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IMPACT OF INDUSTRIAL REVOLUTION (IR) ON INTERNATIONAL BUSINESS

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ABSTRACT

The aim of this paper is to discuss the impact of industrial revolution on international business. The world of IR4.0 not just revolves around smart and connected machines and systems, but it fused the interaction of these technologies with physical, digital and biological domains. Industrial revolution has changed in manufacturing and transportation which began from fewer products being made by hand and more are being made using machines in a large-scale facility. Data for this study were obtained from existing literatures on industrial revolution in multinational companies. The methodology heavily relied on existing previous literatures on the subject being dealt with. The findings indicate that the increasingly inaccessible discourse on technological advancement is making it harder for the public and for governments to mitigate the externalities of automation and other changes. It also dictates the impact of globalization towards the economy is inevitable for companies worldwide; they would have to resort to IR4.0 to sustain and thus stay relevant in the business world. Therefore, companies will have to adopt IR4.0 in their management, implement and strategize to keep their stand in the competitive world.

Key words: Industrial revolution, industrial business, multinational company, technology, globalization

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1. INTRODUCTION

As the world ages every minute, it is unpreventable for business owners to think of various ways to just survive in the market right now, let alone to be relevant present day. For example, these days business owners cannot escape the persuading and effective power of social media to help them market their product and also for the purpose of extending their brand image to a wider range of customers. With this knowledge in their mind, business owners must react and adopt to changes that is happening in the world today, and also accept that most of the changes that influenced the direction of how companies do business nowadays is the Industrial Revolution.

Industrial revolution is defined as the changes in manufacturing and transportation which began from fewer products being made by hand and more are being made using machines in a large-scale facility. The Industrial Revolution has been recorded started as early as 1760's, with the First IR (IR 1.0). IR 1.0 happened in Europe and United States, focused on transfer of method from handmade to machines, introduced chemical manufacturing and iron production processes, increased use of steam power and water power, development of machine tool and also the surge of mechanized factory system. The second Industrial Revolution (IR 2.0) started in the late 19th century, where mass production made possible cultivated by the arrival of electricity and assembly line. It also displayed the transition of technological power from Britain to United States and Germany. By 1960s, the third Industrial Revolution (IR3.0) began, also called the Digital Revolution. It showed the shift from mechanical and analogue electronic technology to digital electronics with the adoption and proliferation of digital computers and digital record keeping that still continues to the present day (Schoenherr, 2004). Besides that, IR 3.0 also catalysed the development of semiconductors, mainframe computing (1960s), personal computing (1970s and 80s) and the internet (1990s) (Schwab, 2016). Lastly, the fourth Industrial Revolution (IR 4.0) started in around 2010 and saw the transformation of industrial revolution which was now covered other areas besides industry, such as urban development of smart cities. Other than that, IR 4.0 also includes among others cyber-physical system, the internet of things (IoT) and industrial IoT (Pune Techtrol, 2019), cloud computing, cognitive computing and artificial intelligence.

Human civilization has only existed around 12 000 years, and in the vast majority of that history we subsisted mainly through agriculture. We worked the land to produce food needed to survive, but we also produce some rudimentary tools and tamed animals to help along. Throughout that time, we only relied on the effort of our muscles, and the muscles of our animals, which are sustained by the biological process of eating the food we produced. The trajectory of human progress would be changed, however, by the advent of new technologies – the first being the steam engine – which helped us to produce a lot more stuff using the same effort, albeit with the help of new tools and knowledge to use them. That is the general story of industrial revolutions: we did certain kinds of work one way, then we discovered and adopted widely new technologies that helped us do it more and better.

Currently, our civilization experienced around four distinct industrial revolutions, so far. The 1st Industrial Revolution brought us the steam engine and mechanization; the 2nd brought us electrification, mass production and new materials. The 3rd Industrial revolution was kick started by the invention of the microprocessor, and the general adoption of computers into daily life (or digitization). The Fourth Industrial Revolution is supposed to a drive towards the adoption of smart technologies, such as the Internet-of-Things (IoT), augmented reality, Big Data analytics, 3D printing, etc. The soon-to-come *Fifth* Industrial Revolution is speculated to carry over the lessons from the 4th, and attempt to allow human beings to interface with machines capable of using Artificial Intelligence (AI).

2. LITERATURE REVIEW

The world of IR4.0 not just revolves around smart and connected machines and systems, but it also fused the interaction of these technologies with physical, digital and biological domains. That is what makes IR 4.0 significantly different from the previous Industrial Revolution. There are four core criteria of IR 4.0 that help companies to identify and thus implement the concept (Herman, Pentek, & Otto, 2016).

Interconnection

The ability of machines, devices, sensors and people are to connect and communicate via the Internet of Things or Internet for People (IoP) (Bonner, 2017).

Information transparency

With interconnectivity allows companies to collect massive amount of data and information from all points, information transparency provides companies with useful information that will help them in making pertinent decisions.

Technical assistance

There are two aspects in this criterion –

- The ability of assistance system to support and simplify humans in making decisions and solve problems on short notice; and
- The ability of cyber physical systems to physically help humans by doing an extensive task that is unpleasant, too exhausting or unsafe for humans.

Decentralized decisions

The ability of cyber physical systems is to make decisions on their own and to perform their tasks as autonomously as possible (Gronau, Grum, & Bender, 2016).

To understand further on the wide range of IR 4.0 concept, listed below are some of the contributing digital technologies as examples (Erboz, 2017). An industrial revolution 4.0 concept is very relatable to the global environment that we are living right now. The advancement in technologies that had happened since the first Industrial Revolution has greatly improved the lifestyle of all humans. Moreover, for the companies, adoption of technology is something that is futile to reject. Technology can ease the management and processes involved and it certainly can be used in profit gain purposes, for example production and marketing. Although technology is inevitable, the transition application from analogue or manual to technology has not always been effortless. For example, the music sharing service, Napster became a global hit when it first came out in 1999. But, due to lack of proper management and overlooked the implication of legal complications, by 2002, the company has declared liquidation and shut down of business (Hill, 2004; Wingfield, 2002). On the other hand, the use of technology has evidently help in increased of sales. In the case of Procter & Gamble (P & G), they began selling their products – Pantene shampoo, Pampers diapers, Cover Girl cosmetics and Gillette razors, among others – via online in 2010. This has further maximised their sales because it also targeted customers outside from retailers (Birchall, 2010). With that in mind, companies must strategize the adoption of IR 4.0 in accordance with company's prospect to ensure the impact that they gain would be beneficial and profitable to the companies.

The current 4^{th} IR predicts a significant loss of both blue-collar and white-collar jobs due to automation. The fears in the larger public is that new advancements in technology may not translate into shared prosperity – a precarious and decreasing jobs market will not permit most people to enjoy the gains in improved technology if they lose their incomes. In his work, Nahavandi (2019) proposed the concept of Industry 5.0 by tying shared prosperity to the new development in human-machine interface. If it becomes necessary that humans are continue to be required to operate intelligent, autonomous machines, it may be possible to save jobs from being lost. In other words, rather than people having to compete with robots for work, it may be possible for human workers collaborate with them instead, via the introduction of human-machine interface.

3. INDUSTRIAL REVOLUTIONS

Human civilization has been through three or four industrial revolutions, so far, and is currently undergoing the fourth or fifth. To make sense of how impactful every time we undergo an industrial revolution, this section will discuss briefly that history, and its effect on our economic life.

3.1. First industrial revolution (1760-1840)

Table 1 Steam technology's contribution to British labour productivity growth

	Economy-wide labour productivity growth	Contribution of steam technology: Stationary steam engines	Railways	Steam ships	Total
1760-1800	0.2	0.01			0.01
1800-1830	0.5	0.02			0.02
1830-1850	1.1	0.04	0.16		0.20
1850-1870	1.2	0.12	0.26	0.03	0.41
1870-1910	0.9	0.14	0.07	0.10	0.31

Source: Derived from Crafts (2004).

The 1st Industrial Revolution began in the United Kingdom, starting around the mid-18th century. Thomas Newcomen invented the first prototype of a steam engine, meant to pump out water from flooded mine shafts. Another engineer, James Watt (along with Matthew Boulton) modified Newcomen's prototype, and made it suitable for work that involved milling. This invention revolutionized work in the textile sector, food production, and iron working. In addition, the steam engines provided the catalyst with which engineers could mechanize the workplace – changing the need to use purely human and animal labour, towards augmenting their work with the help of machines. Just a few labourers can now produce much more goods from a lot more materials.

The 1st IR also changed the way society is organized. Through mechanization of work, factories can be formed to produce goods on a large scale. The emergence of factories created a demand for of a large labouring class to work those factories. The population growth that followed caused a rapid rise of urbanization, as more and more people migrate from a rapidly declining opportunity of farm life in the countryside (due to enclosure of formerly common-held farmlands) to find work in the cities and towns. Fortunately, this growth in city-dwelling coincided with better agricultural productivity from factors before (e.g., fertilizer manufacturing) and during the industrial revolution. Instead, challenges arise from pollution, lack of sanitation, overcrowding, low working standards, and low wages. Each of those challenges required to be solved not just by making new inventions and legislating government regulations, but by social movements demanding better things from either their elected representatives or their bosses at the workplace.

As seen in Table 1, the steam engine did not only revolutionize work, but was adopted for use in other new technologies such as railroads, steam-powered ships, and later to generate electricity. And each time a new technology arises, there will be significant improvements in either labour or capital productivity. So, too, will the negative consequences that need management and mitigation. This trend will be made obvious in all the next IRs to come.

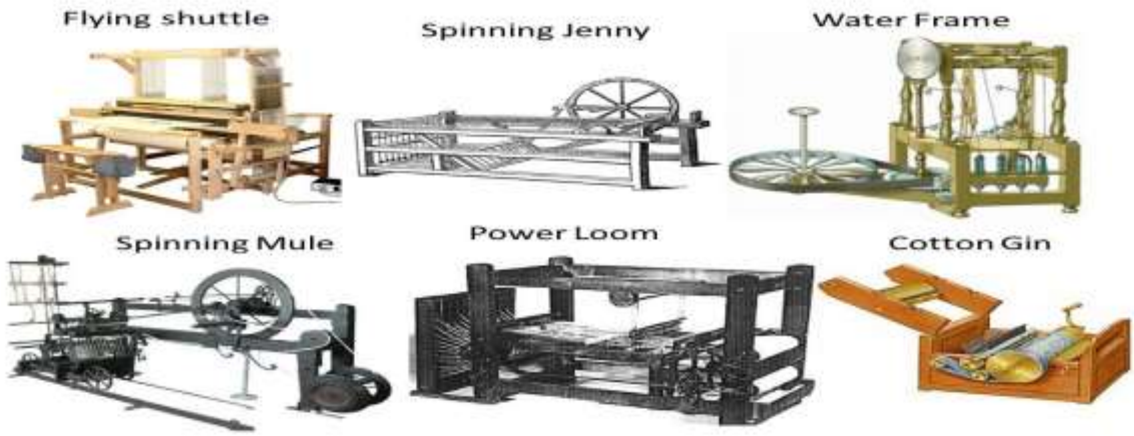

Figure 1 1st IR Inventions in the Textile Industry.

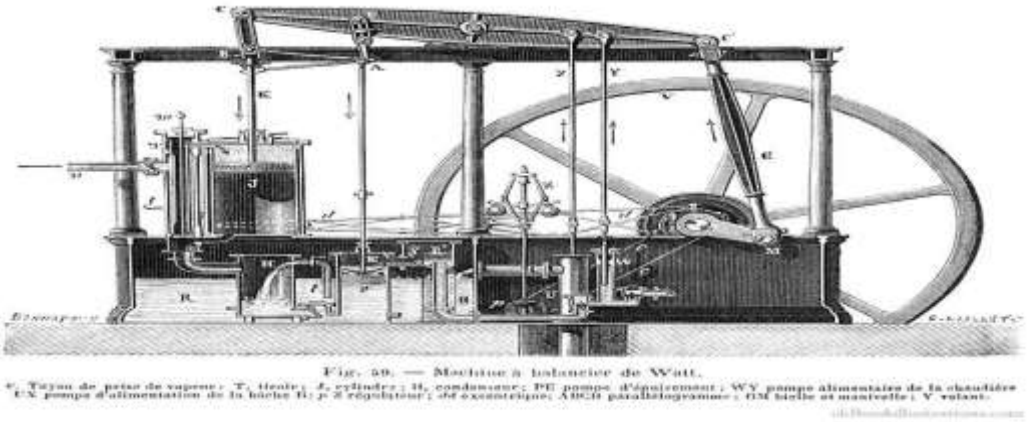

Figure 2 James Watt's steam engine prototype

3.2. Second Industrial Revolution (1840-1917)

With the widespread adoption of new technology and inventions beyond Britain, into continental Europe and North America, historians observed a separately second wave of industrialization. The large-scale production of cost-effective, quality steel made this second explosion of inventions possible. This time, the 2nd IR witnessed the extraction and production of new energy sources, namely from fossil fuels (petroleum, natural gas, coal). These new energy sources did not only power the steam engines; the invention of electricity consumed that new energy precisely. Additionally, inventions from the 2nd IR did not only benefit the industry-side, but also came into homes in the form of the first electrical goods – the telephone (Alexander Graham Bell, 1876), light bulbs (Thomas Edison, 1879), alternating current (Nikola Tesla, 1896) and others.

The best invention of the 2nd IR is arguably not a single invention, but a process – the assembly line. Pioneered at large manufacturing plants owned by Henry Ford (Ford Motor Company, US) – who was influenced by Frederick Winslow Taylor's work, *The Principles of Scientific Management* – streamlined work processes by minimizing the physical movement of labourers and having each set of workers working on a particular part of the *assembly line*. This process massively reduced the time to produce a single finished product and formalized the concept of increasing industrial efficiency in the workplace.

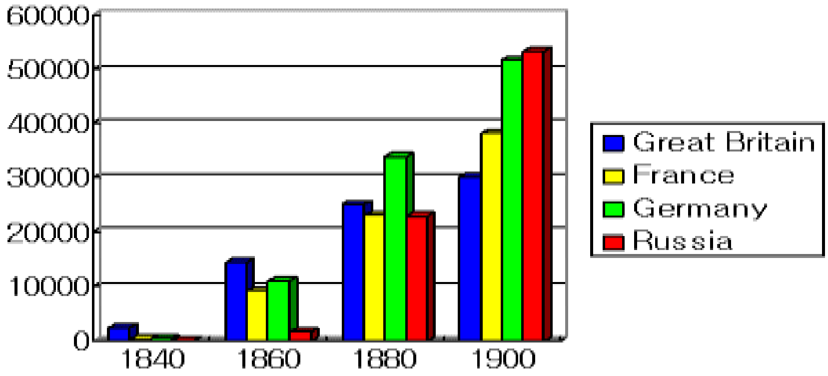

Figure 3 Total Railway Length Built (in km).

Source: https://www.zum.de/whkmla/sp/0910/csj/csj1.html

Figure 4 Ford's assembly line circa 1910s

3.3. Third Industrial Revolution (1940-1970)

The gap between the 2nd and 3rd Industrial Revolutions did not mean a stop in inventions; rather the pressures of the time (the Great Depression and World War 2) meant that resources had to be diverted towards resolving those problems. Only after the post-war, conditions did permit a general return to revolutionizing industry. The main thrust of the 3rd IR was the invention of the integrated circuit, which allowed for the creation of the computer. The 3rd IR is synonymous with the *Digital* Revolution – the transition of work done on analogue devices to computers. New storage devices allowed for the sum of human knowledge to be stored in digital form, while the predecessor to the Internet - ARPANET – was slowly created to allow computer devices to communicate and do work with each other.

The effect of the Digital Revolution could not be overstated; the creation of the computer allowed a single person do the work of previously different clerical professions into one device. Information could be stored and manipulated at the same time, and it became possible for machines to be automated – by incorporating software and programming so that a worker can introduce inputs for a machine to do a repetitive task over and over again.

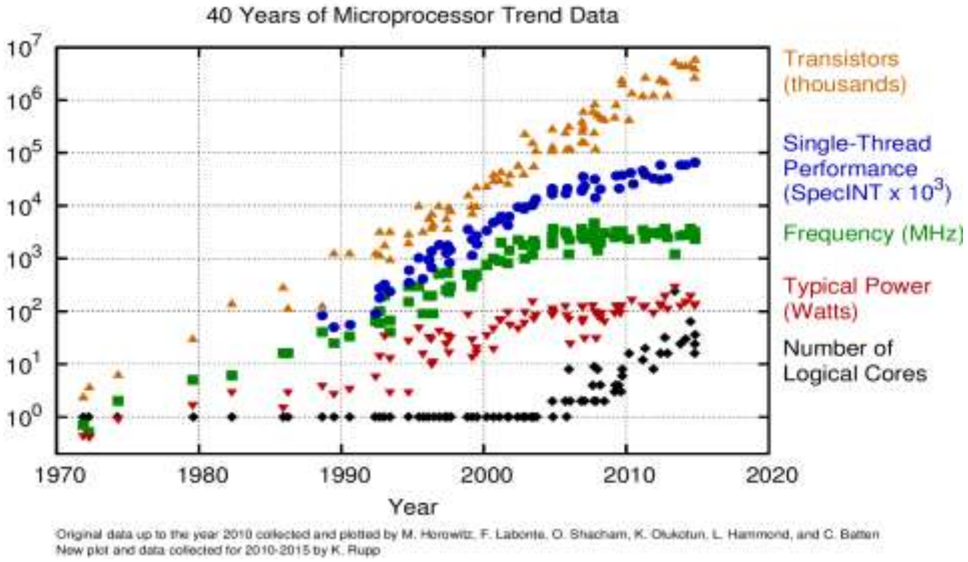

Figure 5 40 years of Microprocessor Trend Data

3.4. Fourth Industrial Revolution (2010-Present)

By the turn of the millennium, computers have been widely used both in industry and in other aspects of human life. More and more people owned not only computers, but mobile devices, and had some kind of access to the Internet. The next wave of technological revolution was getting automated machines to become *autonomous* – being able to make decisions in real-time, through collecting data acquired by state-of-the-art sensors, and using machine learning. Popularized first in Germany though the introduction of *Industry 4.0*, the book published by Klaus Schwab, and by similar announcements by leading industrial countries, the 4th Industrial Revolution was anticipated to make industry more high-tech, less pollute, more sustainable and environmentally-friendly.

The 4th IR is replete with new inventions and concepts such as the Industrial Internet-of-Things, cloud computing, Big Data analytics, augmented reality, AI, smart sensors, additive manufacturing, etc. Ultimately, industrial players seek to incorporate these new technologies and facilitate the emergence of cyber-physical systems. Thus, creating a brand-new form of industry called the ‘smart factory’. While the concept of a smart factory seems to be out of reach for most readers, the gist of it is that with the 4th IR, manufacturing processes can be automated even further, reducing the amount of work to be done by humans.

As IR 4.0 necessitates having an even higher-skilled labour force, while at the same time creating a downward pressure on the labour market, societies will need to address the major concern of job loss. A very peculiar solution may come in the form of continuing the need for humans in the workplace, by allowing us to join and *interface* with machines, rather than just use them as we do now. That is what may occur in the anticipated next industrial revolution – the Fifth IR.

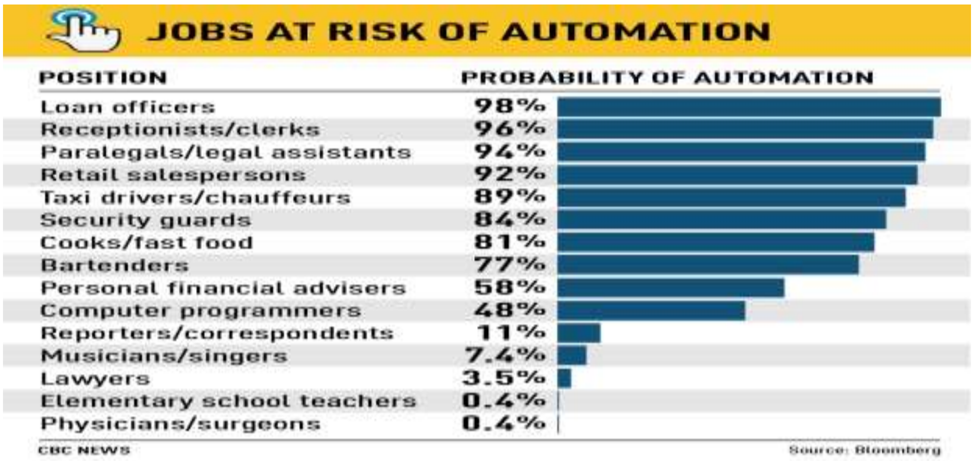

Figure 6 Jobs at risk of automation

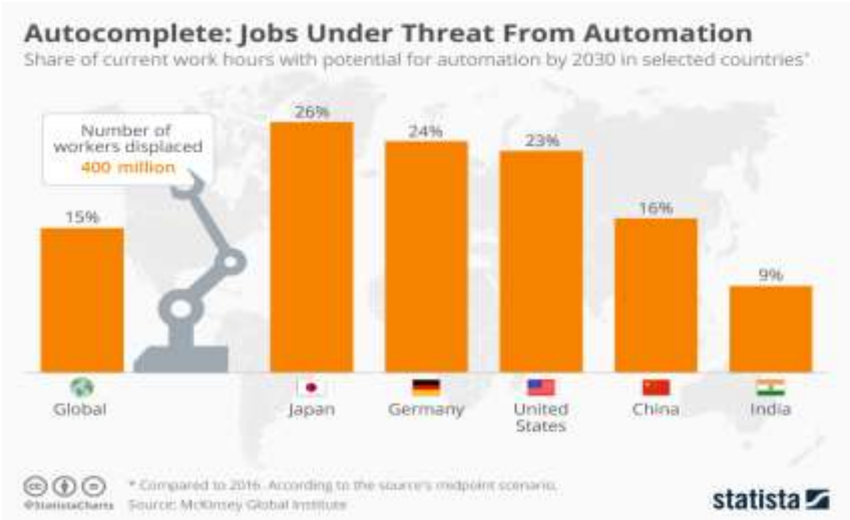

Figure 7 Share of work hours under threat of loss to automation by 5 countries

For Nahavandi, the main driver of IR 4.0 is the synergy between human workers and robots. The essential lesson from IR 4.0 is that since the new inventions appear to threaten human life through job losses, IR 4.0 must be able to bring back a human workforce to work in tandem with autonomous robots. This requires the robotic part of the workforce to learn, adapt and cooperate with human operators – the new generation of robots equipped with AI, other facets of IR 4.0, and HMI can do that.

In simple terms, HMI is to be achieved first by connecting sensors of autonomous robots to our human brains. For the time being, the current technology available so far allows machines to scan parts of our brain, to identify and learn its signals. By familiarizing themselves with our brain signals, autonomous programming would use deep learning in order to learn human instruction, desires, objectives, and intentions. Some of the tools available commercially, such as fitness trackers, smart watches, smart glasses (a class of devices known as wearables), are already facilitating machine-learning for the next generation of AI programmes in understanding the human body.

In addition to HMI, other developments in IR 5.0 include virtual training, digital twinning, and 'shop floor tracking'. Essentially, when the creation of comprehensive digital profiles of users, processes and models becomes possible, a 'digital twin' can help predict future behaviour without the need of manipulating a physical body. This helps reduce waste in manufacturing process while helping businesses predict future models more frequently to achieve optimization. This further digitization also can result in virtual training, where new forms of training can take place – again without wasteful use of physical resources. Trainers and instructors can be placed in believable simulations to prepare them for any situation in the workplace. As for shop floor tracking, the integration of futuristic sensors allows manufacturers to reduce costs and manage workflow.

Figure 8 Wearable devices.

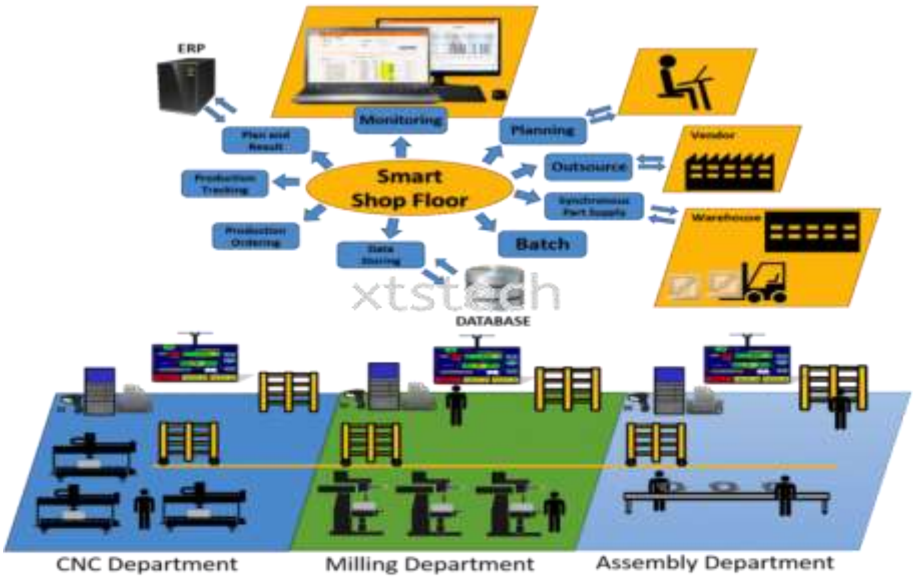

Figure 9 Smart shops tracking environment

4. INDUSTRIAL REVOLUTIONS AND INTERNATIONAL BUSINESS

Below are some of real cases of successful adoption of IR 4.0 in companies and the impact on the business based on the contributing digital examples discussed above (Autonomous Manufacturing, 2019):

4.1. Internet of Things (IoT)

Company: BJC Healthcare

IoT refers to a network of physical devices that are digitally interconnected, aiding the communication exchange of data through the Internet. Smart devices are not just referred to smart phones, but are also household appliances, smart cars and even buildings. Implementation of IoT in industrial machines and systems are called Industrial IoT. It is a subset of IoT, where a sensor, Radio Frequency Identification (RFID) tags, software and electronics are integrated with the machines and systems used. This application is meant to collect real-time data about the company's status and performance.

BJC HealthCare is one of the largest non-profit healthcare organizations in the United States. With net revenue of $5.3 billion at 2018, the company serves the healthcare needs of urban, suburban and also rural communities. The facility in the company includes 15 hospitals and multiple community health locations (BJC HealthCare, 2020).

BJC HealthCare uses Radio Frequency Identification (RFID), a technology that utilises radio waves, to help track and manage vast amount of medical supplies since 2015. The radio waves read and capture the data stored on a tag attached to a supply. This facilitates the inventory management system where the process of checking, tracking and monitoring of supplies has greatly improved from manual labour to automated process. Since the implementation, BJC HealthCare has reduced the amount of stock in the facility by 23 percent and predicted that the company will gain savings estimated $5 million annually when the RFID is fully implemented by this year. What BJC HealthCare has achieved here proves that Industrial IoT substantially improve the operations, efficiency, reduces cost and also contribute to the real-time data of the supply.

4.2. Big Data and Analytics

Company: Bosch Automotive

Big data can be defined is an immense and complex data sets that were generated by IoT devices, from applications, websites, computers, sensors and et cetera. In the industry especially manufacturing industry, there are a lot of data collected from various equipment fitted with sensors and systems. Using data analysis, all these data that were collected can be converted into useable business insights and tangible benefits.

How does data analytics work? Using machine with learning models, it applies powerful computational algorithms to process enormous data sets. In the same time, a data visualization tool helps the producers to fully understand the narrative behind the data. With all these in motion, companies are able to find and strategize suitable approach to optimize the processes that are the most beneficial to the company.

The Bosch Group is a leading global supplier of technology and services, which operates four business sectors: Mobility Solutions, Industrial Technology, Consumer Goods and Energy and Building Technology. The Bosch Group also considered as the leading IoT company in the world where they provide innovative solutions for smart homes and cities and also connected mobility and manufacturing. One of the Bosch Automotive factories in Wuxi, China has been integrating Industrial IoT and Big Data Analytics in its digital transformation.

The factory has been connecting its machines to assess the overall production process of its plant by embedding sensors into the machine's which automatically collects data about the machine's condition and cycle time. With this, the factory is able to forecast the machine's failures so that maintenance can be scheduled well before any failure or error occurs. Besides that, the machines in the factory are able to run and operating for longer time without any faulty. Using data analytics has proven to increase output as much as 10%, which improves the delivery and thus customer satisfaction. Overall, in 2018, there was an increase in profit gain by the company (as a whole) compare to 2017 as shown in Table 2 below (The Bosch Group, 2018):

Table 2 The Bosch Group Statement of Income 2017 – 2018

Statement of income (in millions of euros)	2018	2017
Sales revenue	78,465	78,066
Cost of sales	-51,696	-50,354
Gross profit	26,769	27,712
Distribution cost and administration expenses	-15,308	-15,781
Research and development cost	-5,963	-7,045
Other operating income and expenses	18	84
Result from companies included at equity	-14	-26
EBIT	5,502	4,944
Financial result	-435	-148
Profit before tax	5,067	4,796
Income tax expenses	-1,493	-1,502
Profit after tax	3,574	3,294

Source: The Bosch Group 2018 Annual Report

Consequently, data analytics facilitate in the overall operations with faster and better decision making, thus increasing and optimizing the processes and help to reduce errors.

4.3. Cloud Computing

Company: Volkswagen

Cloud computing is a platform that store and process huge amount of data on remote servers. With the expansion of IR 4.0, specifically IoT, there was a need for an infrastructure that can efficiently store and manage data that was produced at an overwhelm speed and at high volumes. In this case, companies are now not obligated to build infrastructure for their server within the premise, as cloud computing enables the server to be remotely accessible via the internet.

The capability of cloud computing that provides colossal amount of computing resources and storage space helps the companies to implement the business intelligence through big data analytics. Since the information is easily shared across the entire company, cloud computing has transformed every aspect of manufacturing and evidence shows ever increasing in public cloud purchases demand (Figure 10) (Richman, 2016).

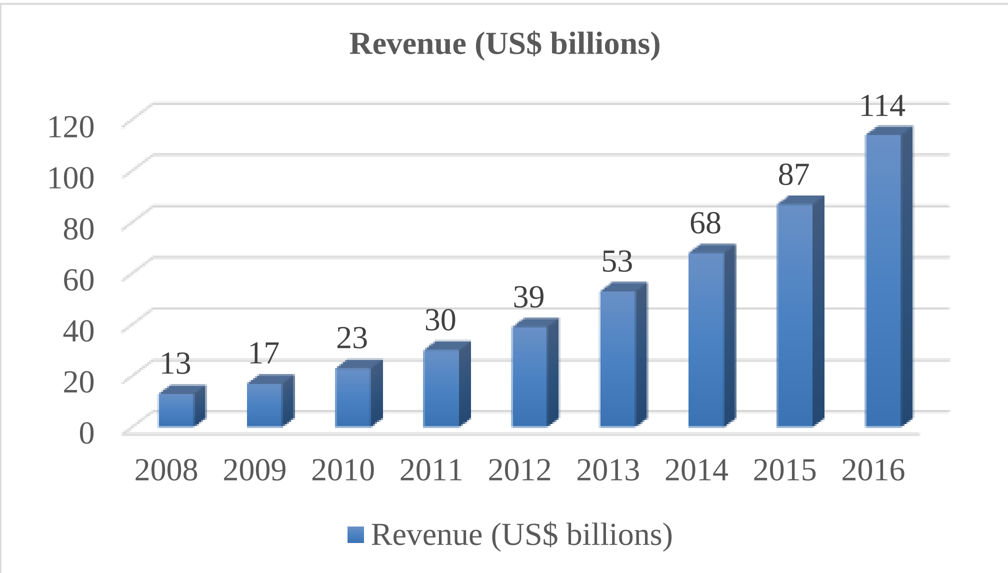

Figure 10 Global public cloud purchases

Volkswagen is one of the first automakers to head start the connected cars trend in the automotive industry. The company has struck a deal with Microsoft to provide cloud computing in their vehicles. This will allow the customers to access Microsoft's remote computer processor via cloud computing to customize their on-board media streaming, aids in parking and also charging (Taylor, 2019). This is one of the examples where cloud computing not only be used within an organization, but when incorporated with other company, they create a whole new area to be explored. This new area when strategize properly, became a trendsetter and thus making it profitable for the respected companies involved.

4.4. 3D Printing

Company: Fast Radius

3D printing or additive manufacturing is a technology to create parts using a 3D model and a 3D printer. It offers a wide range of possibilities for manufacturing. It also enables the parts to be stored as files in virtual inventory; hence the parts can be made on-demand and closer to where it is needed. This will help reduce the distances and cost, as well as simplification of the storage system.

Fast Radius is a leading provider of 3D printing company. Among the services that are provided are as listed (Fast Radius, 2020):

- Additive Plastic
- Additive Metal
- CNC Machining
- Cast Urethane Molding
- Injection Molding
- Reverse Engineering

Named one of top smart factories in the world, Fast Radius owns its own technology platform that enables them to be more agile and flexible in the area. The platform helps the company to collect data and feedbacks from every design that is stored and manufactured at their virtual warehouse. Subsequently, the data is used by the company to identify applications which is appropriate for the 3D printing, in the same time, evaluating the issues concerning producing parts. Besides that, the company also provides supply chain optimization throughout its virtual inventory. Its virtual warehouse reported has stored approximately 3,000 items for heavy equipment. This evidently has cut cost for maintaining physical parts and has seen as an innovative solution for the supply chain management.

Moreover, Fast Radius has signed a partnership deal with UPS service to deliver the supply chain globally, thus combining the digital manufacturing technologies with the world's largest network of distribution hubs. The company also has built up facility located within UPS's world's largest packing facility. With this collaboration, Fast Radius, with its virtual inventory, is able to produce parts on demand, in precise quantity needed and then deliver it to the customer in short amount of time. This strategy has proven to shorten the production time and improves customer satisfaction.

4.5. Augmented Reality (AR)

Company: General Electric Company

AR is a technology that closes the gap between digital and physical world by superimpose virtual images or data onto physical object. This is achievable by using an AR enabled device, for example smart phones, tablets and smart glasses. Despite that, the benefits of this technology are yet to be explored by companies and industries. There are a lot of possibilities that can be emerged from this technology, such as helping with the assembly line to maintaining the equipment's. One example of AR that can be used is helping surgeon during operation. By wearing AR glasses, the surgeon can assess the patient's data such as nerves and blood vessels which are highlighted onto the glasses. This enables the surgeon to safely navigate the region in the patient that needs attention, thus minimising complications and also improving the surgeon's precision. Another example is AR glasses help workers to project data such as layout, guidelines, forecast possible malfunction, so this will improve the assembly process, decision making and easier work procedures.

General Electric Company is a multinational conglomerate that operates in various sectors as follows (Generel Electric Company, 2017)(Egan, 2017):

- Aviation
- Healthcare
- Power
- Renewable Energy
- Digital Industry
- Additive Manufacturing
- Venture Capital and Finance
- Lighting

The company has resorted to AR in its jet engine manufacturing facility. Before this, its jet engine makers are obliged to check the task manually to avoid errors. By using AR glasses, the workers will receive digitized instructions on the glasses. They can also access training videos, voice commands for assistance and also stream their point of view via a live connection (Kloberdanz, 2017).

With this technology, General Electric reported an increase of productivity within workers wearing smart wearable by 11 percent compared to manual. Subsequently, this strategy decreased the costs involved, minimise errors and also improved the quality of product.

In summary, the Industrial Revolution throughout the years can be described in figure 11 below (Rose, 2018):

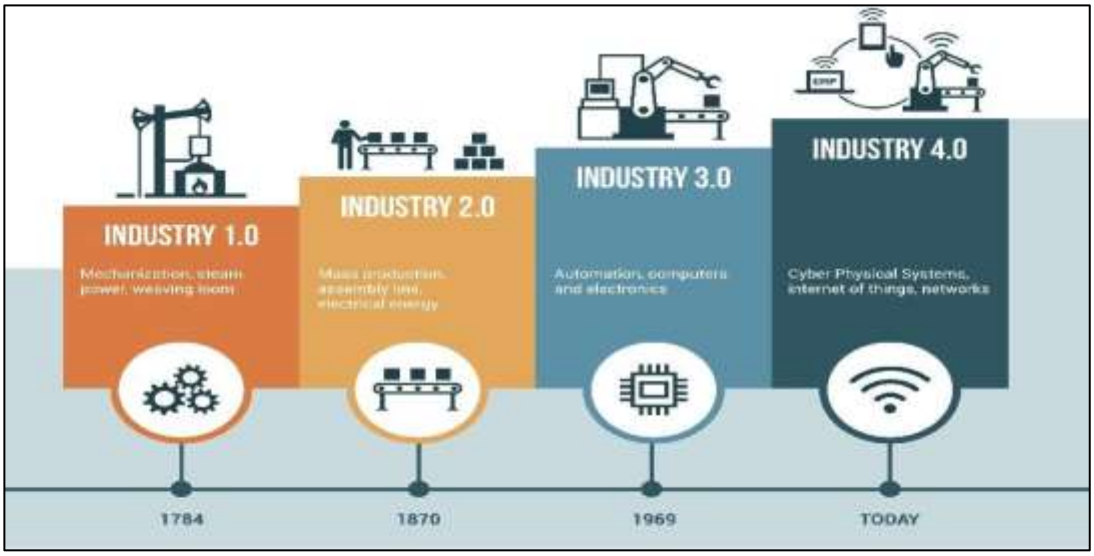

Figure 11 The stages of Industrial Revolution

With the impact of globalization towards the economy is something that is inevitable for companies worldwide, they would have to resort to IR4.0 to sustain and thus stay relevant in the business world. In this matter, companies will have to adopt IR4.0 in their management, implement and strategize to keep their stand in the competitive world.

4. CONCLUSION

The most important target of IR 4.0 is to reintegrate the precarious workforce back to the global economy. By instructing human workers to cooperate with smarter robots and machines, it is not only hoped that the result would be increased productivity, but that the gains in the economy would be shared by all. The discourse is the media on the fourth IR is somewhat new and premature as we are still in the middle of the IR4.0 but the trend appears to not only discuss improvements in technology, but also to discuss how to manage the disruptions in the workplace caused by greater degrees of automation.

Automation is a real threat to jobs, and manufacturing jobs that used to promise decent pay, significant benefits and a comfortable retirement are being replaced by precarious jobs such as those found in the gig economy. When discussing gains of efficiency, many economists, and pundits in the media also seem to forget the real negative impact of job losses on displaced worker. Some older workers are either delaying or coming out of retirement, while younger ones find it difficult to rise through the ranks or land secures jobs that pay decently. Meanwhile, the increasingly inaccessible discourse on technological advancement is making it harder for the public and for governments to mitigate the externalities of automation and other changes.

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