

Article

Investigating the Readiness Factors for Industry 4.0 Implementation for Manufacturing Industry in Egypt

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Abstract: The fourth industrial revolution, or Industry 4.0 (I4.0) is receiving more attention from academics, business leaders, and manufacturers. However, few readiness assessments are currently available that address the difficulties and needs associated with implementing I4.0 to help companies understand how to get ready for an organizational transformation towards I4.0, particularly in developing economies such as Egypt. Accordingly, the current study aims to identify the readiness factors for I4.0 implementation in the industrial sector in the Egyptian context. Quantitative research methodologies were used in this study. The exploratory and deductive approach was used in this study because its goal is to analyse the readiness factors for implementation of I4.0 for Egypt's industrial sector. Descriptive statistics, *t*-test and ANOVA test were used to ascertain the significant difference between the respondents' profile factors and the readiness factors for the implementation of I4.0 in the various industrial sectors. A questionnaire was specifically delivered to Egyptian manufacturing companies. The structural self-interaction matrix (SSIM) approach was conducted to assess and rank the readiness factors of I4.0 implementation as well as examine their hierarchical effects. Then, analytic hierarchy process (AHP) analysis was performed to rank the importance of readiness factors in a different sector. The readiness factors were further analysed using the interpretive structural modelling (ISM) approach for analysis, which was applied by developing a causal relationship between the factors under study through employees' opinions. This was performed after filtering the most significant readiness factors for industry implementation. This study identified fifteen I4.0 readiness elements that could hasten the technology's implementation in Egypt's manufacturing industry and the degree of influence of each element on I4.0 implementation in Egypt within a different culture, sector, and economy from that previously evaluated. The three most critical readiness criteria for implementing I4.0 in the Egyptian manufacturing sector were identified as level of knowledge, management support, and financial support. Results gleaned from the research will help the manufacturing industry be well-prepared for implementation of I4.0. The results of the ISM approach indicated that the factors of financial support, level of knowledge, and management support and leadership are always considered as influencing factors on all other factors. On the other hand, the factors of agility in manufacturing, compatibility with existing technology, and smart factory are always dependent on other factors, such as collaboration and transparency, strategy and organization, and supply chain management and collaboration, in addition to lean, sustainability, and government supportive policies as well as competitiveness, customer-focused innovativeness, financial support, level of knowledge, management support and leadership, and leadership and dealing with insecurity.

Keywords: Industry 4.0; readiness factors; manufacturing industry; Egypt



Citation: Khourshed, N.F.; Elbarky, S.S.; Elgamal, S. Investigating the Readiness Factors for Industry 4.0 Implementation for Manufacturing Industry in Egypt. *Sustainability* **2023**, *15*, 9641. <https://doi.org/10.3390/su15129641>

Academic Editor: Wen-Hsien Tsai

Received: 8 April 2023

Revised: 8 June 2023

Accepted: 10 June 2023

Published: 15 June 2023



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1. Introduction

For economists, industrialists, and researchers, the fourth industrial revolution is becoming more and more significant [1]. In 2011, the German federal government mentioned the “new manufacturing phase” in a speech at the Hannover Messe. The objective was to revolutionize industries through the application of digital and Internet technology to established industries, as well as to advance the German economy using high-tech methods [2].

Industry 4.0 refers to the digital manufacturing system created by the efficient union of methods, information technology, and industrial processes [3]. Its distinctive traits include the Internet of Things (IoT), cyber security, augmented reality, cloud computing, big data, and other technological foundations [4] as well as clustering validity index (CVIs) for fuzzy clustering [5]. I4.0 implementation success is dependent on technological prowess and strategic adaptability, both of which require highly educated and qualified personnel to manage these technologies [2]. I4.0 has gained a lot of traction in both academia and industry, and businesses around the world are investing a lot of money in their efforts to figure out how to take advantage of this evolving paradigm of technology-based manufacturing [6].

Shorter lead times and costs, collaboration with environmental sustainability and worker safety, and small batch customization are a few performance improvements that I4.0 could assist with implementing. Other performance improvements include cost reduction, improved product quality, superior flexibility, better responsiveness, and shortened lead times [1,7–9]). Moreover, it is being promoted as a means of boosting productivity, promoting economic growth, and guaranteeing the long-term viability of industrial businesses [10].

However, certain factors, particularly in manufacturing firms in emerging nations, may make I4.0 implementation less successful. These factors include a general decline in technological intensity, a lack of available investment capital, and a shortage of human resources [11]. Adopting I4.0 presents hurdles for manufacturing businesses [12] Even though I4.0 is becoming more and more popular, many businesses are still having trouble figuring out how to apply its high-tech methods to their daily work [13,14]. Furthermore, operational excellence should be considered, which is economically feasible while also offsetting the high cost that precludes the implementation of I4.0 principles aimed at sustainable development [15].

The above lines suggest that there is no agreement on the factors that impact I4.0 implementation. Few readiness assessments are currently available that address the difficulties and particular needs associated with implementing I4.0. These assessments can help companies understand how to get ready for an organizational transformation towards I4.0, particularly in developing economies such as Egypt. As a result, the most current literature examines the aspects that contribute to I4.0 preparedness. There are few research articles that contribute to the meagre amount of knowledge on I4.0 readiness. As a conclusion, the main aim of this study is to test the circumstances that will allow I4.0 to be implemented in Egypt’s industrial sector. In other words, it is necessary to understand how to plan for an organizational shift toward I4.0, particularly in developing economies such as Egypt. Accordingly, the main question of the study is developed, as follows: what are the readiness criteria for I4.0 deployment within the Egyptian manufacturing sector?

The current study employs I4.0 because Egypt is starting to rely on I4.0 because of its realization of the use of artificial intelligence applications in manufacturing. However, most Egyptian firms are still transitioning or still need to transition from Industry 2.0 to Industry 3.0. The current study employs Industry 4.0 because Egypt is starting to rely on I4.0.

2. Literature Review

Different technologies have been grouped by academics into sets and implementation frameworks e.g., [1,16–20]. The major goals of I4.0 are to address process-related problems that can be technologically solved, such as labour-intensive manual quality controls, to

enable improvements in the value streams of businesses. This is true regardless of how these frameworks differ and how their technologies are categorized.

Because I4.0 is a global revolution, both larger organizations and small and medium-sized firms are utilizing it [21]. However, it runs into issues including miscommunications [22] issues with data ownership, concerns about cyber security, a lack of adequate infrastructure [23], etc. Businesses must consequently make plans for I4.0 and evaluate their systemic levels of preparation.

According to a [24] study, there are nine benefits and seven drawbacks to applying I4.0 in businesses. Furthermore, it is vital to recognize that industrialized economies are better able to implement I4.0 in the manufacturing sector than emerging ones [16,25]. Similarly, I4.0 research is regionally skewed in favour of a more western viewpoint, according to [21]. The Ministry of Communications and Information Technology and the Ministry of Trade and Industry [26] witnessed the signing of a Memorandum of Understanding between the Industrial Modernization Center (IMC), Siemens Egypt, and the Information Technology Industry Development Agency (ITIDA), to establish and equip Egypt's first Industry 4.0 Innovation Center (IIC) and use technologies from the fourth industrial revolution in smart factories. Additionally, this was performed while offering crucial support for encouraging industrial innovation and the development of intelligent factories in a way that encourages knowledge transfer and the growth of the regional industrial sector [27].

Additionally, Egypt took part in a webinar on 8 June 2021, which was presented by the United Nations Industrial Development Organization and was titled "Industry 4.0 in Egypt: Improving the Readiness for the Implementation of Industry 4.0". The Information Technology Industry Development Agency (ITIDA) acted as Egypt's representative. The webinar was being planned in anticipation of Egypt's entry into the five-year United Nations Industrial Development Organization (UNIDO) Program for Country Partnership (PCP) on 1 April 2021. By growing the application of I4.0 technologies in significant industrial areas such as chemicals, electronics, food, textiles, leather, furniture, and handicrafts, the PCP aims to enhance Egypt's inclusive and sustainable industrialization. The Program assists Egypt in pursuing its industrial development objectives, which are described in the Sustainable Development Strategy: Egypt Vision 2030, to position Egypt as a regional leader in cutting-edge electrical advancements [26]. Egypt has also increased its spending on digital infrastructure dramatically, committing \$1.6 billion for this reason. However, the UNIDO stated in their report (20–24) that most Egyptian firms are still transitioning or still need to transition from Industry 2.0 to Industry 3.0. Egypt ranked 68th out of 100 countries and 9th out of 13 Middle East and North Africa (MENA) countries on the "Drivers of Production" tracker, which evaluates the key enablers that position a country to capitalize on industrial automation, in the latest World Economic Forum's Readiness for the Future of Production Report (2018). Also, the industrial robot density stands at less than 0.2 robots per thousand manufacturing workers in Egypt which is significantly lower than MENA countries such as Tunisia, where density is 5x higher, and Turkey, where it is 10x higher, according to UNIDO.

The author [25] examined the components that will allow I4.0 to reach ecological-economic-social high gains in SC using the example of an emerging economy. Six things were determined to be components of cause groups: government supportive policies; infrastructure and IT-based facility development; management support and effective governance; collaboration and transparency among SC participants; improved information sharing system and resource development; and workforce knowledge and expertise in resource management. The three factors that were designated as effect group factors are competitiveness, reduction in waste, and implementation of novel business models. The topic at hand is whether manufacturing firms view those factors as ones that should be implemented across different cultures, industries, and economies.

In manufacturing across European Union (EU) nations, [28] measured the presence of the elements that make up I4.0. The analysis shows that each nation's readiness for I4.0 may be measured by two factors: the presence of digital infrastructure and the ability to

analyse large amounts of data. Five homogenous groupings of nations were discovered at the EU level, demonstrating significant disparities between nations. According to [29] the shift to I4.0 necessitates both the digitization of whole value chains and the organizational integration of numerous IT-based new technologies. Smaller manufacturers can, however, start the I4.0 transformation by digitizing a few operational areas to complement their primary business strategy.

The paragraphs above imply that there is still no agreement on the factors that enable the implementation of I4.0. Few readiness assessments are currently available that address the difficulties and particular needs associated with implementing I4.0. These assessments can help companies understand how to get ready for an organizational transformation towards I4.0, particularly in developing economies such as Egypt. As a result, the most current literature examines the aspects that contribute to I4.0 preparedness. There are not many research articles that supplement the limited corpus of information on I4.0 readiness.

Additionally, some demands are connected to I4.0 in the literature more frequently than others, according to [30]. What will be the benefits for manufacturing enterprises in a new culture, different industry, and different economy is the subject at hand. Later, [31] defined 15 readiness elements for the I4.0 application in SMEs to facilitate its deployment. The conclusions drawn from this study focus on SMEs in the manufacturing sector. Therefore, with organizations from different domains, the observations can drastically vary. What will be the ranking within various cultures, industries of varying sizes and economies is the question at hand. Similarly, [21] assessed SMEs' preparation for I4.0 by modifying the IMPULS model and assigning scores to SMEs' preparation for I4.0. The question is what will be the score of each of those dimensions in manufacturing companies within a different culture, different size of the industry, and different economy?

A model for the strategic misalignment of information systems was later developed [32] and it identifies three stages of misalignment that must be fixed before the vision for the smart industrial revolution can be realized. The I4.0 preparedness model, according to [33] contains ten dimensions before I4.0 implementation in the manufacturing industry can start. These dimensions are: technology readiness, leadership and top management support, I4.0 organizational strategy readiness, organization culture, digitalization of SC, innovative I4.0 business model, employee adaptability, and the digital transformation of the organization. The question is what will be the rank of each of those dimensions in manufacturing companies within a different culture, different size of the industry, and different economy?

To successfully adopt I4.0, 10 key success elements have been established by [34]. Organizations can use this study as a reference point on how to implement I4.0 into their operations and maintain sustainability throughout the process. On the other hand, the research conducted by [35] may serve as a guide for businesses as they choose whether to implement I4.0 early or late, based on their understanding of the performance implications. Later, [36] identified three learning development clusters—beginners, in transition, and advanced—to explain how learning development occurs in firms implementing I4.0. They found a stagnant learning pattern in cluster two and an upward learning tendency in clusters one and three. In addition, [37] developed a model that incorporates essential I4.0 features as indicators for its implementation regarding the nature of causal interactions among the essential I4.0 environmental factors, particularly in developing countries such as India's manufacturing industries, to assist industries to move towards an I4.0 implementation by being aware of their status.

However, numerous experts had noted several I4.0 technology drawbacks [9]. For instance, [38] noted that there is concern about the decline in employment prospects due to the replacement of human labour by robots. In addition, senior management's absence from decision-making processes for I4.0 sustainable SC management practices is another issue [39]. Alternatively, staff members and participants in the SC may not fully comprehend the advantages of technology [40]. Despite the positive synergy between I4.0 and sustainable manufacturing practices, firms must carefully evaluate how to include

economic and environmental concerns in the implementation of their industrial strategy plans. When it comes to operations sustainable management, it is important to pinpoint the crucial success aspects that could facilitate this procedure [41]. Also, due to the conflicting objectives of several service providers, including network, resource, and storage, scheduling on the edge computing platform is difficult. Running various apps on the edge platform also requires considering the user expenditures as well as the provider revenues [42].

3. Research Problem

As was previously said, the foundation of I4.0 technologies is network communication and fast connectivity, which enable the utilization of a massive and varied amount of data (big data) to support management in a unique way [18]. That raised an important question, how does each organization realize whether it is ready to transform to I4.0 especially within developing economies such as Egypt? I4.0 implementation would be different from developed and developing countries depending on the type of government [21]. According to the previous section, there are few readiness assessments available that cover I4.0 challenges and can help firms understand how to prepare for an organizational transformation to I4.0, particularly in developing economies such as Egypt.

Hence, the research gap could be summarized as follows: few researchers have studied the readiness assessments and specific requirements of I4.0 implementation for the industrial sector inside Egypt as a developing country. Accordingly, the current study aims to identify the readiness factors for I4.0 implementation in the industrial sector in the Egyptian context and the degree of influence of each element on I4.0 implementation in Egypt within a different culture, sector, and economy than previously evaluated.

The researcher will merge the drivers [25], prerequisites [30], ranking [31], scores [21], and ranking of the manufacturing sector [33] to formulate readiness assessments tool within a different culture, different size of the industry, and different economy than the one tested before. There are some common dimensions between the four studies and there are some that are unique to each study (as shown in Table 1). The researcher will also add an open-ended question to allow participants to add other factors. Then they will check the ranking/importance readiness factors within the manufacturing industry in Egypt.

Table 1. Readiness factor for implementation of I4.0.

Readiness Factor	Description	Reference
1. Level of knowledge “Comfortability of technology use”	- Employee skill set Employees have all the necessary abilities in a variety of key areas. - Do IT personnel have new cloud computing technologies prepared? - Skill acquisition Hired sufficient qualified staff or ongoing training of present employees. - Training Development programmes for the workforce.	[21,25,30,43–46]
2. Smart factory “Development of infrastructure and IT-based facilities”	- Equipment infrastructure - Systems and machines can be virtually entirely controlled by IT and are totally integrated (M2M) - Data usage Have high speed internet connectivity and capacity. - IT systems IT systems support and unify all company processes.	[21,25,47,48]

Table 1. Cont.

Readiness Factor	Description	Reference
3. Hardware and software connection	Because most industries, particularly those in developing nations, lack advanced technology, it is important to have a communication infrastructure that can handle high data traffic.	[25,30,43,45,49]
4. Dealing with insecurity	• Cloud usage Have a firewall for data security. Have a culture that prioritizes externalizing data privacy. • IT security For all pertinent sectors, IT security solutions have been put in place. • Autonomous Autonomous process is used in selected areas or even cross enterprise.	[21,50]
5. Compatibility with existing technology	Technology from the past and present must be able to coexist without any issues.	[28,51]
6. Management support and leadership “Business strategies”	The organization’s top management is expected to offer a strategy to make sure that the goals of the company are compatible with the implementation of new technologies.	[25,30,47,52–54]
7. Agility in manufacturing	Flexibility in output quantity and product variety.	[30,48,49]
8. Financial support	• Financial aid Multiple aids. • Financial resources Have financial capacity for cloud investments. • Funding strategy Well established strategy towards investing in I4.0.	[21,30,50,54]
9. Competitiveness	Companies may decide to move forward with the implementation of breakthrough technologies under the influence of competition or pressure from business partners.	[25,51]
10. Global engagement	Global connections can aid with a better understanding of the challenges faced by enterprises on their digital journey.	[48,55]
11. Supply-chain management and collaboration	Excellent cooperation and connectedness throughout the entire flow.	[56]
	Understanding of the advantages of technology is shared by both SC partners and employees.	[9,40]
	Senior management involvement in decision-making for sustainable SC management techniques using I4.0.	[9,39]
	Considering both economic and environmental considerations when implementing industrial strategy.	[9,41]
	Concern over the decline of employment possibilities and the workforce.	[9,38]
12. Customer-focused innovativeness	Focusing on cutting-edge products and solutions based on client needs without sacrificing efficiency to uphold positive customer relationships	[51,55,57]
13. Sustainability	To ensure a sustainable structure of production and consumption.	[58]

Table 1. Cont.

Readiness Factor	Description	Reference
14. Strategy and organization	Strategy An I4.0 strategy has been implemented enterprise wide.	[21]
	Innovation management Uniform, interdepartmental innovation management has been established.	[21]
15. Data-driven services	Data-driven services The business model fully incorporates data-driven services (integration with the customers).	[21]
	Share of data used. More than 50% of collected data is used.	[21,30]
16. Government supportive policies	- Strong government policy and support are essential. - When selecting how to integrate I4.0-driven sustainable projects into a business, governance structure is key.	[25,52,59]
17. Collaboration and transparency	Businesses need to foster excellent member coordination and collaboration.	[25,58]
18. Lean	One of the initial actions that should be conducted in a firm before I4 should be continuous improvement.	[30,44]

Accordingly, the originality of the current study is investigating the readiness assessments and requirements of I4.0 implementation inside the industrial sector in Egypt, which represents a guide for the Egypt government and companies to transfer to I4.0.

4. Research Method

To review the literature, this study reviewed articles, survey reports, paradigmatic books, and master and doctoral theses from multiple data sources, including Emerald Insight and Science Direct [60]. This research can be characterized as exploratory and deductive because its goal is to analyse the readiness factors for implementation of I4.0 for Egypt's industrial sector. Table 2 shows the different steps applied in the methodical approach.

Table 2. The different steps in the methodical approach.

Steps	Literature Review	Pilot Study	Questionnaire	Experts Session
Purpose	To investigate what makes the Egyptian industrial sector ready for the introduction of I4.0.	To test the reliability and validity of questionnaire.	To gather data regarding employees' perception about each of the readiness factor within their factories for I4.0 implementation and to recognize the obstacles from participants' point of view.	To rank the importance of each of the readiness factors obtained and determine their influential effect on each other.
Data source	Literature review on relevant literature to I4.0 in various industries especially manufacturing industry.	The data collected from 120 employees (by asking 2 or 3 employees at one company).	The data collected from 632 employees at Egyptian manufacturing organizations.	Thirty experts were considered in a session to fill in the matrix for SSIM modelling.
Outcome	18 factors for implementation of I4.0.	Finding that the questionnaire is reliable and valid so distributed to the rest of companies.	Finding that the most crucial preparation elements for the implementation of I4.0 in Egypt are level of knowledge, financial support, and management support.	Readiness factors were ranked according to their importance and their influential effect considering their driving and independence powers.

To formulate readiness assessments tool within a different culture, different size of the industry, and different economy then tested before, face and content validity were applied by introducing the questionnaire to 10 academics and practitioners in the field to discuss the readiness factor for adopting I4.0. To support the internal validity, only questions that are pertinent to the goal of this study were asked, while questions that are not relevant were removed as they might be inappropriate and unsuitable questions. This

technique, according to [61], is appropriate because it examines both causes and meanings. The questionnaire information was gathered via a structured questionnaire distributed via email and Google Forms. To improve the validity of the research findings, multiple informants from each company were used. The quota sampling technique was used to reach the sample size determined by Saunders equations [62] for a sample size of 95% confidence level for an infinite number population, as there is no sampling frame for the manufacturing industry in Egypt.

Six hundred and thirty-two questionnaires were collected in total (two or three for each organization that took part in the study) from the supply, production, marketing, and information technology departments (as shown in Table 3). All these departments were utilized by Egyptian industrial firms at some point between December 2021 and April 2022. The survey is divided into four components. The first portion requests demographic data, including the participant's name (optional), gender, age, and the type of organization.

Table 3. Descriptive statistics for respondent profile.

Item	Frequency	Percentage	Total
Gender			
Male	519	82.1%	632
Female	113	17.9%	
Age group			
Less than 40 years	395	62.5%	632
40–less than 50 years	157	24.8%	
50–less than 60 years	30	4.7%	
60 years or more	50	7.9%	
Sector			
Food	76	12.0%	632
Automotive and spare parts	77	12.2%	
Iron and steel	75	11.9%	
Pharma	78	12.3%	
Oil/gas	82	13.0%	
Chemical	72	11.4%	
Electronics and electrics	84	13.3%	
Other industries	88	13.9%	
Number of employees			
Between 0 and 9 employees	178	28.2%	632
Between 10 and 49 employees	345	54.6%	
Between 50 and 249 employees	97	15.3%	
>250 employees	12	1.9%	
Have you heard of the Industry 4.0 concept?			
Yes	484	76.6%	632
No	148	23.4%	

From Table 3, four research hypotheses were developed, which will be discussed in the analysis section. These hypotheses are shown as follows:

H1: Readiness factors of I4.0 implementation change from males to females.

H2: As age groups change, readiness factors of I4.0 implementation change.

H3: Readiness factors of I4.0 implementation change among different sectors.

H4: There is a significant difference in readiness factors of I4.0 implementation among different numbers of employees.

Information about the opinions of the workers regarding each readiness criterion in their factories for the implementation of I4.0 was gathered using the questionnaire's second component. The Likert scale is laid out as follows: 1 means not at all, 2 means minimally, 3 means slightly, 4 means significantly, and 5 means extremely. Only variables with a mean value of three or above were chosen for further investigation. The questionnaire's final portion was made to help participants recognize their own challenges. Finally, the fourth section is intended to fill up the matrix based on the relative relevance of the preparedness elements for I4.0 implementation as identified by respondents. The questionnaire statements are shown in Table 4.

Table 4. Survey for the readiness factor for implementation of I4.0.

1. "Comfortability of technology use"
The IT team was ready for the new cloud computing technology
Hiring sufficient competent employees
Have development programs for the workforce
2. Smart factory
Systems and machines can be virtually entirely controlled by IT and are totally integrated
Possess the ability and connectivity for high-speed internet
IT systems are integrated and assist all business processes
3. Hardware and software connection
A communication network that can handle heavy data traffic
4. Dealing with insecurity
Have a firewall for data security
Have a culture that prioritizes externalizing data privacy
For all pertinent sectors, IT security solutions have been put in place
Autonomous process is used in selected areas or even cross enterprise
5. Compatibility with existing technology
The ability of new and old technology to merge
6. Management support and leadership
The organization's goals are ensured by top management's plan
7. Agility in manufacturing
Flexibility in terms of output volume and product diversity
8. Financial support
Have multiple financial aids
Have financial capacity for cloud investments
Have well established strategy towards investing in I4.0
9. Competitiveness
Influence of rivalry and pressure from business partners on brand image
10. Global engagement
Have connections across the globe

Table 4. *Cont.*

11. Supply-chain management and collaboration
Have effective collaboration and connectivity throughout the process flow
Make sure that everyone in the SC, including the staff, is aware of the advantages of technology
Senior management uses I4.0 to engage in decision-making processes for sustainable SC management strategies
Include consideration of economic and environmental factors when implementing your industrial strategy
Being concerned about the decline in employment possibilities and labour force
12. Customer-focused innovativeness
Concentrating on cutting-edge products and solutions based on client needs
13. Sustainability
Organization is sustainable with existing operations
14. Strategy and organization
An I4.0 strategy has been implemented
Innovation management has been established
15. Data-driven services
The business model fully incorporates data-driven services.
More than 50% of collected data is used
16. Government supportive policies
Have strong government support and policies
17. Collaboration and transparency
Have strong coordination and collaboration among members
18. Lean
Lean 4.0 elements support improvement in I4.0 theme
19. Other obstacles that could hinder the I4.0 implementation

Source: modified by researcher.

5. Results and Findings

This section shows the process of data analysis, where the analysis was performed using SPSS version 23. The researcher used a descriptive analysis to explain the respondent profile characteristics in addition to using validity and reliability tests to test the statements in the survey questionnaire used in this study. Then, the ISM analysis approach was used to rank the readiness factors and to ascertain the dependence of these factors. Finally, AHP analysis was used to rank these factors separately in each sector individually. This section is divided into sub-sections as follows.

5.1. T-Test and ANOVA Test

To examine whether there are differences in answers based on demographics, the *t*-test and ANOVA test were used (as shown in Table 5). A *t*-test was first used to examine the variation in responses by gender. From the analysis a significant difference (less than 0.05) was noticed between the genders in coping with insecurity, compatibility with current technology, competitiveness, sustainability, and lean, but not in the other categories.

Table 5. *T*-test of gender variable.

	Gender	N	Mean	Std. Deviation	Std. Error Mean	Sig.
LK	Male	519	4.6763	0.63309	0.02779	0.412
	Female	113	4.6991	0.59589	0.05606	
SF	Male	519	3.7033	0.45725	0.02007	0.377
	Female	113	3.6814	0.46800	0.04403	
HSC	Male	519	2.0983	0.71388	0.03134	0.852
	Female	113	2.0885	0.72651	0.06834	
DWI	Male	519	4.5260	0.55472	0.02435	0.014
	Female	113	4.6283	0.52090	0.04900	
CWET	Male	519	3.7823	0.41310	0.01813	0.038
	Female	113	3.7345	0.44356	0.04173	
MSL	Male	519	4.4123	0.61788	0.02712	0.320
	Female	113	4.5221	0.58397	0.05494	
AM	Male	519	3.9017	0.29796	0.01308	0.953
	Female	113	3.9027	0.29775	0.02801	
FS	Male	519	4.6859	0.61167	0.02685	0.661
	Female	113	4.6991	0.59589	0.05606	
COM	Male	519	4.3738	0.60800	0.02669	0.030
	Female	113	4.3717	0.68393	0.06434	
GL	Male	519	2.1888	0.62678	0.02751	0.512
	Female	113	2.1504	0.67110	0.06313	
SCMC	Male	519	4.0366	0.65510	0.02876	0.561
	Female	113	4.0354	0.68046	0.06401	
CFI	Male	519	4.3738	0.71320	0.03131	0.619
	Female	113	4.3097	0.70811	0.06661	
SUS	Male	519	4.1503	0.35770	0.01570	0.000
	Female	113	4.0796	0.27195	0.02558	
SO	Male	519	4.1387	0.34600	0.01519	0.399
	Female	113	4.1239	0.33093	0.03113	
DDS	Male	519	2.0019	0.52541	0.02306	0.373
	Female	113	2.0000	0.56695	0.05333	
GSP	Male	519	4.3333	0.52234	0.02293	0.293
	Female	113	4.3717	0.53776	0.05059	
CT	Male	519	4.0443	0.63669	0.02795	0.358
	Female	113	3.9912	0.61956	0.05828	
L	Male	519	4.2254	0.47449	0.02083	0.009
	Female	113	4.1593	0.43438	0.04086	

According to the results, it was proved that the first hypothesis “There is a significant difference in readiness factors of I4.0 implementation among different genders” is partially supported.

Age had no discernible impact on any of the research variables, according to the results of an ANOVA test used to evaluate this relationship (as shown in Table 6).

Table 6. ANOVA test of age group.

		N	Mean	Std. Dev.	Std. Error	Significance
LK	Less than 40 years	395	4.6684	0.63637	0.03202	0.537
	40–less than 50 years	157	4.6624	0.62588	0.04995	
	50–less than 60 years	30	4.8000	0.55086	0.10057	
	60 years or more	50	4.7600	0.59109	0.08359	
	Total	632	4.6804	0.62621	0.02491	
SF	Less than 40 years	395	3.7063	0.45602	0.02294	0.178
	40–less than 50 years	157	3.7325	0.44408	0.03544	
	50–less than 60 years	30	3.6333	0.49013	0.08949	
	60 years or more	50	3.5800	0.49857	0.07051	
	Total	632	3.6994	0.45890	0.01825	
HSC	Less than 40 years	395	2.0911	0.71375	0.03591	0.847
	40–less than 50 years	157	2.1338	0.72586	0.05793	
	50–less than 60 years	30	2.0333	0.71840	0.13116	
	60 years or more	50	2.0600	0.71171	0.10065	
	Total	632	2.0965	0.71559	0.02846	
DWI	Less than 40 years	395	4.5494	0.54677	0.02751	0.759
	40–less than 50 years	157	4.5096	0.57309	0.04574	
	50–less than 60 years	30	4.6000	0.56324	0.10283	
	60 years or more	50	4.5800	0.49857	0.07051	
	Total	632	4.5443	0.54983	0.02187	
CWET	Less than 40 years	395	3.7747	0.41832	0.02105	0.310
	40–less than 50 years	157	3.8089	0.39441	0.03148	
	50–less than 60 years	30	3.7000	0.46609	0.08510	
	60 years or more	50	3.7000	0.46291	0.06547	
	Total	632	3.7737	0.41874	0.01666	
MSL	Less than 40 years	395	4.4329	0.60239	0.03031	0.637
	40–less than 50 years	157	4.3949	0.63809	0.05092	
	50–less than 60 years	30	4.5333	0.62881	0.11480	
	60 years or more	50	4.4800	0.61412	0.08685	
	Total	632	4.4320	0.61295	0.02438	
AM	Less than 40 years	395	3.9013	0.29868	0.01503	0.524
	40–less than 50 years	157	3.9236	0.26654	0.02127	
	50–less than 60 years	30	3.8667	0.34575	0.06312	
	60 years or more	50	3.8600	0.35051	0.04957	
	Total	632	3.9019	0.29769	0.01184	
FS	Less than 40 years	395	4.6785	0.61324	0.03086	0.580
	40–less than 50 years	157	4.6688	0.62418	0.04981	
	50–less than 60 years	30	4.8000	0.55086	0.10057	
	60 years or more	50	4.7600	0.55549	0.07856	
	Total	632	4.6883	0.60844	0.02420	

Table 6. Cont.

		N	Mean	Std. Dev.	Std. Error	Significance
COM	Less than 40 years	395	4.3772	0.61039	0.03071	0.522
	40–less than 50 years	157	4.3439	0.62750	0.05008	
	50–less than 60 years	30	4.3000	0.65126	0.11890	
	60 years or more	50	4.4800	0.67733	0.09579	
	Total	632	4.3734	0.62168	0.02473	
GL	Less than 40 years	395	2.1848	0.62419	0.03141	0.731
	40–less than 50 years	157	2.2102	0.65076	0.05194	
	50–less than 60 years	30	2.1000	0.66176	0.12082	
	60 years or more	50	2.1200	0.65900	0.09320	
	Total	632	2.1820	0.63455	0.02524	
SCMC	Less than 40 years	395	4.0532	0.64494	0.03245	0.737
	40–less than 50 years	157	4.0318	0.68332	0.05453	
	50–less than 60 years	30	3.9667	0.66868	0.12208	
	60 years or more	50	3.9600	0.69869	0.09881	
	Total	632	4.0364	0.65916	0.02622	
CFI	Less than 40 years	395	4.3722	0.70942	0.03570	0.926
	40–less than 50 years	157	4.3567	0.71623	0.05716	
	50–less than 60 years	30	4.3667	0.76489	0.13965	
	60 years or more	50	4.3000	0.70711	0.10000	
	Total	632	4.3623	0.71216	0.02833	
SUS	Less than 40 years	395	4.1570	0.36423	0.01833	0.214
	40–less than 50 years	157	4.1146	0.31962	0.02551	
	50–less than 60 years	30	4.1333	0.34575	0.06312	
	60 years or more	50	4.0600	0.23990	0.03393	
	Total	632	4.1377	0.34481	0.01372	
SO	Less than 40 years	395	4.1367	0.34398	0.01731	0.420
	40–less than 50 years	157	4.1210	0.32719	0.02611	
	50–less than 60 years	30	4.2333	0.43018	0.07854	
	60 years or more	50	4.1200	0.32826	0.04642	
	Total	632	4.1361	0.34314	0.01365	
DDS	Less than 40 years	395	1.9873	0.53539	0.02694	0.846
	40–less than 50 years	157	2.0191	0.52467	0.04187	
	50–less than 60 years	30	2.0333	0.55605	0.10152	
	60 years or more	50	2.0400	0.53299	0.07538	
	Total	632	2.0016	0.53261	0.02119	
GSP	Less than 40 years	395	4.3722	0.51449	0.02589	0.093
	40–less than 50 years	157	4.2484	0.53895	0.04301	
	50–less than 60 years	30	4.3667	0.55605	0.10152	
	60 years or more	50	4.3600	0.52528	0.07429	
	Total	632	4.3402	0.52491	0.02088	

Table 6. Cont.

		N	Mean	Std. Dev.	Std. Error	Significance
CT	Less than 40 years	395	4.0177	0.62290	0.03134	0.657
	40–less than 50 years	157	4.0828	0.66950	0.05343	
	50–less than 60 years	30	3.9667	0.61495	0.11227	
	60 years or more	50	4.0600	0.61974	0.08764	
	Total	632	4.0348	0.63350	0.02520	
L	Less than 40 years	395	4.2177	0.44856	0.02257	0.944
	40–less than 50 years	157	4.2166	0.52279	0.04172	
	50–less than 60 years	30	4.1667	0.46113	0.08419	
	60 years or more	50	4.2000	0.45175	0.06389	
	Total	632	4.2136	0.46793	0.01861	

According to the results, it was proved that the second hypothesis “There is a significant difference in readiness factors of I4.0 implementation among different age groups” is not supported.

From the ANOVA test, it was also shown that results did not change through different sectors (as shown in Table 7).

Table 7. ANOVA test of sector.

		N	Mean	Std. Dev.	Std. Error	p-Value
LK	Food	76	4.6842	0.59353	0.06808	0.756
	Automotive and spare parts	77	4.5974	0.69320	0.07900	
	Iron and steel	75	4.7600	0.56569	0.06532	
	Pharma	78	4.6795	0.61356	0.06947	
	Oil/gas	82	4.7073	0.61840	0.06829	
	Chemical	72	4.5972	0.70531	0.08312	
	Electronics and electrics	84	4.7024	0.63587	0.06938	
	Other industries	88	4.7045	0.59033	0.06293	
	Total	632	4.6804	0.62621	0.02491	
SF	Food	76	3.7368	0.44327	0.05085	0.667
	Automotive and spare parts	77	3.6883	0.46622	0.05313	
	Iron and steel	75	3.6667	0.47458	0.05480	
	Pharma	78	3.7051	0.45894	0.05196	
	Oil/gas	82	3.7073	0.45779	0.05055	
	Chemical	72	3.6806	0.46953	0.05534	
	Electronics and electrics	84	3.7738	0.42088	0.04592	
	Other industries	88	3.6364	0.48380	0.05157	
	Total	632	3.6994	0.45890	0.01825	
HSC	Food	76	2.1184	0.76537	0.08779	0.830
	Automotive and spare parts	77	2.1688	0.71456	0.08143	
	Iron and steel	75	2.1067	0.68917	0.07958	
	Pharma	78	2.1410	0.63908	0.07236	

Table 7. Cont.

		N	Mean	Std. Dev.	Std. Error	p-Value
HSC	Oil/gas	82	1.9756	0.70230	0.07756	0.830
	Chemical	72	2.0972	0.71522	0.08429	
	Electronics and electrics	84	2.0952	0.73827	0.08055	
	Other industries	88	2.0795	0.76145	0.08117	
	Total	632	2.0965	0.71559	0.02846	
DWI	Food	76	4.5658	0.52499	0.06022	0.611
	Automotive and spare parts	77	4.5974	0.51961	0.05921	
	Iron and steel	75	4.5333	0.57735	0.06667	
	Pharma	78	4.6410	0.53390	0.06045	
	Oil/gas	82	4.4756	0.59266	0.06545	
	Chemical	72	4.5417	0.57989	0.06834	
	Electronics and electrics	84	4.5000	0.50300	0.05488	
	Other industries	88	4.5114	0.56719	0.06046	
	Total	632	4.5443	0.54983	0.02187	
CWET	Food	76	3.8158	0.39023	0.04476	0.297
	Automotive and spare parts	77	3.7532	0.43395	0.04945	
	Iron and steel	75	3.7333	0.44519	0.05141	
	Pharma	78	3.7692	0.42405	0.04801	
	Oil/gas	82	3.7927	0.40788	0.04504	
	Chemical	72	3.7778	0.41866	0.04934	
	Electronics and electrics	84	3.8571	0.35203	0.03841	
	Other industries	88	3.6932	0.46382	0.04944	
	Total	632	3.7737	0.41874	0.01666	
MSL	Food	76	4.4868	0.62168	0.07131	0.641
	Automotive and spare parts	77	4.4675	0.64040	0.07298	
	Iron and steel	75	4.4133	0.61717	0.07126	
	Pharma	78	4.5385	0.59636	0.06752	
	Oil/gas	82	4.3902	0.64322	0.07103	
	Chemical	72	4.3889	0.57053	0.06724	
	Electronics and electrics	84	4.4167	0.60536	0.06605	
	Other industries	88	4.3636	0.60991	0.06502	
	Total	632	4.4320	0.61295	0.02438	
AM	Food	76	3.9079	0.29110	0.03339	0.563
	Automotive and spare parts	77	3.9351	0.24803	0.02827	
	Iron and steel	75	3.9067	0.29286	0.03382	
	Pharma	78	3.8846	0.32155	0.03641	
	Oil/gas	82	3.9024	0.29855	0.03297	
	Chemical	72	3.9167	0.27832	0.03280	
	Electronics and electrics	84	3.9286	0.25909	0.02827	
	Other industries	88	3.8409	0.36786	0.03921	
	Total	632	3.9019	0.29769	0.01184	

Table 7. Cont.

		N	Mean	Std. Dev.	Std. Error	p-Value
FS	Food	76	4.6974	0.56615	0.06494	0.796
	Automotive and spare parts	77	4.6234	0.62910	0.07169	
	Iron and steel	75	4.7600	0.54127	0.06250	
	Pharma	78	4.6923	0.60961	0.06903	
	Oil/gas	82	4.7195	0.61412	0.06782	
	Chemical	72	4.5972	0.70531	0.08312	
	Electronics and electrics	84	4.7024	0.61663	0.06728	
	Other industries	88	4.7045	0.59033	0.06293	
	Total	632	4.6883	0.60844	0.02420	
COM	Food	76	4.4079	0.63619	0.07298	0.996
	Automotive and spare parts	77	4.3636	0.62637	0.07138	
	Iron and steel	75	4.3733	0.63189	0.07296	
	Pharma	78	4.3205	0.61356	0.06947	
	Oil/gas	82	4.3902	0.62373	0.06888	
	Chemical	72	4.3611	0.61221	0.07215	
	Electronics and electrics	84	4.3810	0.63823	0.06964	
	Other industries	88	4.3864	0.61461	0.06552	
	Total	632	4.3734	0.62168	0.02473	
GL	Food	76	2.2105	0.67953	0.07795	0.884
	Automotive and spare parts	77	2.1948	0.68899	0.07852	
	Iron and steel	75	2.1600	0.63756	0.07362	
	Pharma	78	2.1667	0.61193	0.06929	
	Oil/gas	82	2.0854	0.61265	0.06766	
	Chemical	72	2.2083	0.60369	0.07115	
	Electronics and electrics	84	2.2381	0.59352	0.06476	
	Other industries	88	2.1932	0.65842	0.07019	
	Total	632	2.1820	0.63455	0.02524	
SCMC	Food	76	4.0395	0.64168	0.07361	0.721
	Automotive and spare parts	77	4.0260	0.66834	0.07616	
	Iron and steel	75	4.0000	0.69749	0.08054	
	Pharma	78	3.9744	0.68328	0.07737	
	Oil/gas	82	3.9878	0.63817	0.07047	
	Chemical	72	4.0000	0.69201	0.08155	
	Electronics and electrics	84	4.1190	0.60926	0.06648	
	Other industries	88	4.1250	0.65763	0.07010	
	Total	632	4.0364	0.65916	0.02622	
CFI	Food	76	4.2895	0.79692	0.09141	0.281
	Automotive and spare parts	77	4.4545	0.65985	0.07520	
	Iron and steel	75	4.3333	0.64375	0.07433	
	Pharma	78	4.4231	0.73005	0.08266	
	Oil/gas	82	4.3780	0.69638	0.07690	

Table 7. Cont.

		N	Mean	Std. Dev.	Std. Error	p-Value
CFI	Chemical	72	4.5000	0.69201	0.08155	0.281
	Chemical	72	4.5000	0.69201	0.08155	
	Electronics and electrics	84	4.3095	0.76009	0.08293	
	Other industries	88	4.2386	0.69471	0.07406	
	Total	632	4.3623	0.71216	0.02833	
SUS	Food	76	4.1579	0.36707	0.04211	0.937
	Automotive and spare parts	77	4.1429	0.35222	0.04014	
	Iron and steel	75	4.1333	0.34222	0.03952	
	Pharma	78	4.1026	0.30535	0.03457	
	Oil/gas	82	4.1098	0.31451	0.03473	
	Chemical	72	4.1528	0.36230	0.04270	
	Electronics and electrics	84	4.1667	0.37492	0.04091	
	Other industries	88	4.1364	0.34514	0.03679	
	Total	632	4.1377	0.34481	0.01372	
SO	Food	76	4.0921	0.29110	0.03339	0.691
	Automotive and spare parts	77	4.1948	0.39865	0.04543	
	Iron and steel	75	4.1200	0.32715	0.03778	
	Pharma	78	4.1282	0.33648	0.03810	
	Oil/gas	82	4.1341	0.34291	0.03787	
	Chemical	72	4.1111	0.31648	0.03730	
	Electronics and electrics	84	4.1667	0.37492	0.04091	
	Other industries	88	4.1364	0.34514	0.03679	
	Total	632	4.1361	0.34314	0.01365	
DDS	Food	76	2.1184	0.54079	0.06203	0.338
	Automotive and spare parts	77	1.9091	0.54246	0.06182	
	Iron and steel	75	2.0000	0.43496	0.05022	
	Pharma	78	2.0256	0.48280	0.05467	
	Oil/gas	82	1.9878	0.55542	0.06134	
	Chemical	72	1.9861	0.48912	0.05764	
	Electronics and electrics	84	2.0476	0.57884	0.06316	
	Other industries	88	1.9432	0.59419	0.06334	
	Total	632	2.0016	0.53261	0.02119	
GSP	Food	76	4.3158	0.52181	0.05986	0.886
	Automotive and spare parts	77	4.3896	0.51697	0.05891	
	Iron and steel	75	4.3467	0.53254	0.06149	
	Pharma	78	4.3590	0.48280	0.05467	
	Oil/gas	82	4.2805	0.47854	0.05285	
	Chemical	72	4.3889	0.57053	0.06724	
	Electronics and electrics	84	4.3452	0.52627	0.05742	
	Other industries	88	4.3068	0.57452	0.06124	
	Total	632	4.3402	0.52491	0.02088	

Table 7. Cont.

		N	Mean	Std. Dev.	Std. Error	p-Value
CT	Food	76	3.9605	0.68197	0.07823	0.941
	Automotive and spare parts	77	4.0390	0.67749	0.07721	
	Iron and steel	75	4.0800	0.60983	0.07042	
	Pharma	78	4.0256	0.62365	0.07061	
	Oil/gas	82	4.0122	0.55542	0.06134	
	Chemical	72	4.0278	0.60450	0.07124	
	Electronics and electrics	84	4.0952	0.68757	0.07502	
	Other industries	88	4.0341	0.63334	0.06751	
	Total	632	4.0348	0.63350	0.02520	
L	Food	76	4.2105	0.47091	0.05402	0.920
	Automotive and spare parts	77	4.2727	0.47673	0.05433	
	Iron and steel	75	4.1867	0.45599	0.05265	
	Pharma	78	4.2179	0.41552	0.04705	
	Oil/gas	82	4.2195	0.44512	0.04916	
	Chemical	72	4.1944	0.49330	0.05814	
	Electronics and electrics	84	4.2381	0.48144	0.05253	
	Other industries	88	4.1705	0.50791	0.05414	
	Total	632	4.2136	0.46793	0.01861	

According to the results, it was proved that the first hypothesis “There is a significant difference in readiness factors of I4.0 implementation among different sectors” is not supported.

The ANOVA test was also applied to test the changes that occurred through different companies with different numbers of employees (as shown in Table 8). According to the number of employees, the research revealed a substantial difference with management support, leadership, and sustainability, but not with the other variables.

Table 8. ANOVA test of number of employees.

		N	Mean	Std. Dev.	Std. Error	Sig.
LK	1.00	178	4.6124	0.68169	0.05110	0.062
	2.00	345	4.6725	0.62874	0.03385	
	3.00	97	4.8144	0.48584	0.04933	
	4.00	12	4.8333	0.57735	0.16667	
	Total	632	4.6804	0.62621	0.02491	
SF	1.00	178	3.7191	0.45071	0.03378	0.332
	2.00	345	3.7072	0.45569	0.02453	
	3.00	97	3.6598	0.47624	0.04835	
	4.00	12	3.5000	0.52223	0.15076	
	Total	632	3.6994	0.45890	0.01825	

Table 8. Cont.

		N	Mean	Std. Dev.	Std. Error	Sig.
HSC	1.00	178	2.0674	0.74101	0.05554	0.353
	2.00	345	2.1130	0.70832	0.03813	
	3.00	97	2.0515	0.68269	0.06932	
	4.00	12	2.4167	0.79296	0.22891	
	Total	632	2.0965	0.71559	0.02846	
DWI	1.00	178	4.5337	0.55387	0.04151	0.220
	2.00	345	4.5188	0.56065	0.03018	
	3.00	97	4.6495	0.50086	0.05085	
	4.00	12	4.5833	0.51493	0.14865	
	Total	632	4.5443	0.54983	0.02187	
CWET	1.00	178	3.8315	0.37540	0.02814	0.136
	2.00	345	3.7594	0.42806	0.02305	
	3.00	97	3.7320	0.44524	0.04521	
	4.00	12	3.6667	0.49237	0.14213	
	Total	632	3.7737	0.41874	0.01666	
MSL	1.00	178	4.3652	0.63452	0.04756	0.050
	2.00	345	4.4232	0.61051	0.03287	
	3.00	97	4.5773	0.57437	0.05832	
	4.00	12	4.5000	0.52223	0.15076	
	Total	632	4.4320	0.61295	0.02438	
AM	1.00	178	3.8989	0.30234	0.02266	0.585
	2.00	345	3.9130	0.28218	0.01519	
	3.00	97	3.8660	0.34244	0.03477	
	4.00	12	3.9167	0.28868	0.08333	
	Total	632	3.9019	0.29769	0.01184	
FS	1.00	178	4.6404	0.64216	0.04813	0.063
	2.00	345	4.6696	0.62490	0.03364	
	3.00	97	4.8144	0.48584	0.04933	
	4.00	12	4.9167	0.28868	0.08333	
	Total	632	4.6883	0.60844	0.02420	
COM	1.00	178	4.4213	0.59849	0.04486	0.112
	2.00	345	4.3275	0.61942	0.03335	
	3.00	97	4.4124	0.67319	0.06835	
	4.00	12	4.6667	0.49237	0.14213	
	Total	632	4.3734	0.62168	0.02473	
GL	1.00	178	2.2079	0.60744	0.04553	0.381
	2.00	345	2.1797	0.64443	0.03469	
	3.00	97	2.1134	0.62710	0.06367	
	4.00	12	2.4167	0.79296	0.22891	
	Total	632	2.1820	0.63455	0.02524	

Table 8. Cont.

		N	Mean	Std. Dev.	Std. Error	Sig.
SCMC	1.00	178	4.1292	0.61077	0.04578	0.159
	2.00	345	4.0087	0.65808	0.03543	
	3.00	97	3.9691	0.71376	0.07247	
	4.00	12	4.0000	0.85280	0.24618	
	Total	632	4.0364	0.65916	0.02622	
CFI	1.00	178	4.4607	0.68982	0.05170	0.127
	2.00	345	4.3391	0.71390	0.03844	
	3.00	97	4.2887	0.72109	0.07322	
	4.00	12	4.1667	0.83485	0.24100	
	Total	632	4.3623	0.71216	0.02833	
SUS	1.00	178	4.1742	0.38031	0.02851	0.007
	2.00	345	4.1507	0.35830	0.01929	
	3.00	97	4.0412	0.19987	0.02029	
	4.00	12	4.0000	0.00000	0.00000	
	Total	632	4.1377	0.34481	0.01372	
SO	1.00	178	4.1629	0.37034	0.02776	0.551
	2.00	345	4.1188	0.32407	0.01745	
	3.00	97	4.1443	0.35325	0.03587	
	4.00	12	4.1667	0.38925	0.11237	
	Total	632	4.1361	0.34314	0.01365	
DDS	1.00	178	1.9663	0.49744	0.03728	0.362
	2.00	345	1.9971	0.55247	0.02974	
	3.00	97	2.0619	0.51669	0.05246	
	4.00	12	2.1667	0.57735	0.16667	
	Total	632	2.0016	0.53261	0.02119	
GSP	1.00	178	4.3708	0.53955	0.04044	0.411
	2.00	345	4.3449	0.53362	0.02873	
	3.00	97	4.2887	0.47782	0.04851	
	4.00	12	4.1667	0.38925	0.11237	
	Total	632	4.3402	0.52491	0.02088	
CT	1.00	178	4.0562	0.60804	0.04557	0.518
	2.00	345	4.0029	0.63107	0.03398	
	3.00	97	4.1031	0.66903	0.06793	
	4.00	12	4.0833	0.79296	0.22891	
	Total	632	4.0348	0.63350	0.02520	
L	1.00	178	4.2191	0.47808	0.03583	0.764
	2.00	345	4.2145	0.47657	0.02566	
	3.00	97	4.1856	0.41658	0.04230	
	4.00	12	4.3333	0.49237	0.14213	
	Total	632	4.2136	0.46793	0.01861	

According to the results, it was proved that the first hypothesis “There is a significant difference in readiness factors of I4.0 implementation among different numbers of employees” is partially supported.

5.2. Data Testing Using Validity and Reliability for the Research Variables

In this section, it is discussed whether the statements that were utilized to gauge the study’s variables were accurate. The validity and reliability of the questionnaire were investigated in a pilot study using 120 questionnaires. After being determined to be reliable and valid, the questionnaire was made available to the other companies. The analysis was evaluated using SPSS version 23.0.

The practice of checking data for accuracy and dependability is known as data validation. The validity test is thought to be the most important need for a good test. When a test’s validity is high, it means that the test’s objective is directly addressed by the questions. The two main criteria used to assess validity are that average variance extracted (AVE) should be >0.5 and factor loading (FL) should be greater than 0.4 for each item.

Furthermore, a crucial aspect of test quality is the dependability test. This shows how consistently a measurement is applied. The test performs better the higher the reliability. Examining the Cronbach’s alpha value is the most typical dependability test. [63] asserts that reliability increases as the reliability coefficient approaches 1.0. Reliability coefficients of less than 0.60 are often thought to be poor, those between 0.70 and 0.80 to be acceptable, and those >0.80 to be excellent. A total of 632 valid questionnaires made up the study’s sample size.

It can be observed that all the relevant Cronbach’s alpha values are >0.7 (as shown in Table 9). This indicates that, when the statements of each construct are combined to form this construct, they are reliable.

Table 9. Validity and reliability for research variables.

Variable	Statement	Factor Loading	AVE	Cronbach’s Alpha
Level of Knowledge	LK1	0.991	98.239%	0.991
	LK2	0.979		
	LK3	0.977		
Smart Factory	SF1	0.787	83.670%	0.901
	SF2	0.810		
	SF3	0.913		
Dealing with Insecurity	DWI1	0.753	68.566%	0.847
	DWI2	0.746		
	DWI3	0.551		
	DWI4	0.693		
Financial Support	FS1	0.938	92.570%	0.960
	FS2	0.922		
	FS3	0.917		
Supply Chain Management and Collaboration	SCMC1	0.871	89.171%	0.970
	SCMC2	0.919		
	SCMC3	0.906		
	SCMC4	0.886		
	SCMC5	0.877		

Table 9. Cont.

Variable	Statement	Factor Loading	AVE	Cronbach's Alpha
Strategy and Organization	SO1	0.860	85.964%	0.827
	SO2	0.860		
Data-Driven Services	DDS1	0.950	94.956%	0.947
	DDS2	0.950		

5.3. Principal Component Analysis

The analysis method known as PCA reduces the dimensionality of a dataset while retaining as much “variability” (i.e., statistical data) as possible. As a descriptive tool, PCA does not require any distributional assumptions and is thus essentially an adaptable exploratory method that may be applied to numerical data of various types [64]. Table 10 shows the rotated component matrix of PCA.

Table 10. Principal component analysis.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
LK1	0.985														
LK2	0.975														
LK3	0.972														
SF1			0.879												
SF2			0.851												
SF3			0.953												
HSC					0.929										
DWI1				0.419			0.822								
DWI2				0.923											
DWI3							0.932								
DWI4				0.927											
CWET			0.893												
MSL				0.928											
AM													0.936		
FS1	0.934														
FS2	0.985														
FS3	0.913														
COM										0.961					
GL					0.938										
SCMC1		0.925													
SCMC2		0.958													
SCMC3		0.912													
SCMC4		0.939													
SCMC5		0.899													
CFI														0.844	
SUS											0.976				

Table 10. Cont.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SO1								0.873							
SO2								0.865							
DDS1						0.906									
DDS2						0.909									
GSP		0.436													0.802
CT								0.916							
L												0.948			

5.4. Readiness Factor Importance According to the Mean Values

Table 11 shows the descriptive statistics for readiness factors affecting I4.0 implementation computed according to the employees' opinion, where only fifteen out of the eighteen readiness factors were selected for the next stage of the analysis, as three factors (hardware and software connection, global engagement, and data-driven services) were excluded because their mean was below average. As for the overall importance of readiness factors with respect to different techniques of I4.0 implementation, the fifteen barriers were selected, which are: level of knowledge, smart factory, dealing with insecurity, compatibility with existing technology, management support and leadership, agility in manufacturing, financial support, competitiveness, supply chain management and collaboration, customer-focused innovativeness, sustainability, strategy and organization, government support policies, collaboration and transparency, and lean.

Table 11. Descriptive statistics for readiness factors affecting I4.0 implementation.

Factor	Mean	Std. Deviation
Level of Knowledge	4.6804	0.62621
Smart Factory	3.6994	0.45890
Hardware and Software Connection	2.0965	0.71559
Dealing With Insecurity	4.5443	0.54983
Compatibility with Existing Technology	3.7737	0.41874
Management Support and Leadership	4.4320	0.61295
Agility in Manufacturing	3.9019	0.29769
Financial Support	4.6883	0.60884
Competitiveness	4.3734	0.62168
Global Engagement	2.1820	0.63455
Supply Chain Management and Collaboration	4.0364	0.65916
Customer-Focused Innovativeness	4.3623	0.71216
Sustainability	4.1962	0.39744
Strategy and Organization	4.1361	0.34314
Data-Driven Services	2.0016	0.53261
Government Supportive Policies	4.3402	0.52491
Collaboration and Transparency	4.0348	0.63350
Lean	4.2136	0.46793

The readiness factors were further analysed using the interpretive structural modelling (ISM) approach for analysis, which was applied by developing a causal level of knowledge between the factors under study through employees' opinions. This was performed after filtering the most significant readiness factors for industry implementation. Among the techniques used to accomplish this were the creation of the structural self-interaction matrix, the initial reachability matrix, the final reachability matrix, the level partition, and finally the digraph.

5.5. Development of SSIM for I4.0 Techniques

The development of the structural self-interaction matrix (SSIM) for the evaluation of readiness factors (level of knowledge, smart factory, dealing with insecurity, compatibility with existing technology, management support and leadership, agility in manufacturing, financial support, competitiveness, supply chain management and collaboration, customer-focused innovativeness, sustainability, strategy and organization, etc.) had attracted a total of 632 employees. An SSIM was created by providing the direction of the relationship between components based on the criteria listed below:

1. A forward relationship with the sign V is said to exist if factor i is noticed to lead to factor j.
2. Conversely, if j is found to lead to factor i, it is a backward relationship, which takes the symbol A.
3. If factors i and j interact, it is referred to as a mutual relationship and is denoted by the letter X.
4. No relationship, denoted by the sign O, is the case if factors i and j are unrelated to one another.

The SSIM is created using contextual links as a foundation. A panel of specialists should continue discussing the SSIM in order to come to a consensus. SSIM must be finished based on their answers.

Table 12 illustrates the SSIM developed for the assessment of readiness factors that affect I4.0 implementation, where it could be observed that financial support, level of knowledge, management support and leadership, and dealing with insecurity are always the factors that influence all other factors. Moreover, competitiveness and customer-focused innovativeness always influence government supportive policies. Lean and sustainability are also constant influences on strategy and organization, cooperation and transparency, supply chain management, and collaboration. Additionally, supply chain management and collaboration, collaboration and transparency, and strategy and organization all have an impact on the smart factory, compatibility with existing technologies, and production agility.

5.6. Development of the Initial Reachability Matrix for Assessment of Readiness Factors That Affect I4.0 Implementation

The previously constructed SSIM is now turned into the first reachability matrix by converting its symbols into a binary matrix known as IRij. Table 13 shows the initial reachability matrix, which was subsequently changed as follows:

1. The (i, j) value in the reachability matrix will be 1 and the (j, i) value will change to 0 if the entry of (i, j) in the SSIM is "V".
2. The binary matrix value of (i, j) becomes 0 and the value of (j, i) becomes 1 if the entry of (i, j) in the SSIM is "A".
3. The values of (i, j) and (j, i) in the reachability matrix will both be 1 if the entry of (i and j) in the SSIM is "X".
4. The binary matrix values for (i, j) and (j, i) become 0 if the entry for (i, j) in the SSIM is "O".

Table 12. SSIM for assessment of readiness factors that affect I4.0 implementation.

	LK	SF	DWI	CWET	MSL	AM	FS	Com	SCMC	CFI	Sus	SO	GSP	CT	L
LK	X	V	V	V	X	V	X	V	V	V	V	V	V	V	V
SF	A	X	A	X	A	X	A	A	A	A	A	A	A	A	A
DWI	A	V	X	V	A	V	A	V	V	V	V	V	V	V	V
CWET	A	X	A	X	A	X	A	A	A	A	A	A	A	A	A
MSL	X	V	V	V	X	V	X	V	V	V	V	V	V	V	V
AM	A	X	A	X	A	X	A	A	A	A	A	A	A	A	A
FS	X	V	V	V	X	V	X	V	V	V	V	V	V	V	V
Com	A	V	A	V	A	V	A	X	V	V	V	V	V	V	V
SCMC	A	V	A	V	A	V	A	A	X	A	A	A	A	A	A
CFI	A	V	A	V	A	V	A	A	V	X	V	V	V	V	V
Sus	A	V	A	V	A	V	A	A	V	A	X	V	A	V	X
SO	A	V	A	V	A	V	A	A	V	A	A	X	A	X	A
GSP	A	V	A	V	A	V	A	A	V	A	V	V	X	V	V
CT	A	V	A	V	A	V	A	A	V	A	A	X	A	X	A
L	A	V	A	V	A	V	A	A	V	A	X	V	A	V	X

Table 13. Initial reachability matrix for assessment of readiness factors that affect I4.0 implementation.

	LK	SF	DWI	CWET	MSL	AM	FS	Com	SCMC	CFI	Sus	SO	GSP	CT	L
LK	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
SF	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
DWI	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1
CWET	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
MSL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
AM	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0
FS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Com	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1
SCMC	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0
CFI	0	1	0	1	0	1	0	0	1	1	1	1	1	1	1
Sus	0	1	0	1	0	1	0	0	1	0	1	1	0	1	1
SO	0	1	0	1	0	1	0	0	1	0	0	1	0	1	0
GSP	0	1	0	1	0	1	0	0	1	0	1	1	1	1	1
CT	0	1	0	1	0	1	0	0	1	0	0	1	0	1	0
L	0	1	0	1	0	1	0	0	1	0	1	1	0	1	1

5.7. Development of the Final Reachability Matrix for Assessment of Readiness Factors That Affect I4.0 Implementation

In this step, the initial reachability matrix (IR_{ij}) is transformed into the final reachability matrix using the transitivity rule. By this reasoning, if factor 1 leads to 2 and factor 2 leads to 3, then 1 must lead to 3. The final reachability matrix for evaluating the readiness factors influencing I4.0 implementation is shown in Table 14. The driving power and reliance power of the final reachability matrix are the sum of the values in the rows and columns of each factor, respectively.

Table 14. Final reachability matrix for assessment of readiness factors that affect I4.0 implementation.

	LK	SF	DWI	CWET	MSL	AM	FS	Com	SCMC	CFI	Sus	SO	GSP	CT	L	Driving Power
LK	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
SF	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	3
DWI	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	12
CWET	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	3
MSL	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
AM	0	1	0	1	0	1	0	0	0	0	0	0	0	0	0	3
FS	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	15
Com	0	1	0	1	0	1	0	1	1	1	1	1	1	1	1	11
SCMC	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	4
CFI	0	1	0	1	0	1	0	0	1	1	1	1	1	1	1	10
Sus	0	1	0	1	0	1	0	0	1	0	1	1	0	1	1	8
SO	0	1	0	1	0	1	0	0	1	0	0	1	0	1	0	6
GSP	0	1	0	1	0	1	0	0	1	0	1	1	1	1	1	9
CT	0	1	0	1	0	1	0	0	1	0	0	1	0	1	0	6
L	0	1	0	1	0	1	0	0	1	0	1	1	0	1	1	8
Dependence Power	3	15	4	15	3	15	3	5	12	6	9	11	7	11	9	

It could be observed that some factors have high driving power compared to their dependence power, namely: financial support, level of knowledge, management support and leadership, and dealing with insecurity which are considered the most influencing factors. The second factors in its driving power are competitiveness and customer-focused innovativeness, which are mostly influenced by financial support, level of knowledge, management support and leadership, and dealing with insecurity; however, there is an influencing factor in government supportive policies. The fourth factors in its driving power are lean and sustainability, which influences strategy and organization, collaboration and transparency, and supply chain management and collaboration; however, there are influencing factors in agility in manufacturing, compatibility with existing technology, and smart factory.

5.8. Level Partition for Assessment of Readiness Factors That Affect I4.0 Implementation

The level partition, which includes the reachability and antecedent sets for each element, is created using the final reachability matrix (as shown in Table 15). The element, like the other variables it controls, is a part of the reachability set. The factor and any additional factors that have an impact on it are both included in the antecedent set. We identify these two sets and find their intersection. The intersection set and reachability set of a factor must match for it to be given priority under the ISM structure. One or more top-level factors are found and eliminated from the remaining sets. Up until the amounts of each ingredient are obtained, this process is repeated. It could be observed that the factors of financial support, level of knowledge, management support and leadership, and dealing with insecurity are always considered as influencing factors on all other factors. On the other hand, the factors of agility in manufacturing, compatibility with existing technology, and smart factory are always dependent on other factors, such as collaboration and transparency, strategy and organization, and supply chain management and collaboration, in addition to lean, sustainability, and government supportive policies as well as competitiveness, customer-focused innovativeness, financial support, level of knowledge, management support and leadership, and leadership and dealing with insecurity.

These results are consistent with [65], who found that the main obstacle to the implementation of I4.0 in the industrial sector is a lack of skilled workers. Decisions on innovation are influenced by people, customers, culture, strategy and leadership, governance, and operations.

Table 15. Level partition for assessment of readiness factors that affect I4.0 implementation.

Item	Reachability Set	Antecedent Set	Intersection Set	Level
LK	LK, SF, DWI, CWET, MSL, AM, FS, Com, SCMC, CFI, Sus, SO, GSP, CT, L	LK, MSL, FS	LK, MSL, FS	9
SF	SF, CWET, AM	LK, SF, DWI, CWET, MSL, AM, FS, Com, SCMC, CFI, Sus, SO, GSP, CT, L	SF, CWET, AM	1
DWI	SF, DWI, CWET, AM, Com, SCMC, CFI, Sus, SO, GSP, CT, L	LK, DWI, MSL, FS	DWI	8
CWET	SF, CWET, AM	LK, SF, DWI, CWET, MSL, AM, FS, Com, SCMC, CFI, Sus, SO, GSP, CT, L	SF, CWET, AM	1
MSL	LK, SF, DWI, CWET, MSL, AM, FS, Com, SCMC, CFI, Sus, SO, GSP, CT, L	LK, MSL, FS	LK, MSL, FS	9
AM	SF, CWET, AM	LK, SF, DWI, CWET, MSL, AM, FS, Com, SCMC, CFI, Sus, SO, GSP, CT, L	SF, CWET, AM	1
FS	LK, SF, DWI, CWET, MSL, AM, FS, Com, SCMC, CFI, Sus, SO, GSP, CT, L	LK, MSL, FS	LK, MSL, FS	9
Com	SF, CWET, AM, Com, SCMC, CFI, Sus, SO, GSP, CT, L	LK, DWI, MSL, FS, Com	Com	7
SCMC	SF, CWET, AM, SCMC	LK, DWI, MSL, FS, Com, SCMC, CFI, Sus, SO, GSP, L	SCMC	2
CFI	SF, CWET, AM, SCMC, CFI, Sus, SO, GSP, CT, L	LK, DWI, MSL, FS, Com, CFI	CFI	6
Sus	SF, CWET, AM, SCMC, Sus, SO, CT, L	LK, DWI, MSL, FS, Com, CFI, Sus, GSP, L	Sus, L	4
SO	SF, CWET, AM, SCMC, SO, CT	LK, DWI, MSL, FS, Com, CFI, Sus, SO, GSP, CT, L	SO, CT	3
GSP	SF, CWET, AM, SCMC, Sus, SO, GSP, CT, L	LK, DWI, MSL, FS, Com, CFI, GSP	GSP	5
CT	SF, CWET, AM, SCMC, SO, CT	LK, DWI, MSL, FS, Com, CFI, Sus, SO, GSP, CT, L	SO, CT	3
L	SF, CWET, AM, SCMC, Sus, SO, CT, L	LK, DWI, MSL, FS, Com, CFI, Sus, GSP, L	Sus, L	4

This study's conclusions, however, differ from those of [66] who suggested a framework for assessing Industry 4.0 maturity by combining the following dimensions: physical and virtual worlds, humans, strategy and culture, products and services, value chain, and the greater environment.

These results are different from those of [28], who showed that a nation's preparation for I4.0 could be evaluated by just two factors: the presence of digital infrastructure and the capacity to analyse huge volumes of data. One other way the study of [32] varies from the current study is that it focuses solely on the information systems strategic alignment procedure.

5.9. Development of the Digraph and ISM for Assessment of Readiness Factors That Affect I4.0 Implementation

At this point, a directed graph (digraph) is made using the factor serial numbers from the study. After eliminating transitive interactions between the parts, the reduced digraph for preparatory criteria that affect industry implementation is shown in Figure 1. The digraph can be used to infer the elements' hierarchical relationship. Once all levels have been added to the digraph, the factors with level 1 are placed at the top, followed by those with level 2, and so on.

5.10. AHP Analysis per Sector

In this section, the analytic hierarchy process (AHP) analysis is performed to rank the importance of readiness factors in a different sector, where data are collected from 10 experts in each sector (food, automotive and spare parts, iron and steel, pharma, oil/gas, chemical, and electronics and electrics). It is noticed that each sector has identified different factors; moreover, the ranking changes from one sector to another. The following part introduces the results concluded from the analysis of each sector.

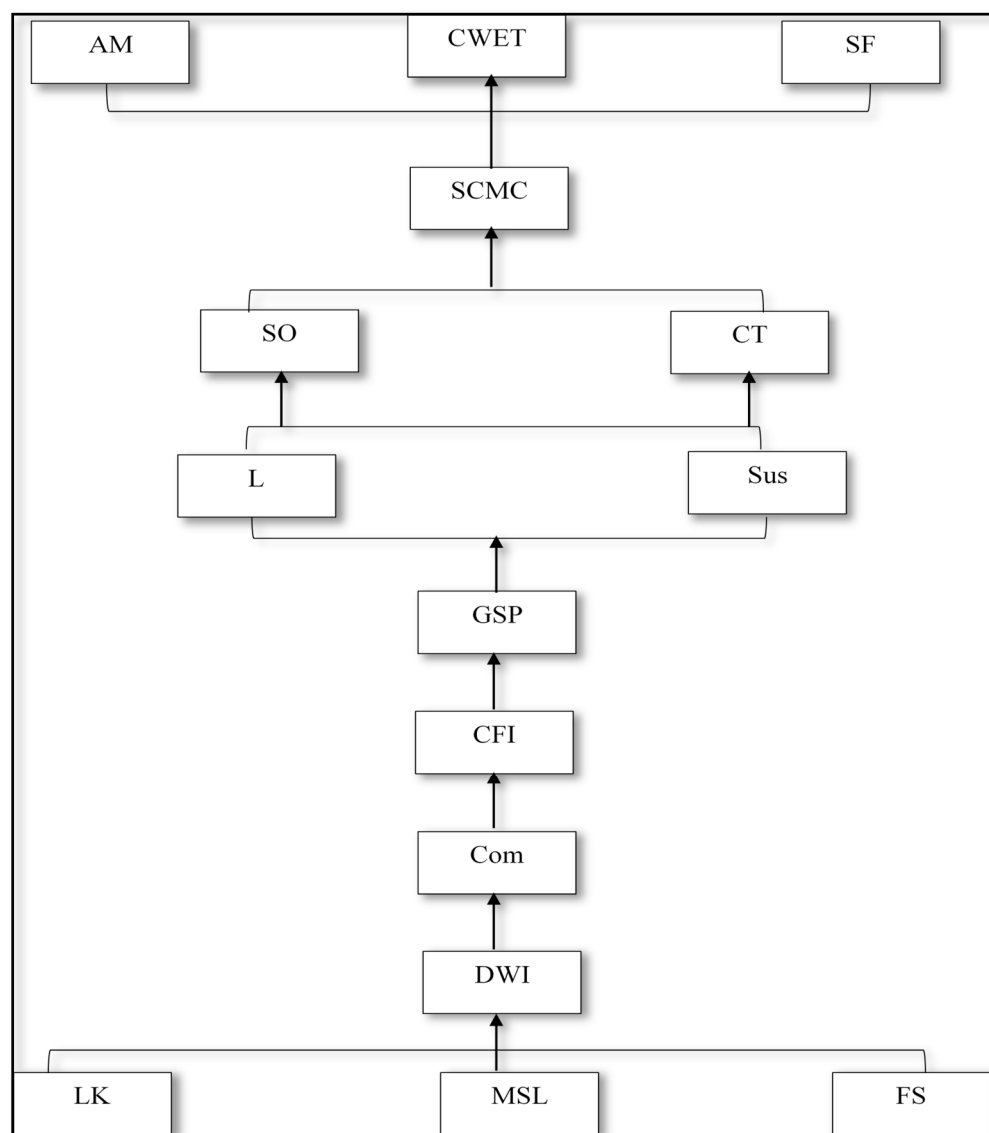


Figure 1. Digraph for readiness factors that affect I4 implementation.

5.10.1. Food Sector

Twelve factors are identified in AHP analysis in the food sector (as shown in Figure 2), which are: level of knowledge, dealing with insecurity, compatibility with existing technology, management support and leadership, agility in manufacturing, financial support, competitiveness, supply chain management and collaboration, customer-focused innovativeness, sustainability, strategy and organization, and lean. From the analysis, it is shown that level of knowledge has the first rank, followed by compatibility with existing technology. The third rank is management support and leadership, followed by sustainability, then competitiveness, strategy and organization, supply chain management and collaboration, customer-focused innovativeness, agility in manufacturing, dealing with insecurity, financial support, and finally lean. Table 16 shows the CR value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

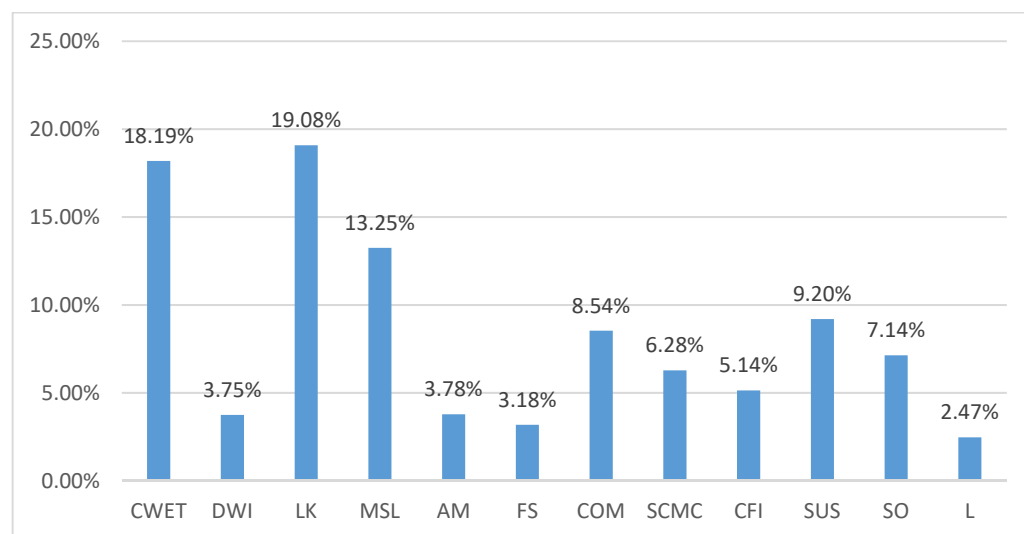


Figure 2. AHP analysis of food sector.

Table 16. Decision matrix for the factors in the food sector.

Factors	CW	Rank
CWET	3.32	2
DWI	0.68	10
LK	3.46	1
MSL	2.44	3
AM	0.69	9
FS	0.58	11
COM	1.57	5
SCMC	1.21	7
CFI	0.98	8
SUS	1.68	4
SO	1.31	6
L	0.47	12

$\lambda_{\max} = 12.0926232$; $CI = 0.0084203$; $CR = 0.0054677$.

5.10.2. Automotive and Spare Parts Sector

Ten factors are identified in AHP analysis in the automotive and spare parts sector (as shown in Figure 3), which are: smart factory, dealing with insecurity, management support and leadership, financial support, competitiveness, supply chain management and collaboration, customer-focused innovativeness, government supportive policies, collaboration and transparency, and lean. From the analysis, it is shown that financial support has the first rank, followed by management support and leadership. The third rank is customer-focused innovativeness, while the fourth is competitiveness, followed by dealing with insecurity, smart factory, collaboration and transparency, supply chain management and collaboration, lean, and finally government supportive policies. Table 17 shows the CR value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

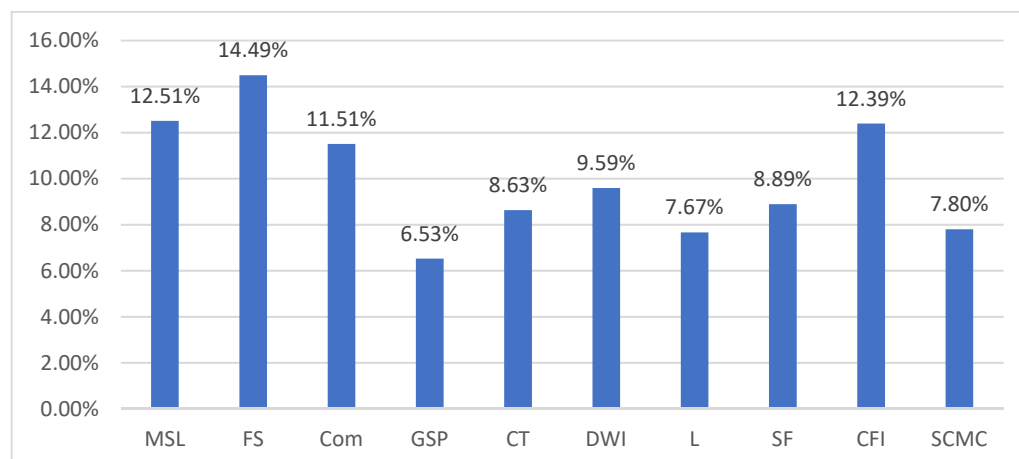


Figure 3. AHP analysis of automotive and spare parts sector.

Table 17. Decision matrix for the factors in the automotive and spare parts sector.

Factors	CW	Rank
MSL	1.36	2
FS	1.55	1
Com	1.23	4
GSP	0.70	10
CT	0.93	7
DWI	1.02	5
L	0.82	9
SF	0.95	6
CFI	1.32	3
SCMC	0.84	8

$\lambda_{\max} = 10.596511$; $CI = 0.0662789$; $CR = 0.0444825$.

5.10.3. Iron and Steel Sector

Nine factors are identified in AHP analysis of the iron and steel sector (as shown in Figure 4), which are: dealing with insecurity, smart factory, management support and leadership, agility in manufacturing, financial support, competitiveness, customer-focused innovativeness, government supportive policies, and collaboration and transparency. From the analysis, it is shown that smart factory has the first rank, followed by collaboration and transparency. The third rank is agility in manufacturing, followed by competitiveness, management support and leadership, financial support, and customer-focused innovativeness. Moreover, government supportive policies are in the eighth rank and dealing with insecurity is in the ninth rank. Table 18 shows the CR value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

5.10.4. Pharma Sector

Nine factors are identified in AHP analysis in the pharma sector (as shown in Figure 5), which are: level of knowledge, smart factory, agility in manufacturing, financial support, customer-focused innovativeness, sustainability, government supportive policies, collaboration and transparency, and lean. From the analysis, it is shown that collaboration and transparency has the first rank, followed by lean. The third rank is smart factory, followed by level of knowledge, agility in manufacturing, financial support, sustainability, customer-focused innovativeness, and finally government supportive policies. Table 19 shows the CR

value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

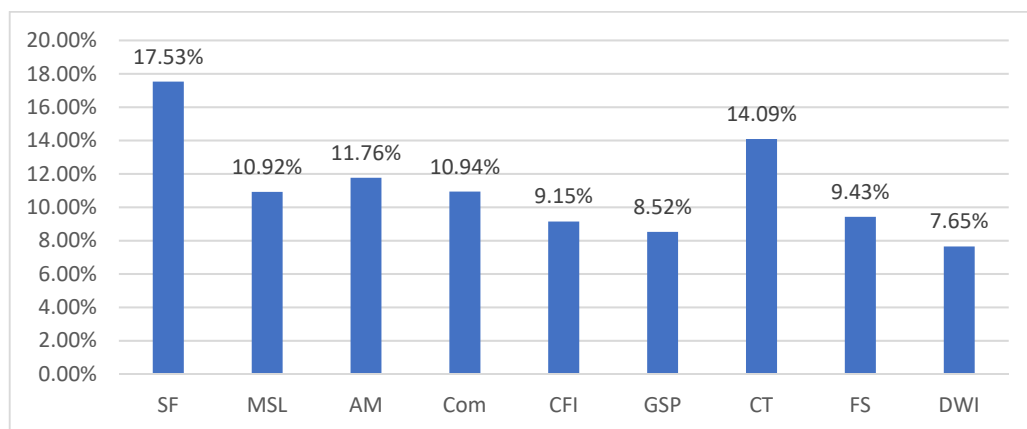


Figure 4. AHP analysis of iron and steel sector.

Table 18. Decision matrix for the factors in the iron and steel sector.

Factors	CW	Rank
SF	1.68	1
MSL	1.05	5
AM	1.13	3
Com	1.04	4
CFI	0.88	7
GSP	0.82	8
CT	1.35	2
FS	0.90	6
DWI	0.73	9

$\lambda_{\max} = 9.0191051$; $CI = 0.0023881$; $CR = 0.001647$.

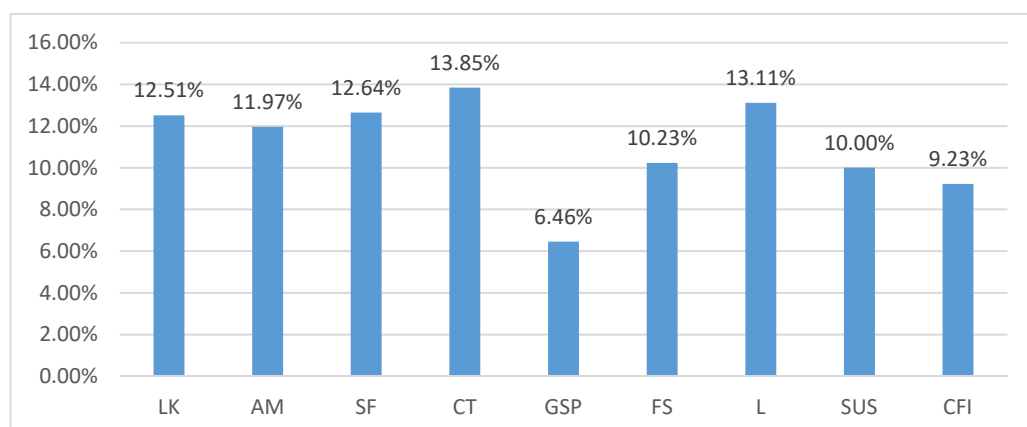


Figure 5. AHP analysis of pharma sector.

5.10.5. Oil/Gas Sector

Twelve factors are identified in AHP analysis in the oil/gas sector (as shown in Figure 6), which are: level of knowledge, dealing with insecurity, compatibility with existing technology, agility in manufacturing, financial support, competitiveness, supply chain management and collaboration, sustainability, strategy and organization, government

supportive policies, collaboration and transparency, and lean. The analysis shows that compatibility with existing technology has the first rank, followed by lean. The third rank is financial support, followed by government supportive policies, competitiveness, collaboration and transparency, dealing with insecurity, agility in manufacturing, level of knowledge, sustainability, supply chain management and collaboration, and finally strategy and organization. Table 20 shows the CR value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

Table 19. Decision matrix for the factors in the pharma sector.

Factors	CW	Rank
LK	1.19	4
AM	1.16	5
SF	1.20	3
CT	1.31	1
GSP	0.61	8
FS	0.98	5
L	1.25	2
SUS	0.96	6
CFI	0.87	7

$\lambda_{\max} = 9.0642762$; $CI = 0.0080345$; $CR = 0.0055411$.

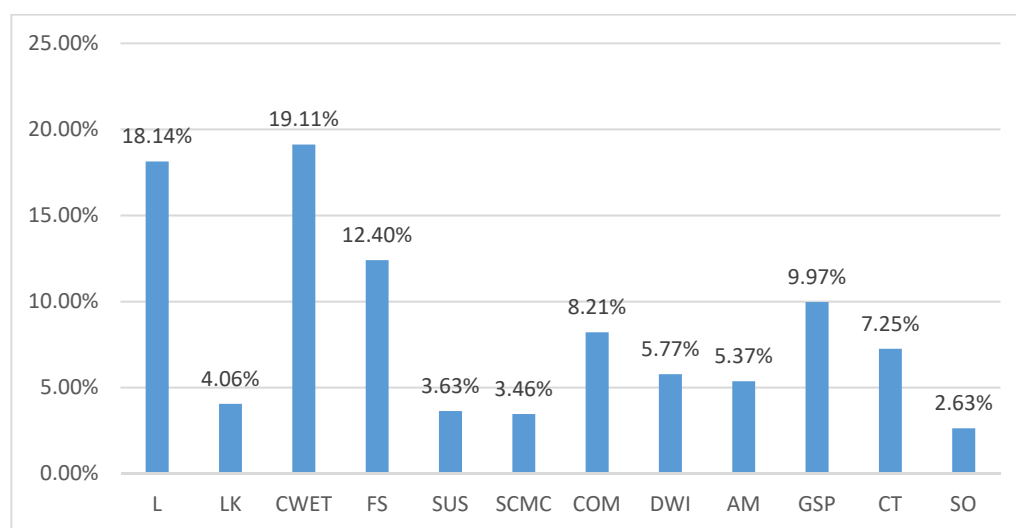


Figure 6. AHP analysis of oil/gas sector.

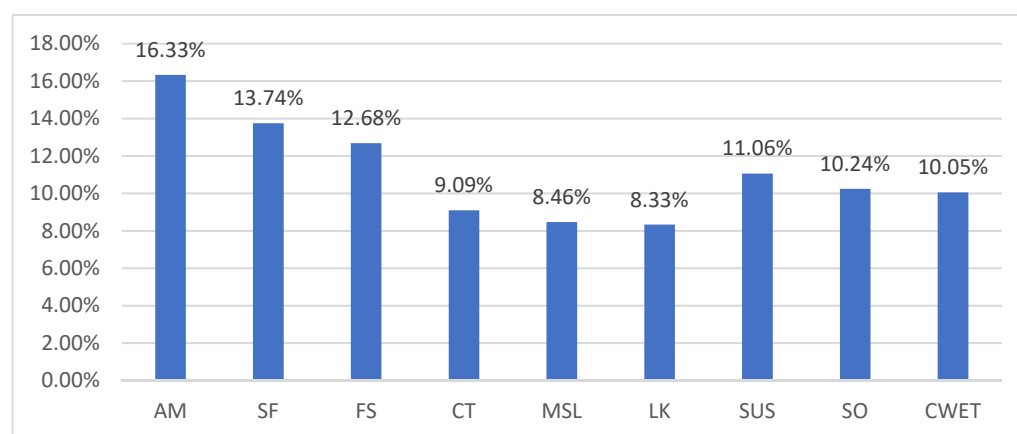
5.10.6. Chemical Sector

Nine factors are identified in AHP analysis in the chemical sector (as shown in Figure 7), which are: level of knowledge, smart factory, compatibility with existing technology, management support and leadership, agility in manufacturing, financial support, sustainability, strategy and organization, and collaboration and transparency. From the analysis, it is shown that agility in manufacturing has the first rank, followed by smart factory, financial support, sustainability, strategy and organization, compatibility with existing technology, collaboration and transparency, management support and leadership, and level of knowledge in the final rank. Table 21 shows the CR value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

Table 20. Decision matrix for the factors in the oil/gas sector.

Factors	CW	Rank
L	3.18	2
LK	0.70	9
CWET	3.31	1
FS	2.18	3
SUS	0.62	10
SCMC	0.60	11
COM	1.44	5
DWI	1.04	7
AM	0.95	8
GSP	1.74	4
CT	1.27	6
SO	0.47	12

$\lambda_{\max} = 12.0948916$; $CI = 0.0086265$; $CR = 0.0056016$.

**Figure 7.** AHP analysis of chemical sector.**Table 21.** Decision matrix for the factors in the chemical sector.

Factors	CW	Rank
AM	1.54	1
SF	1.30	2
FS	1.20	3
CT	0.86	7
MSL	0.80	8
LK	0.79	9
SUS	1.04	4
SO	0.97	5
CWET	0.95	6

$\lambda_{\max} = 9.0304824$; $CI = 0.0038103$; $CR = 0.0026278$.

5.10.7. Electronics and Electrics Sector

Ten factors are identified in AHP analysis in the electronics and electrics sector (as shown in Figure 8), which are: level of knowledge, smart factory, dealing with insecurity, management support and leadership, competitiveness, supply chain management and

collaboration, customer-focused innovativeness, government supportive policies, collaboration and transparency, and lean. From the analysis, it is shown that lean has the first rank, followed by customer-focused innovativeness, collaboration and transparency, dealing with insecurity, government supportive policies, smart factory, customer-focused innovativeness, level of knowledge, collaboration and transparency, and finally supply chain management and collaboration. Table 22 shows the CR value, which is less than 0.1 so the values in the table are acceptably consistent. Therefore, the weights of the factors are used to obtain the decision matrix and give the ranks of the factors.

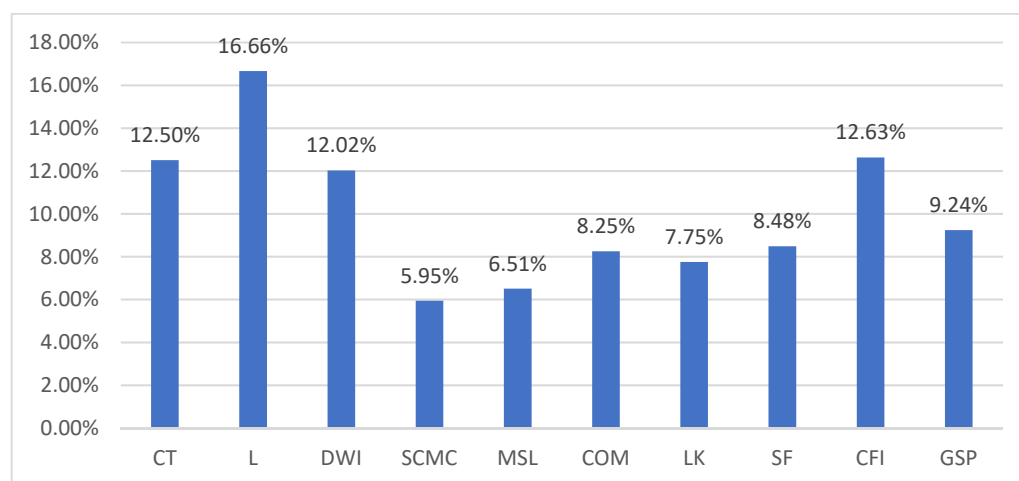


Figure 8. AHP analysis of electronics and electronics sector.

Table 22. Decision matrix for the factors in the electronics and electronics sector.

Factors	CW	Rank
CT	1.38	3
L	1.83	1
DWI	1.34	4
SMC	0.65	10
MSL	0.73	9
COM	0.92	7
LK	0.86	8
SF	0.94	6
CFI	1.38	2
GSP	1.02	5

$\lambda_{\max} = 10.61129$; $CI = 0.0679211$; $CR = 0.0455846$.

6. Conclusions

From SSIM analysis, Table 23 is designed to show the ranks and the degree of influence of each factor that affects I4.0 implementation; it can be observed that the factors “level of knowledge”, “management support and leadership”, and “financial support” come in the first rank, which means these are the most influencing factors among all other factors because nothing could be accomplished without management support. These results agree with previous studies [67,68] which noted the need for significant investment in building and maintaining proper infrastructure within the organizations, as well as the significance of top management support, to adopt I4.0.

Table 23. Ranks of factors that affect I4 implementation within Egyptian manufacturing sector.

Barrier	Industry Implementation
LK: Level of Knowledge.	1
SF: Smart Factory.	9
DWI: Dealing with Insecurity.	2
CWET: Compatibility with Existing Technology.	9
MSL: Management Support and Leadership.	1
AM: Agility in Manufacturing.	9
FS: Financial Support.	1
Com: Competitiveness.	3
SCMC: Supply Chain Management and Collaboration.	8
CFI: Customer-Focused Innovativeness.	4
Sus: Sustainability.	6
SO: Strategy and Organization.	7
GSP: Government Supportive Policies.	5
CT: Collaboration and Transparency.	7
L: Lean.	6

Dealing with insecurity is ranked second, which indicates that it is one of many contributing elements; nonetheless, it may occur owing to a lack of leadership, management support, and financial support. These results agree with previous studies [69–71] which noted that data being accessible online in the environment of cloud computing may raise data security concerns. Therefore, it is required of the staff to be knowledgeable about data security and cyber threats.

The factor “competitiveness” comes in the third rank, which means that it is another influencing factor among other factors; however, it might happen due to dealing with insecurity, level of knowledge, management support and leadership, and financial support. These results agree with [72] who noted that I4.0 technologies aid in cost identification and competitiveness promotion, as well as find potential consumers and sales activities that have a high-profit margin by using databases and information from I4.0 technology.

The factor “customer-focused innovativeness” comes in the fourth rank, which means that it is another influencing factor among other factors; however, it might happen due to competitiveness, dealing with insecurity, level of knowledge, management support and leadership, and financial support. These results agree with [73] who stated I4.0 technologies support the company’s efforts to meet future consumer needs and strengthen its competitive advantages.

The factor “government supportive policies” comes in the fifth rank, which means that it is another influencing factor among other factors; however, it might happen due to customer-focused innovativeness, competitiveness, and dealing with insecurity, level of knowledge, management support and leadership, and financial support. These results are in line with earlier research [74], which claimed that the rise of digitalization is challenging the rule of law because of increased competition and the need to follow proper procedures for data security and artificial intelligence before introducing new digital phenomena.

The factors “lean” and “sustainability” come in the sixth rank, which means that they are influencing factors among other factors; however, they might happen due to government supportive policies, customer-focused innovativeness, competitiveness, dealing with insecurity, level of knowledge, management support and leadership, and financial support. These results agree with previous studies [6,10,11,13,14,75] which declared that I4.0 and lean both employ decentralized control and seek to boost efficiency and adaptability.

The factors “strategy and organization” and “collaboration and transparency” come in the seventh rank, which means that they are influencing factors among other factors; however, they might happen due to lean, sustainability, government supportive policies, customer-focused innovativeness, competitiveness, dealing with insecurity, level of knowledge, management support and leadership, and financial support. These findings support the [76] assertion that the implementation of I4.0 is dependent on important design concepts such as decentralized decision-making and information transparency.

The factor “supply chain management and collaboration” comes in the eighth rank, which means that it is another influencing factor among other factors; however, it might happen due to strategy and organization, collaboration and transparency, lean, sustainability, government supportive policies, customer-focused innovativeness, competitiveness, dealing with insecurity, level of knowledge, management support and leadership, and financial support. These agree with [73] who noted that manufacturing companies can manage their supply chain processes, such as inventory management, with the help of digital technologies. Also, the result is consistent with previous studies [77,78] which claimed that I4.0 may alter how businesses connect with their partners, customers, and suppliers globally.

The factors “agility in manufacturing”, “compatibility with existing technology”, and “smart factory” come in the ninth rank, which means that these are considered as least in their influence and they could be avoided if other factors are solved; however, they might happen due to supply chain management and collaboration, strategy and organization, collaboration and transparency, lean, sustainability, government supportive policies, customer-focused innovativeness, competitiveness, dealing with insecurity, level of knowledge, management support and leadership, and financial support. These agree with [8] who declared that agility in manufacturing operations can help the company save costs, as well as [79] who developed an I4.0 model based on the concept that there will be various significant changes in business brought about by technology, business, society, and individuals. The legal system, for example, is one social subsystem that may simultaneously be significantly impacted or required to assist the revolution. Additionally, the effect on people and their education is crucial to ensuring that society can take advantage of the opportunities brought on by technology.

From the above table, it can be noticed that all the above variables have a significant effect on I4 implementation inside the manufacturing sector in Egypt but this effect includes different ranks, starting with rank one that includes three factors: level of knowledge, management support and leadership, and financial support. Rank two is dealing with insecurity; rank three is competitiveness. Rank four is customer-focused innovativeness. The factor of rank five is government supportive policies, while the factors of rank six are lean and sustainability. Factors of rank seven are strategy and organization, and collaboration and transparency. The eighth rank is supply chain management and collaboration. Finally, factors of rank nine are agility in manufacturing, compatibility with existing technology, and smart factory.

Unfortunately, this implies that a few Egyptian industrial businesses are still working to adapt to Industry 4.0, while there has already been discussion of Industry 5.0 (I5.0).

A better version of the fourth industrial revolution is I5.0. It is envisioned as a way to combine the power, intelligence, and accuracy of technology with the distinctive creativity of human expertise, where data will be gathered from machines in conjunction with highly qualified people, emphasizing the importance of the worker in the production process, while assigning repetitive and boring tasks to robots or machines, and those that need critical thought to people [80–85]. Additionally, several sectors are switching to I5.0 globally, including supply chain management, intelligent healthcare, cloud manufacturing, and manufacturing production [86–88].

Therefore, the Egyptian manufacturing industry should prepare for this transition as I5.0 is already becoming a part of the business landscape. They should make the manufacturing industry “smart” by connecting equipment and technologies that can

communicate with one another throughout their lives, minimizing the need for human intervention in the manufacturing process [80–85]

From the AHP analysis, it is shown that the level of knowledge is in the first rank in the food sector, while financial support is in the first rank in the automotive and spare parts sector. The smart factory has the first rank in the iron and steel industry. Collaboration and transparency has the first rank in the pharma sector, while compatibility with existing technology is in the first rank in the oil and gas industry. Agility in manufacturing has the first rank in the chemical sector and lean has the first rank in the electronics and electrics industry.

7. Theoretical and Practical Contribution

There are not enough readiness evaluations available that address the problems and precise requirements for implementing I4.0 for the theoretical contribution. The study's ranking of I4.0 implementation in the Egyptian manufacturing sector reflects this outcome. In a different culture, industry, and economy than those previously tested, the researcher ranks 15 readiness factors and the strength of each factor's influence on I4.0 implementation within the Egyptian manufacturing sector. This information can help businesses better understand how to get ready for an organizational transformation toward I4.0, especially in developing economies such as Egypt.

For the practical contribution, the research was conducted with input from industry practitioners, so the results are of practical relevance. Also, results gleaned from the research will help the manufacturing industry be well prepared for implementation of I4.0.

8. Limitations and Future Research

To confirm the findings for a wider variety of manufacturing organizations, it is advised that data be gathered from another country (developed or developing) and compared to see if the findings of the current research applied in Egypt are similar if applied to another country. Although most manufacturing firms can benefit from this research, it was only implemented in Egypt. Furthermore, it is encouraged to do additional research over a longer length of time to see whether there are any changes that will occur as time passes. Another drawback is that the sample size is so tiny that an ISM analysis was used throughout the analysis because the current study only uses a small sample. Accordingly, it is suggested to work on a larger sample which could help in applying other techniques such as MICMAC analysis for validating the model adopted.

Author Contributions: Conceptualization, N.F.K.; methodology, N.F.K.; software, N.F.K., S.S.E. and S.E.; validation, N.F.K., S.S.E. and S.E.; formal analysis, N.F.K., S.S.E. and S.E.; investigation, N.F.K.; resources, N.F.K.; data curation, N.F.K., S.S.E. and S.E.; writing—original draft preparation, N.F.K.; writing—review and editing, N.F.K., S.S.E. and S.E.; visualization, N.F.K.; supervision, N.F.K.; project administration, N.F.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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