Industry 4.0 Adoption Challenges in The Manufacturing Organizations in Developing Nations

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Abstract

Industry 4.0, also refers to fourth Industrial revolution, is currently one of the upcoming trends in manufacturing sector organizations. Rapid technological developments defined previous industrial revolutions. Digitalization, the Internet of Things (IoT), and Cyber Physical Systems (CPS) have gained importance throughout industries as a result of technological advancement. The fourth industrial revolution (Industry 4.0) and its integrated technology dissemination progress, on the other hand, is predicted to evolve rapidly in terms of technical change and socioeconomic implications.

The challenges to implement Industry 4.0 technology in the Manufacturing sector in developing economies are discussed in this paper. Fourteen barriers were identified after a thorough literature review by over thirty-five research articles and the interactions with a panel of industry professionals who are subject matter experts.

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In developing nations, the lack of a digital skills, resource limitations combine to significant Investment requirement and security breach risk appears as the most significant challenge. Value chain integration and technological infrastructure are needed to support the adoption of Industry 4.0 technologies in developing countries, according to the influencing constraints identified.

The purpose of this study is to investigate how Industry 4.0 is being implemented in developing nations. The lack of integrated national policies on Industry 4.0 in emerging nations is causing issues in the diffusion of technological innovation, which may prevent organizations from fully experiencing the Industry 4.0 revolution.

The findings of this study may provide insight to decision-makers and practitioners in overcoming the obstacles and opening the path for a successful implementation of Industry 4.0 in the manufacturing sector Organizations in developing nations.

Keywords: Industry 4.0; Constraints; Barriers, Challenges, Manufacturing Organizations, Developing economy

1. Introduction

Industry 4.0, also refers to fourth Industrial revolution, is currently a blossoming topic in research studies. The preceding industrial revolutions were characterized by rapid technological advancements. However, in terms of technical change and socioeconomic consequence, the fourth industrial revolution (Industry 4.0) and its integrated technology dissemination progress is expected to develop dramatically (Rabeh Morrar, 2017).

The value chains in the manufacturing companies are complex. Digitalization, the Internet of Things (IoT), and Cyber Physical Systems (CPS) have gained importance throughout industries as a result of technological advancement. The Fourth Industrial Revolution (Industry 4.0), also known as a German high-tech plan for future manufacturing industries (Hofmann and Rüsch, 2017), is defined using these terms. The transformation of manufacturing processes in industries by Industry 4.0 has a stunning effect. In other words, with the support of Internet of Things (IoT) and Cyber Physical Systems, Industry 4.0 will play a vital role in transforming traditional firms into Smart Factories (CPS).

In Industry 4.0, a decentralized approach is critical, since it promotes independent management of processes and smart objects throughout the network, allowing real and virtual worlds to interact on activities (Ungurean and Gaitan, 2014). Complexity and agility are boosted by the development of integrated processes and human-machine interaction, as well as data transmission between value chains. Industries will increase operational efficiency in terms of time, cost, and production with the support of Industry 4.0. Building IoT infrastructure allows partners in supply chains to share platforms via cloud systems, allowing business processes to be streamlined (Lu, 2017).

There has been past scientific research on the challenges to Industry 4.0 technology adoption. This scientific discussion is still ongoing, and more research is required before a widespread consensus can be formed. Various research methodologies have been used to study this topic in various nations. As a result, the purpose of this study is to investigate the challenges to implementing Industry 4.0 technology in the manufacturing sector in developing nations.

The barriers studied in this article were identified through a comprehensive literature review and discussion with industry experts in manufacturing sector who have extensive experience in operations management and information technology.

This research article is organized as follows: Section 2 of this research paper discusses Industry 4.0 literature and the challenges to implementing Industry 4.0 technologies. The key findings are discussed in Section 3. A "Technology Acceptance Model (TAM)" in Section 4 and finally, the conclusions and suggestions for future research are outlined in Section 5.

2. Literature Review

This section provides a review of the available recent literature on Industry 4.0, followed by a discussion of the challenges to Industry 4.0 adoption in the manufacturing sector.

2.1. Industry 4.0

In 2011, the phrase "Industry 4.0" was introduced at the Hanover Fair. Following that, the German government designated it as a strategic effort to transform the manufacturing industry in 2013. (Xu et al., 2018). Industry 4.0 has recently gotten a lot of attention because of its multiple advantages for Organizations to be competitive (Dalenogare et al., 2018).

Industry 4.0 includes of several emerging concepts and

new technologies, such as artificial intelligence (AI), machine learning (ML), radio-frequency identification (RFID), big data, cloud computing, smart sensors, robotics, additive manufacturing (AM), augmented reality and the Internet of Things (IoT) (Li, 2017; Schwab, 2017).

The concept of Industry 4.0 is defined by nine concepts presented by Boston Consulting Group is presented in figure 1(Rüßmann et al, 2015).

Figure 1: The nine technologies are transforming Industrial Production

Source: BCG

Several researchers (Lu, 2017; Xu et al., 2018; Hofmann and Rüsch 2017) recently conducted literature evaluations to explore potential research options in this field. In their paper, Hofmann and Rüsch (2017) analyze the advantages of Industry 4.0 in terms of logistics. They claim that management is having difficulty implementing Industry 4.0 since organizations may not see any immediate financial benefits.

In a similar manner, Barreto et al. (2017) analyzing the requirements that may help enterprises to be more efficient in implementing Industry 4.0 in the context of logistics. Haddud et al. (2017) and Ben-Daya et al. (2017) take Industry 4.0 beyond logistics and into supply chains. Haddud et al. (2017) focus on the potential benefits and challenges of integrating Industry 4.0 into supply chains, while Ben-Daya et al. (2017) discuss the role of the Internet of Things and its impact on supply chain management.

For Industry 4.0 to be implemented, numerous technologies must be integrated simultaneously across the supply chain. Fettermann et al. (2018) investigate the needs of several technologies, including radio frequency identification, sensors, cloud processing, and cyber-physical systems. Meanwhile, Li et al. (2017) analyze the supply chain's technology drivers of Industry 4.0.

Researchers have attempted to link two different growing concepts linked to operations management, such as lean manufacturing and Industry 4.0, and the circular economy and Industry 4.0, in a number of significant research. Mrugalska and Wyrwicka (2017) investigate how lean manufacturing and Industry 4.0 principles may coexist and complement one another.

Ivanov et al. (2018) investigate the link between big data analytics, additive manufacturing, advanced trace & tracking systems, Industry 4.0, and supply chain disruption threats, as well as how digitalization might help with ripple effect control. These impediments to Industry 4.0 implementation in the manufacturing industry, however, have not yet been examined (Moktadir et al., 2018). These challenges will be discussed in the following section.

2.2 Challenges to the Adoption of Industry 4.0

The majority of scholars agree that the study of challenges to Industry 4.0 adoption is mostly unexplored in the literature and needs further research (de Sousa Jabbour et al., 2018a, b; Kamble et al., 2018; Horváth and Szabó, 2019; Oesterreich and Teuteberg, 2016; Xu et al., 2018).

However, until now, these constraints have only been examined in isolation and from a technology perspective. Industry 4.0 adoption is a complicated process in which multiple elements interact (Horváth and Szabó, 2019); consequently, a thorough examination of all of these factors is required.

According to Machado et al., 2019, the maturity level of a company's digital transformation influences managers' perceptions of barriers to Industry 4.0, and organizational resistance from employees and middle management levels is likely to nullify the adoption of Industry 4.0 technologies in some of developing countries.

Much of the study on challenges to Industry 4.0 adoption has relied on empirical data gathered through survey research (e.g. Turkes et al., 2019; Stentoft et al., 2019) and interview case studies (e.g. Horváth and Szabó, 2019; Machado et al., 2019). These studies point out the roadblocks that prevent organizations in developing nations from being digitally ready.

3. Research methodology

This paper reviews available literature on the basis of the challenges in adopting Industry 4.0 concepts; therefore, several papers are analyzed in accordance with Industry 4.0 and its aspects. A total of over 25 papers were collected by searching for related keywords.

Following the analysis of various research publications, fourteen problems for describing the challenges of Industry 4.0 adoption in the manufacturing sector in emerging economies were identified.

As a result, the challenges of adopting Industry 4.0 are detailed in this article, and how these challenges should be addressed is critical for any manufacturing company that is looking to improve its readiness for a successful implementation of Industry 4.0 concepts.

3.1 Challenges to the Adoption of Industry 4.0

This section provides a discussion of the challenges to Industry 4.0 adoption in the manufacturing sector that identified through literature review and subject matter expert interviews.

3.1.1 Inadequate digital skills

Employees with the requisite knowledge and skills remain critical among the non-technical issues that the IoT (and thus Industry 4.0) faces (Hung, 2016). Many firms admit, according to Breunig et al. (2016), that they lack the essential expertise or abilities to fully fulfill the capabilities of Industry 4.0 applications. Breunig further said that a lack of digital skills and experience paralyzes organizations' capacity to interact with software solution providers because their employees are unable to use what they have purchased. Under-capable individuals are the second key challenge in application Industry 4.0 concepts, as firms become more data-driven and agile, demanding more skilled workforce. (Geissbauer et al., 2014).

3.1.2 Significant Investment Requirement

According to Geissbauer et al. (2014), companies interested in implementing Industry 4.0 projects must commit to increasing their anticipated annual infrastructure investment for the following five years. This not only requires a re-engineering of existing strategies, but it also demands a significant investment to meet Industry 4.0 objectives. Furthermore, Kache and Seuring (2017) reinforce this argument by stating that both at the corporate and supply chain levels, significant investment in people, processes, and technology is required. According to Breunig et al. (2016), most businesses are still hesitant to invest in Industry 4.0-related R&D, which seems to have significant expenditure needs.

3.1.3 Inadequate Infrastructure

In order to accomplish Industry 4.0, a broad internet infrastructure is required. Even in industrialized countries like Germany, a shortage of reliable high-speed broadband for SMEs is a big stumbling block. This kind of technology is now only available to major players with a lot of money (Schröder, 2016). Every channel partner would have to be interconnected as part of Industry 4.0, therefore digital infrastructure is a factor that cannot be overlooked. According to the findings of Penton's poll, 33% of respondents felt that a lack of infrastructure is a barrier to IoT adoption. According to the study, many companies are increasingly collaborating rather than competing to construct the essential infrastructure for Industry 4.0.

3.1.4 Data Quality

According to Chen et al. (2014), consistency, completeness, correctness, and redundancy are four

dimensions of data quality. A vast amount of data would be generated in the age of fully realized big data, in which enterprises would have to be networked, and the complex nature of such data, together with its heterogeneity, makes it impossible to measure completeness and data accuracy. As a result, there's a higher chance of making a mistake (Lohr, 2012). Furthermore, data integrity and consistency become a serious difficulty when data changes often and is shared with various contributors (Khan et al., 2014). This will be the case in Industry 4.0, as businesses will be considerably more networked than before.

3.1.5 Inadequate Internal Digital Culture and Training

According to Breunig et al. (2016), in order to realize the benefits of Industry 4.0, the team must have strong internal competencies as well as a culture that encourages innovation and experimentation. Furthermore, it is believed that in such a scenario, employees with these skills would be in considerably higher demand and much lower supply. As a result, businesses would need to be prepared to transfer their operations to where such personnel were available. Such resources would foster an internal digital culture and allow a team of professionals from many fields to work together (Breunig et al., 2016).

3.1.6 Lack of Clarity on the Financial Benefit

Spending on information technology has always been questioned for its productivity improvements and financial advantages (Brynjolfsson, 1993). As a result of the productivity paradox in technology deployment, it is difficult to provide a precise estimation of the economic benefits of technology investment had become a challenge for the implementation of Industry 4.0.

3.1.7 Value-chain Integration Challenges

According to Breunig et al. (2016), difficulty of removing barriers between different organizational units in order to achieve the seamless collaboration that required for a successful Industry 4.0 environment. When numerous firms in the value chain are required to integrate, the problem becomes even more difficult. According to Geissbauer et al. (2014), the importance of horizontal value-chain integration as well as strong collaboration among value-chain partners is a vital factor. Majeed and Rupasinghe (2017) also claim that most businesses fail owing to a lack of IoT integration in an Industry 4.0 context. Dalenogare et al. (2018) highlights value-chain integration challenges as a significant barrier for a successful application of Industry 4.0.

3.1.8 Security Breach Risk

According to Geissbauer et al. (2014), one of the widespread worries about the security risk of sharing data among partner companies is the increased connectivity. It creates complex links between value-chain partners. Breunig et al. (2016) discuss not only enterprises' cyber-security concerns, but also their fear of losing their data to third-party software and service providers as a major concern in application of Industry 4.0. According to Lee and Lee (2015), 'Hackers' could be a severe concern, as consider this issue as one of the potential problems in IoT adoption.

3.1.9 Increasing Inequality

According to Schwab (2017), the labor market will be tense as a result of Industry 4.0. This could have a beneficial or bad impact, but technology will divide the market into low-skill/low-pay and high-skill/high-pay sectors, causing societal conflict. It is also claimed that Industry 4.0 will benefit intellectual capital owners and their shareholders while widening the divide between those who rely on labor and those who rely on capital, hence increasing inequality.

3.1.10 Low Maturity Level of Preferred Technology's

According to Lee and Lee (2015), the possibility for chaos when untested, early-stage technology are deployed that are unreliable. Such technologies may lack consistency in terms of standards, privacy concerns, and data security, and the growing number of untested gadgets might lead to pandemonium. The study goes on to say that while this isn't a big deal in an unconnected world, it might have a big impact on an interconnected system of technologies within Industry 4.0 environment.

3.1.11 Existing Job Disruption

Ryan and Watson (2017), see human displacement as a potential obstacle in a social and organizational setting, although not seeing human resources displacement as a problem. Haddud et al. (2017) emphasizes the issues that Industry 4.0 poses, as well as the issue of job disruption. According to Schwab (2017), advances in Industry 4.0 will enhance inequality and perhaps upset the job market.

3.1.12 Resistance to Change

Employees who are unwilling to modify their work habits are one of the challenges to IoT implementation in firms. These workers are averse to new technologies and the habits that come with them (Haddud et al.,

2017). According to Lee and Lee (2015), another aspect of resistance, arguing that various IoT technologies generate massive amounts of personal data, such as home, health-related, and financial behavior-related data, which many organizations might utilize. For fear of information leakage, this discourages businesses and individuals from using IoT.

3.1.13 Inadequate Change Management

According to Anderson and Anderson (2010), Technology has drastically impacted the way change occurs in the recent decade. Change used to be seen as transactional and hence simple to manage; today it is seen as radical, open-ended, ongoing, and difficult. In other words, it has evolved into a transformative process that is extremely difficult to execute well. Increasingly open-ended systems would be more complicated than ever under Industry 4.0, and effective change management would be a major problem for businesses.

3.1.14 Scarcity of resources and a lack of digital strategy

According to Schröder (2016), Industry 4.0 demands the consistent availability and flow of data in and across businesses, both horizontally and vertically. In this setting, SMEs confront significant hurdles because, unlike their larger rivals, they have limited resources. According to Ahlers (2015), the majority of medium-sized businesses reject cloud computing, using the Innovation Readiness Index (IRI).

According to Schröder (2016), this problem stems from top management's apprehension about implementing Industry 4.0 technologies. Furthermore, Ahlers (2015) claims that implementing Industry 4.0 is a strategic decision, and that top management reluctance could make developing a digital strategy to execute Industry 4.0 challenging.

Table 1: Summary of the Industry 4.0 Adopting Challenges

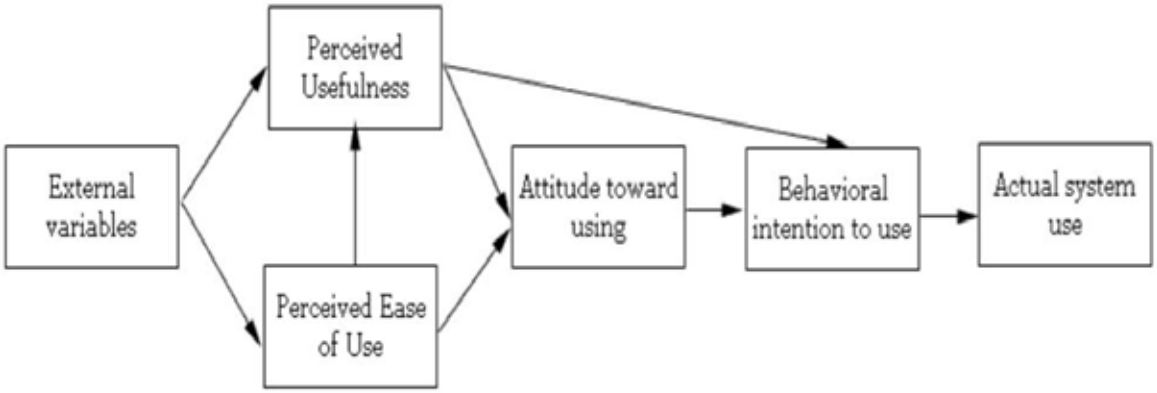
No	Industry 4.0 Adopting Challenge	Reference (Author)
3.1.1	Inadequate digital skills	(Hung, 2016) (Breunig et al., 2016) (Geissbauer et al., 2014)
3.1.2	Significant Investment requirement	(Geissbauer et al., 2014) Kache and Seuring.,2017) (Breunig et al.,2016)
3.1.3	Inadequate Infrastructure	(Schröder, 2016)
3.1.4	Data Quality	(Chen et al.,2014) (Lohr, 2012) (Khan et al., 2014)
3.1.5	Inadequate Internal Digital Culture and Training	(Breunig et al., 2016)
3.1.6	Lack of Clarity on the Financial Benefit	(Brynjolfsson, 1993) (Hofmann and Rüsch, 2017)
3.1.7	Value-chain Integration Challenges	(Breunig et al., 2016) (Geissbauer et al., 2014) (Majeed and Rupasinghe, 2017) (Dalenogare et al.,2018)
3.1.8	Security Breach Risk	(Breunig et al., 2016) (Geissbauer et al., 2014) (Lee and Lee, 2015)
3.1.9	Increasing Inequality	(Schwab, 2017)
3.1.10	Low Maturity Level of Preferred Technology's	(Lee and Lee, 2015)
3.1.11	Existing Job Disruption	(Ryan and Watson, 2017) (Haddud et al.,2017) (Schwab ,2017)
3.1.12	Resistance to change	(Haddud et al., 2017) (Lee and Lee, 2015)
3.1.13	Inadequate Change Management	(Anderson and Anderson, 2010)
3.1.14	Scarcity of resources and lack of digital strategy	(Schröder, 2016) (Ahlers, 2015)

Source: Author's own findings through Literature

4. Technology Acceptance Model (TAM)

The success of new technology implementation, according to the technology acceptance model, is primarily determined by two variables. Perceived utility and perceived simplicity of use are the two criteria. These variables influence how people will use technology and how they will react to change.

Figure 3: Technology acceptance model



(Source: Granić and Marangunić, 2019)

As a result, it is critical to convince people that the technologies are beneficial so that they can readily accept digital technology. Aside from that, it's critical to show people how simple it is to use those tools (Al-Emran et al. 2018). Their acceptance of those technologies will be aided by their ease of use. The organization's ability to successfully deploy Industry 4.0 may improve as a result of this procedure.

5. Conclusion

In the manufacturing industry, the implementation of Industry 4.0 is a top priority for developing economies. Based on a comprehensive literature search and discussions with experts from both established and emerging economies, fourteen challenges to implementation were identified to lessen the probability of failure. The study shows how these constraints have distinct effects in developing economies.

As many authors argued that in developing economies, the lack of a digital skills, resource limitations combine to significant Investment requirement and security breach risk appears as the most significant challenge. "scarcity of resources and a lack of a digital strategy" appeared as the most significant barrier. As a result, it is evident that managers should develop roadmaps and plan strategically in order to direct activities and resource investments in order to make the transition to Industry 4.0 as smooth as possible. Taking on the fundamental causes of the impediments to Industry 4.0 adoption should show to be an efficient strategy to thrive in the digital revolution.

Value chain integration issues and technological infrastructure were identified as the most important influencing elements in developing nations, whereas 'poor maturity level of the required technology' was also identified as a important influencing factor. In this setting, Organizations management, which is reliant on market and regulatory conditions, can address the influencing barrier. As a result, advances in standards and government regulation may make it easier for businesses to embrace Industry 4.0, while infrastructure to support technological systems may encourage the use of Industry 4.0 technology.

Like many other research, this study has gaps. The findings are only based on the Literature reviews and the relationships between the variables has not been tested and understand the significance of the variables.

Future research can investigate other factors that challenge the readiness for Industry 4.0 adoption in manufacturing Industries covering different sectors.

The outcome of the proposed study will help to guide future research on the development of standardized readiness assessment model for Industry 4.0 technology application in manufacturing companies in developing nations.

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