain by the manufacturers as to monitor the products and materials flow. Meanwhile, the recalled products occurred, the defective production batches were identified and isolated at specific counter parties [41].

IIoT is a subset of the IoT as a foundation and applied in the industry area with the industrial application [42]. IIoT is a new revolution resulting from the integration of industrial systems with advanced computing, sensors and ubiquitous communications system [42]. In dealing with the communication bandwidth, it required a big data transmission. IIoT is very different from the general IoT because the cost is reduced, prolong the delay time, and the connection is robust. Thus, real-time decision making will improve efficiency, security and stability large scale IIoT, and other engineering systems will be achieved [43].

Cybersecurity

Cybersecurity is one of an act that can protect ICT systems and their contents [44]. Cybersecurity also is a main tool for monitoring privacy and information availability, and information sharing and intelligence gathering maybe useful tools for network security [44]. With the increase of connectivity and the application of advance communication protocols, it is necessary to shelter key industrial setups and production lines from cybersecurity threats [45]. With this mind, reliable and secure communications and sophisticated identity management, machine and user access levels are crucial [45]. By applying Industry 4.0, there will be an increase in connectivity and utilization of norm communication protocols so that crucial industrial systems and production lines from dramatic increase in cybersecurity threats are preserved [21].

Cyber Physical System

Integration and networking of data has been in the key notion for theoretical understanding and engineering concepts. Cyber physical system (CPS) is a kind of a new generation digital system where data is monitored by computer-based algorithms. CPS have full potential to innovate the world with efficient and reliable system enabling smart revolutionary devices that can address national priorities [23]. CPS have shown its footsteps in the field of transportation and energy, healthcare and medicine, environmental and sustainability and thus its advancement will enable the simple embedded systems of today through advancement in capabilities, adaptability, scalabilities, safety, security and usability of the system [62]. CPS provides updates and service cause the new forms of customer loyalty due to customer highly rely on a vendor who give innovative services with a high quality [63].

The cloud

Cloud computing is a model that can easily access the network on demand, anywhere and anytime. It is the sharing of configurable computing resources pools such as servers, services, storage, applications and networks that can be quickly supplied and published with minimal administrative endeavor or service provider interaction [46]. Cloud computing is the major change in modern ICT and enterprise applications service. It performs a large-scale and complex computing as a powerful architecture [23]. Recently, cloud computing has become one of the important driving forces of manufacturing; it can change the business model of traditional manufacturing. Business strategy will link product innovation, and create a smart factory network to encourage effective cooperation [47].

The flexibility and borderless resources provided by cloud computing encourage manufacturers to use cloud application services to improve and innovate their manufacturing processes [48]. Cloud application services provides manufacturers with cloud based software applications, web based management dashboards and cloud based collaboration to bring manufacturing processes, management and monitoring to the cloud, driving the emergence of cloud manufacturing [48].

Additive manufacturing

According to DLG-Expert report 5/2015, in the era of Industry 4.0, additive manufacturing with other activities as to create new production ways flexibility such as mix of additive manufacturing, injection-moulding and human-robot cooperation can be integrated. 3D printing is one of the examples of additive manufacturing which can print out the model layer-by-layer from the data to solid 3D objects [41]. These additive manufacturing methods would be utilized abroad to generate small-volume custom outputs that give architectural benefits such as complex, lightweight designs [21]. Additive manufacturing which help components or objects built from 3D models by adding materials into production line becomes reality, allowing the design of more customized parts, lowering material usage costs and rapid prototyping [50]. The new development in 3D printing technology is metal additive manufacturing (MAM) that had led attempts in this active research area [51].

Augmented reality

Augmented Reality (AR) or Industrial Augmented Reality (IAR) is a type of technology which furnishes powerful tools that support task-bearing operators and help them to assembly tasks, solution assistance, data visualization and Human-Machine Interfaces (HMI), indoor positioning, maintenance applications, quality control or material management [52]. The direct result of the discrepancy is that the standard and inexpensive microprocessors will be driven by augmented reality systems since the PC processors have the computing power to change and draw simple graphics in real time [53]. AR is using the virtual objects as representing a computer-aided enhancement of human perception [54]. By using AR, the artificial information about the environment and its objects can be superimposed on the real world to enhance operator perception of reality [55].

Impacts of industry 4.0 on manufacturing industries

Industry 4.0 is a novel concept that brings various impacts to industry as well as to the world in general. There are 9 pillars of technologies in Industry 4.0 which will bring impacts to industries. Thus, for this research, there is a need to verify the impacts of industry 4.0 on manufacturing industries and the **table 1** shows the impacts that taken from other journals.

Table 1 Impacts of Industry 4.0.

Impacts	Reference
Accomplishing high wage economy	[33]
Achieving individual customer requirements	[33]
Autonomous controlling	[56]
Backup system in cloud storage more safer and reliable	[56]
Coordinating real time	[5]
Creating value opportunities	[5,33]
Demographic of workplace will change	[3,33]
Developing a powerful data security environment	[56]
Flexibility	[33,56]
Forming business models evolution	[5,35]
Forming proactive maintenance	[57]
Forming smart factory	[9]
Gaining financial benefits	[9]
Improving energy consumption more efficient	[56]
Improving mass customization	[57]
Improving safety and reliability in operation	[58]
Improving the efficiency of the production processes	[59]
Increasing productivity	[21]
Increasing revenue growth	[21]
Leading to innovation	[56]
Mass production becomes highly flexible	[5]
Optimizing decision making	[33]
Optimizing in procurement process	[59]
Precise Risk management	[5]
Real time detailed end-to-end product transparency	[5,56,59]
Reducing costs	[5,59]
Resources become more productivity and efficient	[3,33,56]
Value chains optimized	[3,5]
Work-life-balance	[33]

First impact is accomplishing high wage economy because the dual strategy of Industry 4.0 will enable Germany become a leading supplier and leading market for Industry 4.0 solutions [33]. Leading supplier is focusing on equipment supplier industry whereas leading market is Germany's domestic manufacturing industry [33]. In order to create and successfully extend this leading market, it is necessary to closely link some companies located in different locations and to strengthen close cooperation between different companies. The combination of high cost economic and resources costs will reduce energy costs and personal costs [60].

Second impact is achieving individual customer requirements [33]. They mentioned that Industry 4.0 consents individual buyer to participate in the configuration, ordering, layout, planning, manufacturing and operation stages and can be incorporated in last minutes change. Manufacturers can satisfy customer demands at any production frequency while sustaining last-minutes changes in production and other flexibility which is far from being achieved in traditional industry [61].

Autonomous controlling in the field of artificial intelligence (AI) also impacted the hierarchical structure under Industry 4.0 [56]. The low-skilled workers who carry out easy and monotonous works will be replaced by the greater automation [21]. When the machine and system are connected in the factory, manufactures apply the information to automate the work process and maintain and optimize the production system without human intervention [64]. Automation can accelerate the efficiency and decrease mistakes and waste in energy and other resources [57]. The algorithm traces the real-time motion of goods and compute their arrival period, taking into account weather status, harbour overcrowding and the impact of natural disasters in logistics application [65].

Backup system in cloud storage have connected many resources as a backup system that is safer and more reliable [56]. Data stored in the cloud will improve the availability and accuracy [21]. Although physical products maintain unchanged, it still can update through software in the cloud [65]. Outsourced data processing models have encountered difficulties (such as in the area of cloud computing) because local data conservation standards familiarly do not apply to countries outside Europe, which means that it is virtually impossible for client companies to execute with their data preservation responsibilities [33].

Impact of Industry 4.0 on manufacturing industries is coordinating real time [5]. Real-time data access in production is extremely important no matter how it relates to the product, the process, or machine in the factory [6]. Customized labors schedules generate daily operation in real time to lower the possibility of errors and failures [6]. Because of the immediate availability data, machines or people carry out their work quicker. This may result to having a positive feedback from the employees and the overall activities has been optimized [6].

Industry 4.0 will develop novel methods for creating value opportunities [33]. Industry 4.0 can form fresh business opportunities for example service model [67]. Smart algorithms can be implemented through big data that can be recorded in smart devices to furnish innovative services [33]. This also will bring a new chance to SMEs and initiate to apply B2B (business-to-business) services for Industry 4.0. IoT opens up a new method before and after customer purchase of creating services and values [57].

Furthermore, demographic of workplace will change because of the interplay between humans and technology systems in industry [33]. Given the imminent deficiency of skilled workers, this will enable experience workers to expand their working life and keep longer-term productivity [45]. Work on the assembly line and factory floor and the recruitment of engineering staff are the most affected especially in the case of a shortage of talent in the United States [68]. Moreover, Industry 4.0 will bring negative impact on people losing their jobs because the machines will replace them [58]. Industry 4.0 have high threat from cyber criminals that may access or control internet infrastructures that could lead to environmental or economical disasters.

Industry 4.0 can develop a powerful data security environment [56]. They argue that in order to manage advanced and targeted cybersecurity threats and attacks, the security services industry must also be developed and strict government rules and regulations must be established to protect and secure the data. The smart factory faces larger security problems than traditional Internet applications [4]. Some CPS may have low computing power, which may lead to denial of service attacks and prevent security software [63]. Besides, the issue is no longer confined to the always quite complex physical copy of products, targeted theft of corporate and product knowledge is turning into more commonplace in this moment, specifically in the pattern of software or configurations that are still simple to replicate [33]. Produced electronic products involve viruses from production facilities when send in the market, resulting in heavy penalties for organization or product backtrack [6]. Device lifetime has been shortened due to immense availability of latest software versions. This may lead to systematic failure as the dependency on the software will become much higher that ratchet the challenges.

Industry 4.0 will assist industry more flexibility because CPS-based ad hoc network can configure dynamically in various business process area such as price, robustness, risk, time, quality and environmental protection [33]. Robots, smart machines and smart products can be connected to each other and make autonomous decisions [21]. Flexibility assists to quickly configure new capacity and quick move or migrate workloads [25]. Furthermore, working time flexibility, other staff-related levers that companies can utilize to achieve a successful situation in the volatile sales market consist of content-related reasons such as job rotation and multiple skills, and dimensional flexibility such as recruitment and selection [69]. Flexibility is second driving force for Industry 4.0, for instance through the resilient factory which permit companies in orders and capacities can react optimally to fluctuations [70].

Industry 4.0 will form business models evolution by applying the smart data that provide new services [35]. They said that applying this development will determine new sustainable business model. The speed of development of new business models for IoT and services industries will be closed to speed and vitality of the Internet itself [33]. Innovation in business model for sustainability is defined as major positive creation or lowered negative impacts on environment or society by changing the method which organizations and their value networks are created, achieving value and gaining value [71]. Digital business models share is that the manufacturing company's machine tools can provide online information, programs and solution to facilitate its optimal deployment [67].

Next impact of Industry 4.0 is forming proactive maintenance [57]. Real-time monitoring of the production system and the collection of performance data have a positive effect on improving active maintenance [57]. Sensors equipped machines generate large amounts of data and examples of data are including machine temperature, vibrations, velocity, overwhelming force, condition and other worth, note the operating status which machine operation [6]. IoT enables the machine estimates failures and the maintenance process is triggered autonomously, rather than depending on insecure monitoring by maintenance crews [64].

In addition, Industry 4.0 will form smart factory [9]. Smart factory is a special application of CPS which is according to the widespread and in-depth implementation of message of information technology in manufacturing [4]. However, smart adjectives are used to characterize and contribute to additional meaning which introduces multi-platform communications and increases computing power [57]. Emergence of intelligent through network cooperation with smart device, smart device can check system updates and decide whether or not to take action [57].

The implementation of Industry 4.0, will gain financial benefits because of elimination and reduction of redundant waste [9]. When the workers are losing their jobs and replacing by the self-checkout systems, it will bring clear financial savings that can help companies to reduce large labour cost [58]. ICA argues that nearly half of executives from Germany companies trust that Industry 4.0 is high investment and cause lack of high economic benefits from a control point of view. The definitive development of the Industry 4.0 model will at first comprise higher financial expenditure than methods that do not explicitly utilize modelling due to value added activity is being advanced to the early stage of the process so as to reduce costs later [33].

Improving energy consumption more efficient is also one of the impacts [56]. Therefore, when the fluctuating of energy purchase price, energy consumption data can be considered from the IoT to minimize the energy cost of the production plan by defining the start time of the work process [57]. Manufacturers save their cost by using variety methods in IoT and automation of environmental controls for example HVAC (Heating, ventilation, and air conditioning) and electricity [64]. Thus, the industry is trying to reduce the consumption of energy and resources or discovery alternative sources [33].

Another impact of Industry 4.0 is improving mass customization [57]. In manufacturing environment, mass customization is a production plan that pay attention on the production of personalized mass products, mainly via flexible activities, modular product pattern and integration between supply chain members in the value chain [2]. The increasing vital of mass customization has led to fundamental shifts in product and production architecture [2]. It permits individuals to patterns and supports the final shift although production maybe low but still profitable [57].

Improving safety and reliability in operation is also an impact of Industry 4.0 [58]. When applying Industry 4.0, the workers in the work stations are decreasing and human highly depend on machines so this can ensure their safety. Operation machines can work under dangerous situation which above the human limits and this can reduce the occurrence of industrial accidents. On the other hand, machines can operate in 24 hours whereas human cannot and need to take shift to work.

It also improves the efficiency of the production processes by using specific apps [59]. For example, using a system that can track and trace specific product components or apply a software that can help human activities in company. Conduct more efficient production when there are huge volumes of operating, current state and environment data [67]. Furthermore, with the assistance of big data feedback and coordination because the production process optimized, the average manufacturing path shrinks and the utilization of machines and other resources improves [4].

Moreover, the impact of Industry 4.0 is the increase of productivity in manufacturing industry [21]. They discuss that Industry 4.0 will be accepted by more companies because it can help manufacturing industries increase their productivity by €90 billion to €150 billion in Germany. On the other hand, smarter machine systems should be able to organize administrators to recommend task scheduling and adjust operating parameters to maximize productivity and product quality [72]. Smart product is a metaphor for reducing media shredding and frequent interruptions based on a single product. Meanwhile, the disruption of production in these media often leads to loss and decrease productivity [57].

Industry 4.0 also increases the revenue growth because the demands of manufacturers for enhancing equipment and new data applications, and consumer demands for more customized products contribute to an additional annual revenue by increasing about €30 billion per year or 1 percent of Germany's GDP [21]. In 2025, the productivity of Germany will increase the amount around €78 billion [67]. Approaching smart manufacturing in a piecemeal manner further drives revenue; thus, the return on investment of the integrated approach increases the financial risk of deployment [73].

Accordingly, the impact of Industry 4.0 on manufacturing industries leads to innovation [56]. Germany is guiding innovator in embedded systems and automation engineering in Industry 4.0 [33]. Meanwhile the overall achievement of Germany is to strengthen competitiveness and innovation by ensuring employment and fair working conditions. This is done to establish a sustainable personnel development structure at the company level to make sure a high level of industrial value [74].

Mass production becomes highly flexible [5]. However, in order to have a major impact in mass production, autonomous systems still require a lot of research and the Federal Ministry of Economics and Technology in Germany supports autonomous system by planning "Autonomics" technology program [2]. Compared with traditional mass production systems, decentralized self-organizing systems are not certainly better or more productive and mass production in traditional way have been optimized to the greatest level [49].

Next impact is optimizing decision making due to Industry 4.0. It offers end-to-end transparency in real time, permitting design decisions in engineering. It can be verified early so that a more flexible response will be taken to disruption and global optimization of production sites of all companies in the production aspect [33]. For example, waste was reduced by providing decision makers with production situation in real time where applying mobile technology will shorten the time between issues and work effective decisions [57]. In addition, transparency also includes knowledge of the energy consumption behaviour of the production process.

They mention that the impacts of Industry 4.0 are optimizing in procurement process since suppliers can completely flexible and autonomously selected through specific software [59]. The purpose of the procurement optimization is to buy the same for less [75]. So, applying procurement optimized can save the purchasing cost. Optimized the procurement process can pay attention to actual activities and renegotiation, rather than over-analyse spending base [75]. Therefore, an efficient procurement process after optimization will help to successful suppliers and immature suppliers.

Therefore, Industry 4.0 can precise risk management [5]. Intelligent algorithms deal with data in cyberspace calculates and synchronizes information about health, outcomes, and risk of physical components in real time [61]. Manufacturers can reduce the risks involved in the project by early detection of errors or early verification of system requirement and proposed solutions to meet these needs [33]. Thus, better data and manufacturing process models can be used to forecast, plan and manage product transitions, dynamic material and energy conditions and machine operation risk [73].

Industry 4.0 can create real time detailed end-to-end product transparency [56] and it also can help to trace material flow in real-time [5]. Big data analytics enable to make effective and accurate decisions quickly, promote production planning and accelerate response to market search [4]. Embedded sensor technology allows to link within the supply chain to convey and collaborate with each other in real time to facilitate smarter and faster decisions [68]. As a result, the responsiveness of the whole supply chain including design, manufacturing, quantity, rework, and life-long service regulations has been improved [68]. In addition, they also mentioned that the requirement for tracking and localization (product orders) as well as mapping to mobile worktable are challenging, especially the products in the assembly line are not produced sequentially but interrupted [76].

The application of Industry 4.0 can reduce costs [5,59]. The transportation cost, warehousing cost and production costs will be reduced through electronic miniaturization [59]. The operating costs are quite low contrast to the certain line due to flexibility, resources and energy efficiency for the upcoming small-scale customization [4]. Industry 4.0 will decrease labour costs and give a better working environment [72].

Furthermore, resources become more productive and efficient as an impact [33]. The impact of Industry 4.0 will improve the resources sustainability and efficiency in manufacturing industries [3]. It provides the highest possible product yield from a given number of resources (resource productivity) and utilize resources at lowest as possible to provide specific outputs (resource efficiency) [33]. Industry 4.0 brings novel method of developing smart products and introduces new technology tools that can develop lean principles to optimize resources and eliminate wastes [77].

Moreover, value chains also will be optimized [5]. Otherwise, Industry 4.0 will distribute manufactured products through collaborative processes as well as enable mass customization of products and services [3]. The value chain can be deployed really because Industry 4.0 enables companies, departments, functions and capabilities to turn into further compact for example they can share customer relationship management (CRM) systems [45].

Work-life-balance will be formed as the manufacturing industries implemented CPS. CPS is able to meet the employees' growing needs to maintain their work, personal lives, personal development and proceed professional development [33]. A flexible work organization will allow workers to be more effective when they unite their tasks, personal lives, and continuing professional development [45].

Conclusions

Although the Industry 4.0 is a new world trend that improves working surrounding in industries, there were a number of problems that need to be addressed. There is a limited information about Industry 4.0 and not every people understand the real meaning of Industry 4.0. Besides, some industries lack the awareness to implement Industry 4.0 because there is not enough market size. According to this research, the manufacturing industries and government will get advantages as they can understand the impacts of Industry 4.0. The industries can understand more the impacts of Industry 4.0 and the government can refer to this research to give an encouragement to the industries as implementing Industry 4.0. Unlike the past three industrial revolution, Industry 4.0 might also get terminated if there is network misconfiguration in the system and the information is not delivered correctly or reliably. There can be operational disruption that may impact the bottom line of the organization. Finally, cyber threats might devastate the reputation and bottom line of the organization. Thus, proper visibility of the network with continuous monitoring of industrial automation is obvious for the survival and existence of Industry 4.0.

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