Analyzing the key barriers of adopting Industry 4.0 in Bangladesh's ready-made garment industry: an emerging economy example

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Abstract

Purpose – Since Industry 4.0 (I4.0) is a new idea in Bangladesh, this study supports I4.0 adoption. Companies struggle to implement I4.0 and fully profit from the fourth industrial revolution's digital transformation due to its novelty. Although barriers to I4.0 adoption are thoroughly studied, the literature has hardly examined the many aspects that are crucial for I4.0 adoption in Bangladesh's Ready-Made Garment (RMG) industry. So, the purpose of this study is to investigate the barriers of adopting I4.0 in relation to Bangladesh's RMG industries to enhance the adoption of I4.0 by developing a framework. Ultimately, the goal of this research is to improve the adoption of I4.0 in Bangladesh.

Design/methodology/approach – Through a comprehensive analysis of the existing research, this paper aims to reveal the barriers that must be overcome for I4.0 to be adopted. For evaluating those barriers, a decision analysis framework based on the combination of Delphi technique and Decision-Making Trial and Evaluation Laboratory (DEMATEL) method has been developed. The use of DEMATEL has led to a ranking model of those barriers and a map of how the barriers are connected to each other.

Findings – The findings reveal that "I4.0 training", "Lack of Motivation" and "Resistance to Change" are the most significant barriers for adopting Industry 4.0 in RMG sector of Bangladesh based on their prominence scores.

Research limitations/implications – These findings will help the people who make decisions in the RMG industry of Bangladesh, such as company owners, managers and the executive body, come up with a plan for putting I4.0 practices into place successfully. The decision-making framework developed in this research can be utilized by the RMG industry of Bangladesh and other similar industries in developing countries to figure out how important each barrier is for them and how to get rid of them in order of importance.

Originality/value – As far as the authors are aware, there has not been a comprehensive study of the barriers inhibiting the adoption of I4.0 within the scope of Bangladeshi RMG industry. This work is the first to uncover these barriers and analyze them using the combination of Delphi technique and DEMATEL.

Keywords Industry 4.0, Ready-made garment industry, Emerging economy, Delphi method, DEMATEL method

Paper type Research paper

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1. Introduction

The term "Industry 4.0" (I4.0) is commonly used to describe the transformation of the manufacturing sector brought about by the widespread use of cutting-edge digital technology and automation. Industry 4.0 is changing product design, production and delivery. It gives organizations huge chances to innovate and acquire a competitive edge in a quickly changing digital age. There is no agreed-upon definition of Industry 4.0, a critically important idea that was first introduced at the 2011 Hannover Fair in Germany (Salkin *et al.*, 2018; Yüksel, 2020). Many different technologies, such as the Internet of Things (IoT), cyber-physical systems, big data, system integration, simulation, autonomous robots and artificial intelligence (AI), are grouped together in the literature under the umbrella term "Industry 4.0" (Chauhan *et al.*, 2021; Neumann *et al.*, 2020; Kumar *et al.*, 2020a,b; Sony and Naik, 2020). The importance of Industry 4.0 in the modern world cannot be overstated. To start, I4.0 can boost efficiency, production and adaptability while lowering prices (Yüksel, 2020). I4.0 can assist businesses in adjusting to today's dynamic and unpredictable business environment and enhancing their competitiveness (Castelo-Branco *et al.*, 2019). I4.0 also enables businesses to build smart factories with operational flexibility, integration with clients and suppliers, and connectivity through virtual networks (Yüksel, 2020; Kamble *et al.*, 2018). The competitiveness of a nation can be enhanced if industries embrace I4.0 technology (Psarommatis *et al.*, 2022). Last but not least, I4.0 adoption results in sustainable business practices as well (Javaid *et al.*, 2022). As a result, I4.0's significance is acknowledged in both research and practice and is well known for what it is. I4.0 is still not widely used since a number of intricate and interconnected aspects are involved.

Industries, governments and stakeholders' awareness of I4.0 technologies might affect its adoption. I4.0 implementation can also be hindered by a lack of understanding or exposure. Technology infrastructure, including dependable power supplies, Internet connectivity and communication networks, is necessary for adoption (Elibal and Özceylan, 2021). Moreover, I4.0 technologies require complex machinery, sensors, software and worker training, which can affect acceptance (Elibal and Özceylan, 2022; Lyly-Yrjänäinen *et al.*, 2016). Upskilling the workforce and preparing new hires for I4.0 in many industries requires adequate training and education. Technology adoption, data privacy, cybersecurity, intellectual property rights and standards regulations can affect I4.0 implementation. I4.0 adoption needs local innovation and entrepreneurship. Implementing I4.0 requires overcoming change resistance, fostering creativity and raising awareness of its benefits. Additionally, adopting I4.0 depends on a nation's readiness for the technologies that make up I4.0, making undeveloped nations less likely to do so than industrialized nations (Castelo-Branco *et al.*, 2019).

As a developing country, the ready-made garment (RMG) sector of Bangladesh is also in the line of slow adoption. RMG sector of Bangladesh has around 11.2% contribution to the gross domestic product (GDP) of this country (Islam and Halim, 2022). The biggest industrial sector in the nation is comprised of more than 4600 RMG factories which account for 36% of manufacturing jobs and employ 4.1 million people (Islam and Halim, 2022). The most lucrative industry right now in Bangladesh is the RMG sector. Despite the considerable potential benefits of Industry 4.0, emerging economies like Bangladesh have been facing difficulties adopting it due to several barriers in RMG sector. These barriers, including limited resources, weak infrastructure and a lack of expertise, can impede the successful implementation of Industry 4.0 technologies (Luthra and Mangla, 2018). In Bangladesh specifically, there is a shortage of financial and technological resources, weak infrastructure and a lack of skilled personnel. Despite these obstacles faced by emerging economies such as Bangladesh in implementing Industry 4.0 technologies, the benefits of these technologies are substantial enough to justify the effort required to overcome these barriers and promote their adoption. By addressing the barriers to adoption, emerging economies can take advantage of the potential advantages of I4.0, such as increased productivity, greater competitiveness and improved economic growth.

One of the key reasons behind the low rate of adoption rate is lack of awareness among manufacturers. Without proper knowledge, manufacturers are less likely to invest in such technologies, and this lack of interest and investment can further impede the development of the sector (Raj *et al.*, 2020). However, a lot of research has been done on the crucial variables and barriers to I4.0 adoption (Chauhan *et al.*, 2021; de Sousa Jabbour *et al.*, 2018; Kamble *et al.*, 2018; Oliva *et al.*, 2021; Sony *et al.*, 2021; Wankhede and Vinodh, 2021; Yadav *et al.*, 2020a; Yilmaz *et al.*, 2021). Among the 15 barriers to adopting I4.0 identified by Raj *et al.* (2020), the lack of a digital strategy and resources stands out as the most significant. Lack of standards, expertise, and human and financial resources are only a few of the ten barriers to I4.0 that were identified by Stentoft *et al.*, (2020). Therefore, both the developed and the developing countries continue their delayed adoption of I4.0 technology.

Several studies such as Laskurain-Iturbe *et al.* (2023), Senna *et al.* (2022), Ghobakhloo *et al.* (2022) and Chauhan *et al.* (2021) have examined the benefits and drawbacks of Industry 4.0 adoption in manufacturing industries worldwide, but few have modeled paths specific to Bangladesh's RMG industry. Existing research on I4.0 deployment generally lacks sector-specific modeling that accounts for Bangladesh's RMG sector's unique difficulties and potential. This study addressed these research gaps and established effective and context-specific models and frameworks to adopt I4.0 in Bangladesh's RMG industry which will be helpful for policymakers, industry stakeholders and researchers of this specific field to promote sector growth, innovation and competitiveness. This research proposes a hierarchical framework for analyzing the barriers that stand in the way of the adoption of I4.0 in the Bangladeshi RMG industry. These studies are guided by the following questions:

RQ1. What are the critical barriers contributing to I4.0 adoption in the field of Bangladeshi RMG industry?

RQ2. How to set a framework for supporting decisions while studying the elements influencing the adoption of I4.0?

RQ3. How to support the design of a plan for the adoption of I4.0 in relation to Bangladesh's RMG industry?

To address these questions, this research contributes to the literature as follows. An exhaustive literature study answers the first research question by identifying Bangladesh's RMG industry's major I4.0 adoption barriers. As a means of addressing the second research question, a novel framework combining the Delphi technique and decision-making trial and evaluation laboratory (DEMATEL) method has been developed. To pinpoint the crucial barriers in the context of Bangladesh's RMG business, the Delphi approach was employed. Then causal diagram and causal interactions among the barriers are presented by using DEMATEL. By mapping the elements and identifying the hierarchical links between the barriers, the third research question is addressed. This study has chosen the DEMATEL method since it has the capability of mapping the barriers with influential relationships from the imprecise data. Additionally, by employing matrices or graphs, the DEMATEL approach aids in the transformation of causal links between components of a complicated system into a comprehensible structural model (Moktadir *et al.*, 2018). Regarding practical contributions, the findings of the study may aid RMG manufacturers in making decisions about adopting I4.0 and transforming current systems into competitive ones. The Delphi-based DEMATEL model will also help industrial managers to formulate effective strategies for the adoption of I4.0, which can facilitate to improve economic growth. Using a revolutionary approach, this study is one of a kind since it analyzes the barriers to I4.0 transformation in relation to the field.

The remaining parts of the article are organized as follows. Section 2 outlines research background, whereas Section 3 gives the methodological approach. Section 4 shows the results and analysis, and Section 5 discusses the important findings of this research.

The conclusions of the study are discussed in Section 6, along with recommendations for further research.

2. Research background

This section highlights the barriers that affect I4.0 adoption and justifies the use of the Delphi technique and the DEMATEL method.

2.1 Aspects of Industry 4.0 in Bangladesh

Bangladesh has taken steps to use I4.0 technology in its manufacturing and services sectors. Its economy is one of the world's fastest-growing where 50.63% of the country's GDP comes from the service sector, 32.80% from industry and 12.46% from agriculture. However, the industrial sector's share is rising (Manik, 2023). The author Manik (2023) also claims that Bangladesh's economy is shifting in favor of industry. The adoption of I4.0 can enhance the intensifying economic growth and speed up output.

The Bangladesh government passed the National I4.0 Policy in 2020 to bring the manufacturing sector of the country modernized. Advanced technologies are being used by the government, the private sector and start-ups to improve productivity, efficiency and competitiveness (Mazumdar and Alharahsheh, 2020). The policy illustrates how to digitize and automate industrial processes using IoT, AI and Big Data. I4.0 technologies are part of the Digital Bangladesh initiative, which aims to build a digital ecosystem in the country (Mazumdar and Alharahsheh, 2020).

2.2 Bangladeshi garment industry and Industry 4.0

Over the past few decades, the Bangladeshi garment industry has become a prominent player in worldwide textile and apparel market. Bangladesh, a dedicated exporter to the international market for ready-to-wear apparel, shipped $30.1 billion in 2017. There are 4222 RMG industries, and they employ over 4 million people. It produces 14% of the GDP and 81% of the nation's overall export revenue (Summary and History, 2020). Western fast fashion brands are the second-largest export of clothing from Bangladesh (Farhana *et al.*, 2022). These contributions can be enhanced largely by adopting advanced I4.0 technologies. However, the Bangladeshi RMG sector, which employs millions and contributes significantly to the country's GDP (Islam, 2021), is struggling to adopt these technologies. Despite the potential benefits of I4.0, the industry is facing challenges like low productivity, high costs and low-quality products. To stay competitive, the sector must embrace I4.0, and stakeholders should raise awareness, provide infrastructure and support, and create policies to promote its adoption (Karuppiah *et al.*, 2023).

2.3 Barriers to the adoption of Industry 4.0

The I4.0 implementation barriers were explored through the extensive literature review. In order to identify the barriers, the authors conducted a thorough literature review. Between 2012 and 2022, the Scopus database, Web of Science and Google Scholar were used for this literature search. After reviewing the relevant literature, the authors came up with a list of barriers from Calabrese *et al.* (2021), Chen *et al.* (2021), Bhuiyan *et al.* (2020), Tripathi and Gupta (2021), Rumi *et al.* (2020), Cimini *et al.* (2021), Yadav *et al.* (2020a), Moktadir *et al.* (2018), Stentoft *et al.* (2020), Kumar *et al.* (2020a), Shabur *et al.* (2021), Kumar *et al.* (2022), Yadav *et al.* (2020b), Kumar *et al.* (2020b), Weerabahu *et al.* (2022) and Bhuiyan *et al.* (2020), which consists of several barriers to I4.0 implementation. Calabrese *et al.* (2021) claim that to build I4.0 infrastructure, organizations must spend a large amount of money on capital. Moreover, resistance to change is also mentioned as a barrier by the authors. According to Stentoft *et al.* (2020), to foster the development and the usage of I4.0-compatible hardware, equipment makers must adopt standards that are both thorough and widely accepted. Kumar *et al.* (2020a) and Shabur *et al.* (2021) stated that motivation for a company is important to make the transition to green manufacturing and waste management. Cimini *et al.* (2021) and Rumi *et al.* (2020) found that an organization's attitude toward exchanging data and materials inside the company is inadequate. Weerabahu *et al.* (2022) identified digital strategies that consider both the vertical and horizontal parts of the value chain are becoming more and more important to create and use. In the final stage, 15 major barriers to the adoption of I4.0 were selected based on the mentioned articles and professional opinions as shown in Table 1.

2.4 Research gap and contributions of the study

As mentioned in Table 2, several research projects have examined the tactical aspects of adopting I4.0. In these studies, the scholars have come up with a plan for how to adopt digitalization practices in a good way. Several researchers (Bhuiyan *et al.*, 2020; Shabur *et al.*, 2021; Moktadir *et al.*, 2018; Rumi *et al.*, 2020) have investigated this and tried to figure out what the biggest obstacles are. Also, there are studies that give a conceptual clarification of how adopting I4.0 affects a company in terms of performance (Yadav *et al.*, 2020b; Kumar *et al.*, 2020a; Weerabahu *et al.*, 2022). Two studies (Weerabahu *et al.*, 2022; Stentoft *et al.*, 2020) examined how I4.0 affects lean processes and how they affect a company's bottom line, while others studied about how to improve circular performance, i.e. Dantas *et al.* (2021) and Rajput and Singh (2019) describe the challenges and enablers to digitalization that each firm faces. They also describe how each digitalization construct affects the organization's ability to stay in business. Table 2 represents some existing works based on implementation barriers and challenges of I4.0 in different fields.

I4.0's production philosophy requires organizational adjustments in the face of high levels of uncertainty (Gadekar *et al.*, 2022). Researchers are being motivated by this situation to identify and get a better understanding of the barriers that businesses have while attempting to implement I4.0. Despite this, the present study on the subject has been conducted by a large number of people and has concentrated on certain technologies or situations rather than aiming to take a wider and more holistic perspective. Previous research has concentrated on analyzing certain I4.0 technologies, such as blockchain, in an effort to discover their limitations (Tortorella *et al.*, 2023; Ajwani-Ramchandani and Bhattacharya, 2022) even inside the context of a particular sector of the manufacturing industry, such as the automotive sector or of a particular category of businesses, such as small and medium-sized businesses (Wankhede and Vinodh, 2022). I4.0 technologies are transforming organizations' organizational and strategic frameworks. It emphasizes the restructuring of business processes, operational routines and organizational skills, and it has a direct impact on supply chains and their management (Messeni Petruzzelli *et al.*, 2022).

The author has chosen to include studies that cover a range of topics such as the barriers and enablers to digitalization, the link between I4.0 and the performance of the firm in terms of improving circular performance. Additionally, the author includes studies that provide a conceptual definition of how adopting I4.0 affects a company's performance. However, from the viewpoint of emerging economies, no extensive research has been done on the barriers and challenges of I4.0 technology adoption in RMG sectors in Bangladesh by incorporating Delphi technique and DEMATEL methods by using programming code R.

2.5 Rationale behind this study

Recent studies about the RMG sector of Bangladesh have focused on the theoretical side of I4.0 adoption such as Karim and Habiba (2020). However, Summary and History (2020) discussed the problems that are created by the improper implementation of I4.0 in various industries. In the same way, Farhana *et al.* (2022) presented some challenges but the method is

No.	Barriers	Descriptions	References
1	High-level investment	To build I4.0 infrastructure, organizations must spend a large amount of money on capital	Calabrese *et al.* (2021), Chen *et al.* (2021), Bhuiyan *et al.* (2020)
2	Inadequate knowledge management and data knowledge	Requirement for far more resilient knowledge management solutions is driven by the inadequacy of the present systems to process data in real time	Tripathi and Gupta (2021), Rumi *et al.* (2020)
3	Lack of organizational openness	The company's policy on sharing information and content with its workers	Cimini *et al.* (2021), Rumi *et al.* (2020)
4	Lack of digital communication	All levels of management and nonmanagerial staff must communicate effectively and continuously	Yadav *et al.* (2020a), Moktadir *et al.* (2018)
5	Lack of skills and aptitude	Employee skill requirements for adopting I4.0 technologies	Calabrese *et al.* (2021), Stentoft *et al.* (2020)
6	Lack of motivation	Reasons behind the company's shift toward recycling and environmentally friendly production	Kumar *et al.* (2020a), Shabur *et al.* (2021)
7	Organizational culture	Organizational norms and routines that may influence the transition to I4.0	Tripathi and Gupta (2021)
8	I4.0 training	Educating people to become experts in I4.0 technologies	Kumar *et al.* (2020a)
9	Resistance to change	Leadership style and strategy of upper- and lower level managers throughout I4.0 implementation	Kumar *et al.* (2022), Joshi *et al.* (2022), Bhuiyan *et al.* (2020)
10	Effective change management	Capacity of the organization to plan and execute a seamless upgrade to I4.0 from legacy systems	Stentoft *et al.* (2020)
11	Stakeholders' awareness of I4.0 technologies	Meaningful adoption of I4.0 technologies depends on the capacity of many parties to see their value	Kumar *et al.* (2022), Yadav *et al.* (2020b), Bhuiyan *et al.* (2020)
12	Lack of clear comprehension about IoT benefits	Technically, IoT devices should result in potential financial advantages for businesses once completely integrated	Kumar *et al.* (2020b)
13	Inadequate standardization efforts	Equipment makers must implement detailed, generally acknowledged standards to promote I4.0-enabled componentry development and use	Stentoft *et al.* (2020)
14	Lack of regulatory framework	Organizations must have tougher internal standards, codes of behavior, and processes where legislation pertaining to human resources, data protection, computer networks and user experience become more critical	Calabrese *et al.* (2021), Bhuiyan *et al.* (2020)
15	Lack of digital strategy	It is becoming more and more crucial to develop and implement digital strategies that take into account both the vertical and horizontal axes of the value chain	Weerabahu *et al.* (2022)

Source(s): Authors' own contributions

Table 1.
Barriers affecting the implementation of I4.0

different which is the cross-check analysis by comparing the export of the last three decades of Bangladesh RMG sector. Hossain and Uddin (2021) also took the same approach of trend analysis but using a semi-log parabolic trend model. The studies mentioned in this paragraph advised the government and policymakers to take the necessary actions to advance Bangladesh's RMG sector, but it is unclear what factors are impeding its development and

Model	Researcher	Work
DEMATEL	Kumar *et al.* (2020b)	The DEMATEL technique is used to analyze the challenges of using Industry 4.0 to create greener industrial processes
	Nimawat and Gidwani (2021)	Using a DEMATEL technique, barriers to Industry 4.0 may be identified together with their cause-and-effect correlations
TISM	Jain and Ajmera (2021)	This research seeks to identify facilitators for Industry 4.0 deployment in India's manufacturing sector, since literature suggests that the sector is still skeptical
AHP	Sevinc *et al.* (2018)	This study identifies and analyzes Critical Success Enablers (CSEs) that simplify Industry 4.0 deployment. Industry 4.0 implementation weights were calculated using fuzzy AHP (used as a baseline for prioritization of CSEs)
GRA	Yüksel *et al.* (2021)	Evaluation of Industry 4.0 challenges using GRA method
BWM	Moktadir *et al.* (2018)	Impact on process safety and the environment due to challenges in implementing Industry 4.0

Source(s): Authors' own contributions

Table 2. Existing studies related to the implementation of I4.0

how specific industries are having difficulty in implementing I4.0. The purpose of this study is likely to inform policymakers, industry leaders and other stakeholders about the factors that need to be resolved to promote the adoption of I4 technology in the RMG sector in Bangladesh.

3. Research methodology

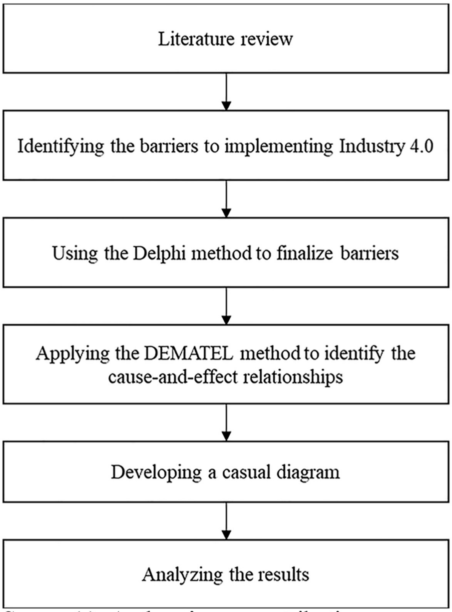
A methodical framework that combines the DEMATEL approach with the Delphi methodology is described in this section. The combination of these two approaches has two objectives. It first makes use of the DEMATEL method's capacity to evaluate the underlying correlations among these barriers and the Delphi technique's effectiveness in successfully identifying barriers. Secondly, it addresses the limitations of both techniques, such as the Delphi technique's challenges in accurately analyzing barriers and the DEMATEL method's limitations in examining initial barriers comprehensively (Taqi *et al.*, 2023). The research framework employed in this study is shown in Figure 1.

3.1 Delphi method

3.1.1 Study design. Validating the barriers identified in this study is crucial as they were derived from the literature, which encompasses diverse situations such as varying geographic contexts, prevalence rates, incidence rates and other factors (Debnath *et al.*, 2023). Hence, the Delphi technique is employed in this study as it allows participants to provide confidential feedback on the viewpoints of others, continually modify their own thoughts, and adjust their opinions iteratively (Wang *et al.*, 2022).

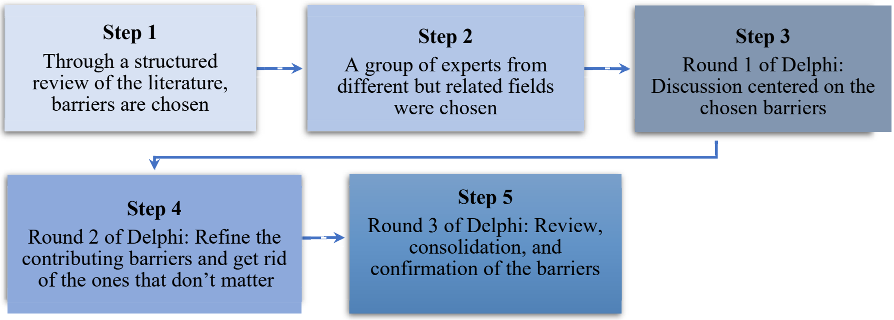
In this study, a three-stage Delphi methodology is used to pinpoint the important barriers affecting I4.0 adoption. Figure 2 (adopted from Taqi *et al.*, 2023) illustrates the involved steps in the three-stage Delphi method. The figure illustrates how a thorough literature study is used to first identify the pertinent barriers. The next step is to choose experts who can offer knowledgeable feedback regarding the barriers that have been discovered as well as add, eliminate and validate the pertinent and irrelevant barriers.

3.1.2 Data collection and validation. During the data validation process, the authors utilized a purposive sampling method to select a group of 13 experts from various industries as well as academic backgrounds (Taqi *et al.*, 2023). The purposive sampling method is a non-probability sampling technique that involves deliberately selecting specific respondents



Source(s): Authors' own contributions

Figure 1.
Research framework used in this study



Source(s): Adopted from Taqi *et al.* (2023)

Figure 2.
Steps of the three-stage Delphi technique

based on their characteristics or attributes that are relevant to the research objective (Ali *et al.*, 2022). To preserve the experts' privacy, their names are not disclosed in this study. The authors assured that the experts they chose had the requisite degree of knowledge for adopting I4.0 by conducting panel sessions. The three standards used to choose the experts were

(1) Expertise in I4.0 adoption from industry or academia,

(2) Sufficient understanding of I4.0 and

(3) Familiarity with the function that people play in the success or failure of new technologies.

The resulting panel of experts includes professors and executives with a combined decade of expertise in I4.0. Table S1 (see Supplementary Material) provides backgrounds of these experts.

The three-stage Delphi technique was used with the experts by a facilitator. Analysis of the variable's applicability in terms of cognitive, psychological and human factor components was done. First, the experts considered the context of I4.0 adoption and reduced the 15 barriers found in the literature review to 13. In the second round, the experts narrowed the list of barriers by concentrating on cognitive and human psychology, and nine barriers were chosen. The experts arrived at ten barriers in the end after adding two barriers and eliminating one, which are given in Table 3. Seven of these ten barriers were chosen from the literature while four additional barriers were included by the experts. The 4 barriers that were included are Lack of skills and aptitude, Lack of digital strategy, I4.0 training and Effective change management. The degree to which upper management works with frontline managers to implement I4.0 technology is known as "cooperation". Faster adoption of I4.0 technology requires collaboration across formerly separate departments. Employee empowerment refers to the degree to which workers are given the authority to make strategic and operational choices about the use of I4.0 technologies. Resistance to I4.0 projects has the potential to slow the organization's widespread adoption of the technology. The last component of strategy orientation toward I4.0 is the dissemination of top-level plans across the company.

Three experts were chosen to assess the relationships matrix within the barriers in order to use the DEMATEL approach. The panel of experts included the head of human resources of a prestigious textile firm, an industrial engineer from the manufacturing sector and a policymaker from the leather industry. The computational steps used by DEMATEL are discussed in the next section.

3.2 DEMATEL method

DEMATEL is a methodology designed to tackle intricate global decision problems by discerning the cause-and-effect relationships among different factors. The technique has garnered extensive acclaim for its effectiveness in addressing immensely intricate decision problems, which has led to its widespread application across various fields and its adaptation for use in multi-criteria decision-making processes (Braga *et al.*, 2021).

The DEMATEL method assesses the relative importance of each barrier and establishes causal connections between them. The DEMATEL method includes the following steps (Taqi *et al.*, 2022):

Code	Barriers	Source
B1	High-level investment	Literature
B2	Lack of skills and aptitude	Experts
B3	Resistance to change	Literature
B4	Lack of motivation	Literature
B5	Stakeholders' awareness of I4.0 technologies	Literature
B6	Lack of digital communication	Literature
B7	Lack of regulatory framework	Literature
B8	Lack of digital strategy	Experts
B9	I4.0 training	Experts
B10	Inadequate knowledge management and data knowledge	Literature

Source(s): Authors' own contributions

Table 3. List of the barriers developed from the experts' input

(1) Constructing the direct-relationship matrix

(2) Normalizing the initial influencing matrix (N)

(3) The calculation of the total relationship matrix (T)

(4) Calculation of the row and column sums from the total relation matrix

(5) Calculation of the overall significance status and net effect values of the barriers

(6) Drawing the diagram of the significant importance/effect of DEMATEL and mapping only relationships over a threshold value

4. Analysis and results

The research presented here identifies the top 10 barriers facing the RMG industry in adopting the practices of I4.0. The DEMATEL approach was employed for the analysis of the interrelationships between the major barriers and to identify the barriers that arise as a direct result of those barriers.

Expert input was used to construct Table 4 in accordance with the direct-relation matrix (step 1). Options were presented to the experts based on a scale of linguistic words. No influence (DM-1), very low influence (DM-2), low influence (DM-3), moderate influence (DM-4), high influence (DM-5) and very high influence (DM-6), as indicated in Table 4. For instance, the effect between barriers B1 and B2 is quite strong, thus the number "6" has been assigned there; likewise, the impact between barriers B4 and B5 is extremely low, so the value "1" has been assigned there. Table 4 summarizes the findings of a direct-relation matrix-based evaluation of the effects of barriers when considered in pairs (the "average matrix" of three experts is available in Supplementary Material in Tables S2, S3 and S4).

Next, the DEMATEL normalization of the direct-relation matrix was computed in R, as per step 2 of the DEMATEL procedure (see Supplementary Material Table S5). Step 3 involves calculating a total-relation matrix with R code (see Supplementary Material Table S6). It evolves by disregarding an initial crucial link in order to acquire a connection of importance. To create the causal diagram, we use the R programming language to define the threshold value (α). The α value is computed as 0.2327744 and is used to differentiate between the major and minor barriers (steps 4 and 5). Barrier values less than the calculated value of 0.2327744 were disregarded in the DEMATEL analysis. In addition, R code was used to

Barriers		Direct relationship matrix B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
High-level investment	B1	*1*	5	4	4	5	1	2	1	1	1
Lack of skills and aptitude	B2	6	*1*	4	5	5	1	2	1	1	1
Resistance to change	B3	1	1	*1*	4	1	3	2	1	1	2
Lack of motivation	B4	1	1	1	*1*	1	2	4	3	5	1
Stakeholders' awareness of I4.0 technologies	B5	1	1	1	1	*1*	1	1	1	4	1
Lack of digital communication	B6	1	1	4	2	1	*1*	2	1	4	1
Lack of regulatory framework	B7	1	1	1	2	1	2	*1*	1	2	1
Lack of digital strategy	B8	1	1	2	1	1	3	4	*1*	5	2
I4.0 training	B9	1	1	4	2	1	3	4	1	*1*	1
Inadequate knowledge management and data knowledge	B10	1	1	4	2	1	3	5	2	1	*1*

Source(s): Authors' own contributions

Table 4. Direct relationship matrix from the experts' input

determine Ci and Ri values, as depicted in Table 5 (step 6). The results of Ci and Ri confirm the degree of relational influence among each key barrier, respectively. Then, the authors formulated (Ri + Ci) and (Ri − Ci) values as shown in Table 5. For example, calculations of (Ri + Ci) and (Ri − Ci) are for B1; the Ci value is 3.065279 and the Ri value is 1.720668, so adding them together is 4.785948 (Ri + Ci) and subtracting them is 1.3446108 (Ri − Ci).

According to Table 5, an effective group is represented by a barrier whose (Ri − Ci) value is less than zero, while a cause group is represented by a barrier whose (Ri − Ci) value is more than zero. Table 5 displays the DEMATEL results that indicate the relationships and levels of effect between the various obstacles to the RMG industry's adoption of I4.0.

The I4.0 training program or B9 is ranked first with an (Ri + Ci) value of 5.302179. Lack of motivation or B4 is rated second with an (Ri + Ci) value of 5.277010. The third-ranked B3 factor, which is Resistance to Change, has an (Ri + Ci) value of 5.108271. These scores are almost equal and fairly close to one another (Ri + Ci). According to the (Ri + Ci) score, the top barriers with a significant effect on other barriers are B9, B4 and B3. They have a significant impact on the RMG industry's adoption of I4.0. B5 or stakeholders' awareness of I4.0 technologies scored the lowest (Ri + Ci) value of 3.616452 of all the barriers making it the least significant one.

Based on (Ri − Ci), the ten components were split into the cause group and the effect group. The barriers with (Ri − Ci) > 0 were classified in the effect category and were predominantly influenced by other barriers, but all those with (Ri − Ci) > 0 were classified as cause barriers and directly influenced the others. Figure 2 illustrates this categorization of cause-and-effect barriers. Four different barriers are identified as cause group in total: B1 (High-level Investment), B2 (Lack of Skills and Aptitude), B8 (Lack of Digital Strategy) and B10 (Inadequate Knowledge Management and Data Knowledge). The causal diagram of the barriers is displayed in Figure 3 and the causal interaction among the barriers is displayed in Figure 4, it can be seen that almost all the barriers have an impact on the barrier I4.0 training (B9). This barrier is the most influential barrier among all the barriers. The literature supports the concept that the deployment of I4.0 presents workers with challenging work environments. The organization should create tailored training programs for current employees so that they perform effectively in the new jobs because previous workers who do not adapt to these abilities will find it difficult to remain in employment. Eventually, the worker will resist to changes and lose motivation (Sony and Naik, 2020). Not only that, Kamruzzaman and Hamid (2020) emphasized on training because direct training to the workplace refers to a person's ability to use the knowledge and skills he has learned in his job. The next two barriers that are affected by the other barriers are lack of motivation (B4) and resistance to change (B3). For the use of smart technologies of I4.0, customer and original

Barriers	Ri	Ci	Ri + Ci	Ri − Ci
B1	1.720668	3.065279	4.785948	1.3446108
B2	1.635663	3.305162	4.940825	1.6694988
B3	3.044043	2.064228	5.108271	−0.9798153
B4	2.905405	2.371605	5.277010	−0.5338002
B5	2.026137	1.590316	3.616452	−0.4358212
B6	2.513985	2.151665	4.665650	−0.3623200
B7	3.256059	1.593371	4.849430	−1.6626874
B8	1.613672	2.472164	4.085836	0.8584924
B9	3.082672	2.219506	5.302179	−0.8631658
B10	1.479131	2.444139	3.923271	0.9650077

Source(s): Authors' own contributions

Table 5. Relationships between criteria

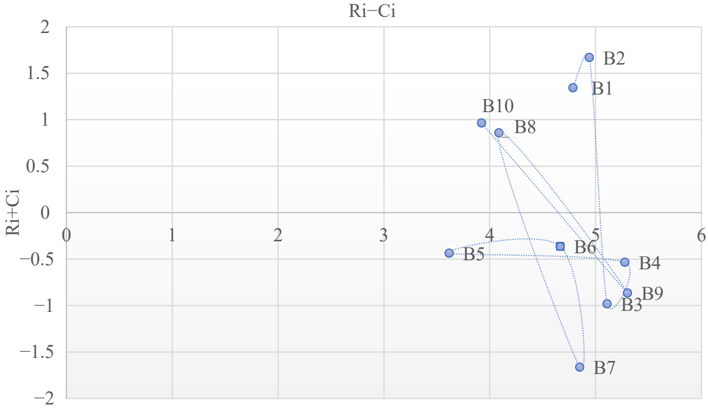


Figure 3. The Casual diagrams of the barriers

Source(s): Authors' own contributions

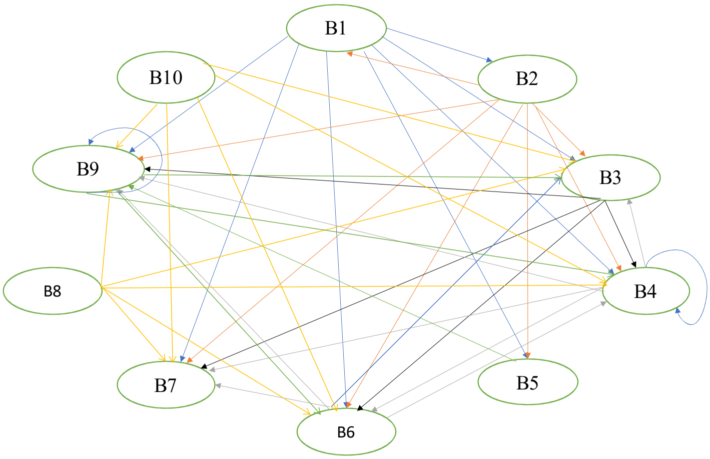


Figure 4. Casual interactions between the barriers

Note(s): B1,B2,B3……….B10 = Code for expressing Barriers

Source(s): Authors' own contributions

equipment manufacturer (Partner), motivation as well as top management support are crucial (Kumar *et al.*, 2020a). Developing proper training program to facilitate the digital communication, required skills and aptitude will motivate the worker to take part in these activities rather than resisting the change (Saraji *et al.*, 2021). The other crucial barriers are lack of digital communication (B6) and lack of regulatory framework (B7) that is changing upon the other barrier interaction.

Further, on the basis of (Ri – Ci) score, B3 (Resistance to Change), B4 (Lack of Motivation), B5 (Stakeholders' Awareness of I4.0 Technologies), B6 (Lack of Digital Communication) and B9 (I4.0 Training) are the barriers which are categorized as "effect group". The implementation of I4.0 is hampered by these barriers influenced by the cause barriers. Lack of Regulatory Framework (B3) is most affected by B1, B2, B8 and B10. It has been found that B3 has been ranked fifth.

Despite working independently, I4.0 technologies have cross-cutting effects on other technologies. Workforce skill development is hampered by the most crucial and important barrier according to our study which is lack of I4.0-related training programs and resources. Without access to sufficient training opportunities, employees could not have the skills and knowledge needed to use digital technologies efficiently and reap their benefits (Kamruzzaman and Hamid, 2020). Secondly, a slow rate of adoption may be caused by stakeholders' lack of drive to implement I4.0 technologies. This is as a result of another important barrier which is lack of knowledge about the potential advantages or a belief that the necessary adjustments are not worthwhile (Mondal *et al.*, 2021). As we can see, the widespread implementation of I4.0 practices in the RMG sector may be slowed down by stakeholder resistance, particularly that of employees and management, to accepting new technologies which is the third important barrier according to our study. This resistance may be brought on by worries about job security, apprehension about technology taking jobs away from people, or a lack of experience with digital systems (Saraji *et al.*, 2021). However, other barriers have also impact on the effective implementation of I4.0 in the RMG industry as well. Such as, the efficient application of I4.0 technology can be hampered by inadequate digital communication practices and infrastructure. Real-time communication and cooperation can be hampered by unreliable Internet connectivity, inappropriate data exchange protocols and improper digital system integration Sony and Naik (2020). For the RMG industry, the absence of a thorough regulatory framework designed specifically for I4.0 might lead to uncertainty and hurdles. Companies may find it difficult to deal with the legal and regulatory framework while using digital technology if there are not any defined standards, rules or procedures. The appropriate management and utilization of the enormous amounts of data produced by I4.0 technologies may provide difficulties for the RMG sector. The industry's capacity to generate practical insights and make well-informed decisions may be constrained by insufficient data management procedures and a lack of data analysis expertise.

5. Discussion of the key findings

These findings could lead to I4.0 transformation that is effective and strategic. In order to understand how to enhance the application of I4.0 and how to accomplish effective I4.0 transformation in businesses, it is vital to identify these elements and analyze the correlations between these aspects and I4.0 transformation. However, there are very few articles that examine all of these elements simultaneously and their degree of significance in I4.0 applications. There are publications in the literature that concentrate on one of the variables that affect I4.0 implementation in RMG sector, particularly I4.0 training. According to some authors (Sony and Naik, 2020; Kamruzzaman and Hamid, 2020), I4.0 training has a crucial impact in the I4.0 transformation. As mentioned in the literature review, modern technologies like robotics, AI and the IoT have become deeply embedded in numerous industries including the RMG sector, so it is necessary to have proper training in order to remain competitive. This leads to another barrier which is lack of skilled human workers (Mondal *et al.*, 2021; Bhuiyan *et al.*, 2020; Stentoft *et al.*, 2020). The demand for knowledge and skills in I4.0 is becoming more diversified and unique than before. The skills and expertise required by I4.0 are frequently lacking among the current workforces. The implementation and integration of technological advances may be hampered by this labor deficit, which would reduce overall industry productivity and competitiveness. Hence, I4.0 training is an influencing factor (i.e. cause) that must be present in order to adopt I4.0. Another significant, decisive aspect in the model is lack of motivation. With each revolution, new production techniques with increasing levels of effectiveness and efficiency are introduced. The amount of human labor and muscle power at work has drastically decreased at every stage of the revolution. Organizational leaders must play a crucial role in connecting the new revolutionary technique to the employees if they are to succeed in this industrial revolution. For the company to be able to give the workers the assistance they require, it is crucial that the job motivation is given the proper acknowledgment and understanding (Saraji *et al.*, 2021; Raj *et al.*, 2020; Kumar *et al.*, 2020a,b). According to Saraji *et al.* (2021) and Raj *et al.* (2020), employees' aversion to change is cited as a hindrance to the widespread implementation of I4.0 in companies. These workers object to utilizing new technologies and the accompanying procedures. The current study's findings have also emphasized on the factor "Resistance to Change" as it is the third-ranked barrier which is affecting I4.0 adoption. The findings of this investigation suggest that barriers such as I4.0 Training, Lack of Motivation and Resistance to Change should be prioritized more when developing plans. The other barriers are also hampering the I4.0 transformation of RMG sector. According to Sony and Naik (2020) by facilitating intelligent operations and thorough integration between technical advancements, production and enterprise systems, digital communication can add significant value for businesses in the manufacturing sector. Big data that is open and accessible could help managers exploit Industry 4.0 advancements for a sustainable transition, but this is impossible without greater data quality, which in turn necessitates better management of data and data skills (Saraji *et al.*, 2021). Creating, transforming and utilizing these kinds of digital technologies will need a large financial outlay from each of the aforementioned sectors, making this component the most crucial (Bhuiyan *et al.*, 2020). It's critical to understand the barriers that influence an organization's I4.0 transformation in order to overcome these challenges (Bhuiyan *et al.*, 2020). This paper assesses which elements are influential for the transition of Bangladesh's RMG sector to I4.0 so that it can help businesses assess their preparation for the I4.0 revolution and the barriers on which they should concentrate. This study becomes more significant in this context in order to determine which barriers businesses should focus on for the I4.0 transformation.

The authors have noticed that the outcomes under various circumstances do not significantly change. It demonstrates how reliable our model is. I4.0 adoption of Bangladesh RMG sector is primarily influenced by three barriers. The first (B9) is I4.0 training which can lead to a skilled workforce while the second (B3) is lack of motivation of the industries for this transformation. The third one (B3) is resistance to change that is indicating people preferring the traditional method for production by ignoring the potential of I4.0 transformation and the drastic change that it can bring to this sector. The rest of the barriers are being influenced by these three barriers. However, the technique used in this study enabled them to be combined, producing a framework that all the decision-makers involved could utilize to recognize and comprehend cause-and-effect links between groups of decision criteria.

6. Concluding remarks, limitations and future research scopes

In summary, the adoption of I4.0 is essential for the continued viability of the manufacturing sector in developing nations like Bangladesh. This is because of its impact on both competitiveness and sustainability. This research offers managers, decision-makers and policymakers information that will allow them to adopt I4.0 more effectively in their industries without incurring an excessive amount of financial strain.

6.1 Main findings of the study

The purpose of this study was to provide a taxonomy of the most significant barriers to the widespread adoption of I4.0 and their hierarchical relationship, as well as the important evaluation criteria and implementation priorities for the RMG industries in Bangladesh. The findings demonstrate that I4.0 training, lack of motivation and resistance to change are the most important barriers for I4.0 adoption. Additionally, this study contributes to the existing domain of research on I4.0 adoption in emerging economies. While the barriers to I4.0 adoption have been widely studied, this study specifically focused on the RMG industry of Bangladesh, which is the largest industrial sector in the country. The findings of this research provide valuable insights into the barriers that are critical for successful I4.0 adoption in this context, and how these barriers are interrelated. The Delphi technique and DEMATEL method used in this study provide a systematic approach for decision-makers (such as company owners, managers and executive body) to assess and prioritize the barriers for I4.0 adoption in their organizations. The decision support framework developed in this study can be used as a guide for the RMG industry of Bangladesh and other similar industries in developing countries to evaluate the importance of each factor in their context and prioritize their implementation.

6.2 Theoretical implications of the study

The proposed research has several theoretical implications. Such as, it can provide a literary contribution to I4.0 implementation by identifying and ranking the barriers in the context of developing countries. This study can provide a framework for researchers to investigate the implementation of I4.0 in other developing economies. On the hand, this research can add to the existing knowledge of the impact of I4.0 on the RMG industry, which is one of the largest manufacturing sectors in many developing countries. In addition, this study can help to reconcile the differences between theoretical perspectives and practical implementation of I4.0.

6.3 Managerial implications of the study

The research that is being suggested has a number of important practical consequences for managers and decision-makers in the RMG business as well as in other industries that are quite comparable. Firstly, it can provide them with a roadmap to implement I4.0 by identifying and ranking the critical barriers. Secondly, this research can help managers to evaluate the impact of I4.0 on their business processes and operations, which can lead to increased efficiency, productivity and competitiveness. Thirdly, this study can aid managers in making wise resource allocation choices for I4.0 adoption, particularly in contexts with limited resources. Lastly, this research can guide policymakers to formulate strategies that facilitate the implementation of I4.0 in the RMG industry and other similar sectors.

6.4 Limitations of the study and future research directions

While the study did yield some interesting findings, it did have several drawbacks that should be taken into account. Firstly, the study's findings might not apply to other businesses or nations because it solely examined Bangladesh's RMG sector. Secondly, the study did not consider the potential cultural and social barriers that could impact the adoption of I4.0 in the RMG industry of Bangladesh. Although this study sheds fresh light on the barriers of I4.0 in relation to the RMG industry, it is limited by the inherent difficulties in collecting and validating relevant data. As only ten barriers are considered in this study, the model could be improved by considering additional barriers in future research. The model is built and checked for accuracy based on the advice of experts, therefore it may include some biasness as well.

There are several areas for future research that could build on the findings of this study. Firstly, the study could be extended to include other industries in Bangladesh or other developing countries to explore the barriers and drivers of I4.0 adoption in different contexts. Secondly, future studies may concentrate on the potential cultural and social barriers that could impact the adoption of I4.0 in the RMG industry of Bangladesh. Thirdly, future research could investigate the economic, environmental and social impacts of I4.0 adoption in the RMG industry and other similar industries. In addition, future research could explore the potential for public–private partnerships and government support to facilitate the implementation of I4.0 in the RMG industry and other similar industries in developing countries. Future research can extend this study to include other industries and explore the challenges and drivers of I4.0 implementation. In addition, other multi-criteria decision-making approaches such that Grey-based TISM approach, Fuzzy TISM and Fuzzy DEMATEL can be used further.

Last but not least, our research can aid in the long-term success of the RMG sector by shedding light on the crucial barriers standing in the way of the widespread implementation of Industry 4.0 in developing countries.

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Further reading

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Supplementary material

Expert	Size of industry	Experience level (years)	Professional role	Type of organization
1	Large	21	Manufacturing director	Sewing thread manufacturing company
2	Large	17	Vice president, HR tech and talent development	High-tech company
3	Medium	16	Assistant director, supply chain department	Fast-moving consumer goods company
4	Small	13	Head of procurement	Ready-made garments manufacturer
5	Small	12	Operations manager	Steel manufacturing company
6	Medium	11	Production and shop floor control manager	Fast-moving consumer goods company
7	Medium	14	Researcher	University
8	Large	10	Product development manager	Adhesive and packaging company
9	Small	11	Researcher	University
10	Medium	12	Environment, health and safety manager	Consumer goods company
11	Large	16	Operation specialist	Energy corporation
12	Medium	14	Category manager	Ready-made garments manufacturer
13	Medium	11	Quality production leader	Sports equipment manufacturer

Source(s): Authors' own contributions

Table S1. Experts' profiles used for the study

Barriers		Decision matrix B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
High-level investment	B1	*1*	5	6	4	4	1	2	1	1	1
Lack of skills and aptitude	B2	6	*1*	3	5	5	1	1	1	1	1
Resistance to change	B3	1	1	*1*	2	1	2	2	1	1	1
Lack of motivation	B4	1	1	1	*1*	1	2	2	3	4	1
Stakeholders' awareness of I4.0 technologies	B5	1	1	1	1	*1*	1	1	1	2	1
Lack of digital communication	B6	1	1	4	2	1	*1*	2	1	2	1
Lack of regulatory framework	B7	1	1	1	2	1	1	*1*	1	2	1
Lack of digital strategy	B8	1	1	2	1	1	5	2	*1*	4	2
I4.0 training	B9	1	1	4	2	1	5	4	1	*1*	1
Inadequate knowledge management and data knowledge	B10	1	1	4	2	1	3	4	2	1	*1*

Source(s): Authors' own contributions

Table S2. Direct relationship matrix from expert 1

Table S3. Direct relationship matrix from expert 2

Barriers		Decision matrix B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
High-level investment	B1	*1*	4	2	3	6	1	2	1	1	1
Lack of skills and aptitude	B2	6	*1*	5	5	4	1	2	1	1	1
Resistance to change	B3	1	1	*1*	4	1	4	2	1	1	2
Lack of motivation	B4	1	1	1	*1*	1	2	4	3	6	1
Stakeholders' awareness of I4.0 technologies	B5	1	1	1	1	*1*	1	1	1	4	1
Lack of digital communication	B6	1	1	4	2	1	*1*	1	1	6	1
Lack of regulatory framework	B7	1	1	1	2	1	2	*1*	1	3	1
Lack of digital strategy	B8	1	1	1	1	1	1	4	*1*	6	1
I4.0 training	B9	1	1	2	1	1	3	4	1	*1*	1
Inadequate knowledge management and data knowledge	B10	1	1	4	2	1	3	6	3	1	*1*

Source(s): Authors' own contributions

Table S4. Direct relationship matrix from expert 3

Barriers		Decision matrix B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
High-level investment	B1	*1*	6	4	5	5	1	2	1	1	1
Lack of skills and aptitude	B2	6	*1*	4	5	6	1	3	1	1	1
Resistance to change	B3	1	1	*1*	6	1	3	2	1	1	3
Lack of motivation	B4	1	1	1	*1*	1	2	6	3	5	1
Stakeholders' awareness of I4.0 technologies	B5	1	1	1	1	*1*	1	1	1	6	1
Lack of digital communication	B6	1	1	4	2	1	*1*	3	1	4	1
Lack of regulatory framework	B7	1	1	1	2	1	3	*1*	1	1	1
Lack of digital strategy	B8	1	1	3	1	1	3	6	*1*	5	3
I4.0 training	B9	1	1	6	3	1	1	4	1	*1*	1
Inadequate knowledge management and data knowledge	B10	1	1	4	2	1	3	5	1	1	*1*

Source(s): Authors' own contributions

Table S5. Normalized_matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.03704	0.18519	0.14815	0.14815	0.18519	0.03704	0.07407	0.03704	0.03704	0.03704
B2	0.22222	0.03704	0.14815	0.18519	0.18519	0.03704	0.07407	0.03704	0.03704	0.03704
B3	0.03704	0.03704	0.03704	0.14815	0.03704	0.11111	0.07407	0.03704	0.03704	0.07407
B4	0.03704	0.03704	0.03704	0.03704	0.03704	0.07407	0.14815	0.11111	0.18519	0.03704
B5	0.03704	0.03704	0.03704	0.03704	0.03704	0.03704	0.03704	0.03704	0.14815	0.03704
B6	0.03704	0.03704	0.14815	0.07407	0.03704	0.03704	0.07407	0.03704	0.14815	0.03704
B7	0.03704	0.03704	0.03704	0.07407	0.03704	0.07407	0.03704	0.03704	0.07407	0.03704
B8	0.03704	0.03704	0.07407	0.03704	0.03704	0.11111	0.14815	0.03704	0.18519	0.07407
B9	0.03704	0.03704	0.14815	0.03704	0.03704	0.11111	0.14815	0.03704	0.03704	0.03704
B10	0.03704	0.03704	0.14815	0.03704	0.03704	0.11111	0.18519	0.07407	0.03704	0.03704

Source(s): Authors' own contributions

Table S6. Normalized_initial_direct_relation_matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.2117044	0.3300919	0.4132269	0.4215564	0.3789951	0.2610551	0.3621570	0.1882032	0.3254405	0.1728489
B2	0.3847274	0.2164606	0.4348109	0.4750297	0.3966792	0.2778822	0.3861918	0.2014260	0.3489313	0.1830231
B3	0.1383112	0.1339898	0.2235320	0.3198940	0.1538404	0.2668728	0.2811330	0.1432706	0.2392726	0.1641117
B4	0.1521854	0.1474305	0.2559388	0.2360998	0.1692724	0.2606146	0.3829634	0.2217216	0.4028064	0.1425720
B5	0.1169201	0.1132670	0.1876678	0.1745280	0.1300475	0.1613338	0.1973300	0.1128375	0.2893110	0.1070730
B6	0.1422579	0.1378132	0.3399231	0.2636259	0.1582302	0.2078547	0.2870239	0.1412470	0.3391338	0.1345554
B7	0.1170580	0.1134006	0.1844793	0.2101465	0.1302009	0.1949255	0.1956802	0.1155925	0.2247175	0.1071701
B8	0.1567244	0.1518277	0.3045712	0.2497942	0.1743210	0.3038069	0.3904836	0.1538735	0.4041467	0.1826152
B9	0.1453201	0.1407797	0.3408910	0.2688486	0.1616362	0.2805848	0.3571741	0.1442452	0.2428117	0.1372151
B10	0.1554594	0.1506022	0.3590024	0.2858823	0.1729140	0.2990548	0.4159217	0.1912547	0.2661008	0.1479469

Source(s): Authors' own contributions

Table S7.
Total influence_matrix

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
B1	0.211704	*0.330092*	*0.413227*	*0.421556*	*0.378995*	*0.261055*	*0.362157*	0.188203	*0.325441*	0.172849
B2	*0.384727*	0.216461	*0.434811*	*0.47503*	*0.396679*	*0.277882*	*0.386192*	0.201426	*0.348931*	0.183023
B3	0.138311	0.13399	0.223532	*0.319894*	0.15384	*0.266873*	*0.281133*	0.143271	*0.239273*	0.164112
B4	0.152185	0.147431	*0.255939*	*0.2361*	0.169272	*0.260615*	*0.382963*	0.221722	*0.402806*	0.142572
B5	0.11692	0.113267	0.187668	0.174528	0.130048	0.161334	0.19733	0.112838	*0.289311*	0.107073
B6	0.142258	0.137813	*0.339923*	*0.263626*	0.15823	0.207855	*0.287024*	0.141247	*0.339134*	0.134555
B7	0.117058	0.113401	0.184479	0.210147	0.130201	0.194926	0.19568	0.115593	0.224718	0.10717
B8	0.156724	0.151828	*0.304571*	*0.249794*	0.174321	*0.303807*	*0.390484*	0.153874	*0.404147*	0.182615
B9	0.14532	0.14078	*0.340891*	*0.268849*	0.161636	*0.280585*	*0.357174*	0.144245	*0.242812*	0.137215
B10	0.155459	0.150602	*0.359002*	*0.285882*	0.172914	*0.299055*	*0.415922*	0.191255	*0.266101*	0.147947

Note(s): The italics values are greater than the threshold value (α). The α value is computed as 0.2327744
Source(s): Authors' own contributions