The Role of Knowledge Management in Adopting Industry 4 Technology: The Mediating Role of Market Orientation

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Abstract

Industry 4.0 is a concept that refers to the widespread adoption of modern techniques such as big data analytics, the Internet of Things (IoT), and artificial intelligence (AI). It can be adopted using different knowledge management (KM) activities. Thus, this research seeks to explore the impacts of KM activities on Industry 4.0 adoption through the mediating functions of market orientation. Precisely, the paper investigated the effects of some KM activities, namely: Knowledge Creation, Knowledge Acquisition, Knowledge Sharing, Knowledge Storage, Knowledge Dissemination, and Knowledge Application on Industry 4.0 adoption in Egyptian manufacturing and service companies.

To achieve the aim of this study, a questionnaire was employed to investigate the assigned relationships in the manufacturing and service sectors in the Egyptian context. Data was collected from 666 respondents and analyzed using SEM analysis.

Results revealed that all studied KM activities (Creation of Knowledge, Acquisition of Knowledge, Sharing of Knowledge, Storage of Knowledge, and Knowledge Dissemination) were found to have positive significant effects on Industry 4.0 adoption and market orientation. Additionally, market orientation has a significant influence on Industry 4.0 adoption and performs a limited mediation role in the relationship between KM activities and Industry 4.0 adoption. Further statistical analysis confirmed that the level of KM activities or the degree of technology 4 adoption; and market orientation, would differ according to organization size, maturation stage, sector and organization type. Practical implication and theoretical contribution for future research is provided.

***Keywords**: Knowledge Management, Industry Four Adoption, Market Orientation Egypt.*

Introduction

Implementation of emerging technologies including the analytics of big data, artificial intelligence, cloud computing, the internet of things, and robotics is anticipated to not only change the manufacturing and distribution of goods and services, but additionally to have a major effect on issues ranging from staff skill improvement to environmental influence (Nez-Merino et al., 2020; Klingenberg et al., 2019). Thus, the widespread usage of these techniques has become one of the top priorities for global economic development between 2020 and 2030 (Kolyasnikov & Kelchevskaya, 2020).

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The adoption of these new technologies has been generally acknowledged as "Industry 4.0" both in Brazil and Germany (Drath & Horch, 2014; Lasi et al., 2014), and as "Smart Factory" in the United States of America (Chen et al., 2017).

Industry 4.0 (I4.0) has emerged to be the modern industrial revolution that may generate intelligent and autonomous systems (Karre et al., 2017), enhance organizational performance, and speed up collaboration with both clients and vendors, (Szász et al., 2020; Abubakar et al., 2019; Schneider, 2018). Also, I4.0 technology adoption can lead to high job performance, innovation, and creativity (Malik et al., 2021; Cassia et al., 2020).

For many years, knowledge has been seen as valuable to the development and efficiency of organizations. In line with this, 14.0 technologies necessitate learning and the sharing of knowledge, as well as the assimilation of it to obtain all available technological advantages, (Manesh et al., 2021; Feng et al., 2017). Thus, Knowledge Management can play a critical role in the adoption of 14.0 technologies.

Although KM is a fast-growing academic discipline (Serenko & Bontis, 2017), the argument on KM in I4.0 application is new (Manesh et al., 2021; Cassia et al., 2020;), and its influence on Industry 4 adoption is still under researched (Muniz et al., 2021, 2022); especially in developing countries (Ode & Ayavoo, 2020). Thus, this research's main goal is to debate how KM can support the I4.0 embracing, as well as to provide insights and assist future research. It also means to answer the following overarching question: To what extent can knowledge management practices support Industry 4.0 adoption?

It should be noted that knowledge management enables businesses to establish their own objectives and recognize the long-term growth and survival of a company. However, additional supporting drives, such as market orientation may be appropriately viewed as an endeavor to become competitive in the marketplace and may not be the primary reason to establish the supremacy of performance. Market orientation is one of the most important prescriptions that must be established; it is a method of creating strategically oriented organizations (Setiyono et al., 2022). Therefore, market orientation could be considered a mediator between KM activities and Industry 4.0 adoption. KM activities allow companies to collect and analyze data as well as know the marketing practices required by customers (Castagna et al., 2020). Such orientation regarding the market and customers' needs allows companies to gain new understanding of how products are able to generate value for customers, enabling improved concepts of offerings as well as more operative communication of product value to customers which is defined as market orientation. This helps in adopting technologies and smart products which could potentially reshape the configuration options available to organizations (Naglič et al., 2020). Hence, examining the function of market orientation in the associations between KM and Industry 4 adoption is another important aim of this study.

This paper consists of seven sections, the first is the introduction currently presented. The second section represents the conceptual background of this research. The third section provides the previous studies relevant to this research. The fourth section presents the research methodology, while the fifth section provides the findings. The sixth section represents the discussion and conclusion. Finally, the recommendations and limitations are presented in the seventh section.

Conceptual Background and Literature Review

Industry 4.0 Adoption

Industry 4.0, also known as the industrial fourth revolution, is among the most popular subjects in both academic and professional circles (Kwiotkowska & Gębczyńska, 2022). This idea's core component is smart manufacturing. It also considers the interaction of a manufacturer with a full product lifecycle and supply chain operations, altering even how individuals perform their jobs (Javaid et al., 2022). The use of digital technologies is essential to Industry 4.0 because they allow for the real-time collection and analysis

of data, which gives the industrial system vital information. This has been proved feasible by the development of the Internet of Things, cloud services, big data analytics, and the cyber-physical orientation concept of Industry 4.0 (Frank et al., 2019).

Industry 4.0 refers to intelligent machines that may interact with the environment and make choices with little to no human intervention if networked computers, intelligent machines and smart materials can communicate with one another. Accordingly, the interconnectedness of digital techniques, individuals, and other physical aspects, in addition to the merging of the physical and digital worlds through the Internet of Things and cyber-physical applications, are what set Industry 4.0 apart from the Industry 3.0. Hence, the evolution to Industry 4.0 is reliant on technical advancements, including technology for artificial intelligence, adaptive robotics, virtualization, cloud computing, additive manufacturing, and data analytics (Khin & Kee, 2022).

Industry 4.0 began to materialize in 2015. It has since been driven by a group of innovative internet technologies that have fundamentally altered how companies develop, produce, deliver, and support their goods (Tsaramirsis, 2022.). Industry 4.0 technologies have assisted manufacturers in raising productivity, reducing downtime, cutting costs, standing out in the market, and enhancing service, delivery, and quality. Information and communication technologies (ICT) are used by I4.0 implementation organizations to fully integrate the whole value generation and delivery systems while achieving real-time digital transformation of all vertical and horizontal business activities (Narula et al., 2020).

As a matter of fact, Industry 4.0 is the concept of "smart factories", which are facilities where equipment is enhanced by web connectivity to function as autonomous decision-making systems that can see the whole manufacturing process and subsequently act (Nardo et al., 2020). Better communication, increased automation and self-monitoring of machinery are all made possible by the new digital techniques of I4.0. The concept of Internet of Things, cloud computing, robotics, cyber-physical concepts, and artificial intelligence are examples of manufacturing technologies that are trending towards automation and data exchange. These technologies enable businesses to respond more quickly to changes in demand, implement new configurations more easily, or re-plan production. For instance, IoT enables devices to do many tasks without human involvement, yet users can still engage with the gadgets. Overall, I4.0 has several beneficial effects on companies and economic growth (Khin & Kee, 2022).

By making it easier for industrial processes to connect with one another, digitalization will enable the possibility of sustainable organizations. The advantages of digitization have been heavily emphasized. For instance, Industry 4.0 technology will address problems that manufacturing companies face, such as mass personalization, making choices in real time, and monitoring demand unpredictability, among others.

The influence of accepting Industry 4.0 on companies has attracted a lot of study interest in recent years. Decentralized systems, interoperability, virtual linked applications, modular production, real-time capabilities, service orientation and other digitalization ideas are components of Industry 4.0. As businesses concentrate on the process, product, and business models, these concepts and the enabling technology can improve corporate operations (Chauhan et al., 2020).

Numerous academic research indicate that technologies related to Industry 4.0 can improve responsiveness, promote traceability, increase operational efficiency, strengthen capacity utilization, and lower costs, all of which improve the sustainability of the company. Additionally, data transparency may lower incorrect deliveries and unneeded material flows, minimize damage along the whole value chain, and decrease waste while improving environmental performance. Therefore, digitalization will not only allow for linkages between the real and virtual worlds but also give industrial companies the chance to increase their productivity and efficiency (Chauhan et al., 2020).

However, in developing countries, Industry 4.0 is now considered relatively new in emerging economies and thus requires extensive study and commercial experience (Luthra & Mangla, 2018). Developing nations have implemented Industry 4.0 technology on a business level, relying on individual company initiatives rather than national and coordinated policies. New technology adoption and diffusion barriers are frequently present. Investigating the many obstacles that prevent the implementation of Industry 4.0 in both established and emerging economies is crucial (Raj et al., 2019). In developing countries, managers are striving for new technological advancements and process improvements in the value chains from an organizational perspective (Joshi & Sharma, 2022).

In Egypt, Haddara and Elragal, (2015) argued that justifying investments in smart manufacturing is one of the major obstacles. Many firms' top-management cultures in Egypt are entirely focused on cutting costs. Suggesting that creating an investment case for the I4.0 is challenging. In addition, they argued that decision-makers in Egyptian industries may not be sufficiently knowledgeable or aware of I4.0 techniques and applications, which can impede investments in the future. Nevertheless, the decision-makers in Egyptian manufacturing companies may be persuaded to invest in such technologies when supplied with the appropriate data and knowledge transfer, as well as well-improved business and use cases. The whole production cycle also strongly depends on human connection and involvement due to low wages and skill requirements (Haddara & Elragal, 2015).

Knowledge Management

There are many explanations with more or less traits in common that emphasize different aspects of the KM idea. Lee (2001), for instance, defines KM as "the procedure of recording, preserving, sharing, and employing knowledge." According to Martensson (2000), KM is a competitive advantage for the control of an organization over intellectual capital management. As a result, Dzenopoljac et al. (2018) describe KM as the systematic management of every task and process including the development and growth, codification and storage, and transmission and exchange of information in order to sustain an organization's competitive advantage.

Darroch (2005: 211) describes KM as a "command and control function resulting in or locates knowledge, regulates the data flow within organizations, and guarantees that the expertise is utilized successfully for the future use of the business "as an important management role".

In this regard, KM can be identified as "an evolving set of organizational design and functional values, procedures, organizational structures, programs, and technologies that assist experts in dramatically leveraging their inventiveness and capacity to deliver company value" (Gurteen, 1998).

In the past twenty years, the theory and implementation of knowledge management have become increasingly popular in the existing literature on management. Within this discipline, the proposed models have directed managerial attention to the hidden assets of firms; and one of the famous models adopted in this notion is that of the Resource-Based View (RBV). From the standpoint of this model, knowledge refers to a unique resource that a firm can utilize within the work sequence to acquire a competitive edge (Barney, 1991: 101; Raudeliuniene, Davidaviciene, Jakubavicius, 2018: 544).

Derived from the RBV, knowledge is regarded as the primary strategic resource through which organizations can acquire a competitive advantage, this is partly due to the internal, professional expertise accumulated by companies that is difficult to copy (Grant, 1996; Kogut & Zander, 1992). Thereby introducing the Knowledge based-view (KBV) concept. Employing the Knowledge based-view (KBV) concept, Grant's (1996), emphasized that the major significance of an enterprise is to apply knowledge appropriately through transmission and security, which may lead to sustainable competitive advantage.

Organization Knowledge

Despite a company not possessing a mind of its own in a literal sense, the combined knowledge created, shared, and applied therein is called organizational knowledge (OK).

A predominant perspective of that knowledge in the organizational context treats it as a level of the so-called informational pyramid where there exists a vertical upward flow. Data are the basis of this flowing process and can be defined as collections of evidence of one or more observed facts, or transactions records. Considering the fact that a firm does not have its own faculties in the literal sense, the combined information created, exchanged and utilized within it is referred to as organizational knowledge (OK).

A common view of that knowledge in the corporate environment regards it as a level of the designated informational pyramid with a vertical upward flow. The cornerstone of this fluid operation is information, which may be characterized as compilations of evidence of one or more observable facts or transaction records. However, information is located at the next phase and is the result of multi-data interpretation with the goal of reaching consensus for a specific audience. Knowledge, in consequently, is the result of human reflection and analysis based on information, and it is impacted by the models and mental values of individuals who create it.

Types of Knowledge

In the literature, there are two types of knowledge Tacit and Explicit knowledge. Explicit knowledge refers to codified information - facts and symbols that are able to be preserved and utilized in a variety of ways and thus readily shared (Polanyi, 1966; Spekman and Davis, 2016), while tacit knowledge is knowledge held by company employees which is difficult to codify, confusing to comprehend, and difficult to be absorbed (Li, 2020; Polanyi, 1966). While organizations can efficiently exchange explicit information among vast impersonal groups, intensive interactions must be enabled in order to convey tacit knowledge (Alavi & Leidner, 2001).

In this context, four mechanisms were applied by Nonaka et al. (2000) to be used in this conversion to adapt to the detailed nature of the knowledge in their theory of knowledge creation: socialization (refers to tacit to tacit), externalization (refers to tacit to explicit), combination (refers to explicit to explicit), and internalization (explicit for tacit). The SECI model refers to this procedure of exchanging either explicit or tacit knowledge; and the acronym corresponds to the initials of the titles of each step.

Nonetheless, these flows are not inherently smooth and unobstructed. They, on the other hand, confront challenges on both an individual and organizational level (Sartori et al., 2022). As a result, Knowledge Management arises as a deliberate endeavor to conquer those constraints and improve knowledge development and dissemination through various strategies and technologies. Fundamentally, an organization's technology infrastructure, particularly databases, systems, data centers, and other technologies employed and coordinated systematically by information management, supports Knowledge Management. Nonetheless, knowledge flows are dependent not only on technical challenges, but also on social and psychological issues. Knowledge development and dissemination should also be considered as something that should be encouraged rather than imposed. Among the different approaches to those features is Ba, which can be interpreted as "place" or "enabling context," which provides the required physical framework because "there is no creation without a place." (Nonaka et al., 2000).

According to Nonaka et al. (2000), knowledge sharing at the executive level requires a common contextual circumstance. This common context ("Ba") includes physical space (for example, the office), mental space (shared thoughts), and virtual space (e-mail). Nonaka et al. (2000) recommend categorizing knowledge assets into four groups as well. Knowledge assets are explained in the conceptual group using images, symbols, and language, whereas systematized knowledge is organized and standardized in the form

of documents, specifications, manuals, databases, and so on. The experimental category relates to shared tacit knowledge gained via shared experiences. Finally, the routine category includes tacit knowledge as well as organizational behaviors and procedures. Nonaka et al., (2000) provided a model to show how, by combining the concepts of Ba, SECI, and Knowledge Assets, an ongoing process by which companies preserve and explore knowledge is generated.

Knowledge Management Practices

The procedures and dimensions of knowledge management differ from investigation to investigation. For example, initial KM research, such as Addis (2016), focused on the Knowledge Creation KC method and knowledge transfer KT, with an emphasis on explicit and implicit knowledge. Recent research, however, identifies "knowledge creation, acquisition, communication, and application" as the primary components of KM processes (Ode and Ayavoo, 2020). Despite the multiplicity of KM-related activities, it appears that researchers agree that the most significant practices are knowledge acquisition, knowledge sharing, and knowledge application (Al-Sa'di et al., 2017; Al-Emran et al., 2018; Ode & Ayavoo, 2020).

This study follows a comprehensive context through evaluating all activities of the KM system, namely, knowledge creation, acquisition, storage, sharing, dissemination, and application. A brief on each activity is presented next.

Knowledge Creation

Knowledge creation is fundamental in order to prepare an organization to recognize and utilize the process. By using accessible and/or previous data or information, new tacit or explicit knowledge can be developed, leading to the creation of knowledge (Deokar et al., 2010).

To create knowledge, attributes such as having the resources to access information, training programs, problem-solving, and acquiring the suitable knowledge and knowledge programs need to be managed (Braganza et al., 2009). The process of mining data, KBS (knowledge-based systems), and algorithms are all part of the diversity of systems and techniques available to enhance knowledge creation processes (Deokar et al., 2010).

Accordingly, Markus (2001) emphasizes the relevance of data systems in generating conducive conditions for knowledge development and enabling team linkages. Email and group systems may be employed to strengthen group interactions; the intranet enables information to be acquired and internalization to be encouraged. However, while creation is important, it is difficult to manage and less open to IT help (Markus, 2001).

Teams contribute greatly to knowledge creation because an organization has to have knowledgeable employees in order to learn (Gibson & Vermeulen, 2003). One of the main sources when it comes to creating knowledge also includes communities of practice (Ofek & Sarvary, 2001). To summarize, successful knowledge production necessitates the following steps: first, a study of the current state and intended improvements; second, the selection of a mental scheme and process which involves a combination of insights and communication; and finally, codification and execution (Shehata, 2015).

Knowledge Acquisition

The acquisition of knowledge is crucial to the knowledge management system since tacit knowledge has a high loss risk due to the retirement, redundancy, termination or death of employees (Liu & Tsai, 2007). Therefore, knowledge may be generated internally or externally; as external knowledge is sourced from the adjacent environment, and it needs to be modified to a form that may be implemented or/and internalized (Holsapple & Joshi, 2004). In contrast, knowledge is acquired internally through the collection of tacit and explicit knowledge (Alavi & Leidner, 2001).

Regulations, clarifications, and patterns in long-term or declarative memory are acquired in knowledge acquisition and then employed in interpretive problem-solving - problem-solving by reviewing and comparing precedents. It is closely followed by procedural acquisition, which concentrates on implementing declarative information learned in the production rule, and ultimately, declarative knowledge is updated or enhanced (Arnold et al., 2008).

Liu and Tsai (2007) identified two main techniques for apprehending knowledge. The direct technique allows for the collecting of knowledge by merely inquiring questions via interviews, observations, and so on. On the contrary, software programs employ the indirect method to capture the abilities they want of specialists, which would be difficult to accomplish using direct methods.

Knowledge acquisition necessitates a thorough comprehension of two linked notions: knowledge sourcing and knowledge selection. According to Badger et al. (2003), sourcing of knowledge is preferable for gaining current external information. Gottschalk (2006) described the sourcing of knowledge as the transfer of knowledge found inside and between three structural forms of intangible assets. The first is the exterior structure, which includes the external environment; the client is positioned in the external environment for the vendor. The vendor is in the client's external environment. The internal structure, which includes models, procedures, and information systems, gives increase in the second type. The third derives from the individual structure, which reflects the skills of individuals.

The selection of knowledge refers to gathering knowledge within an organization and applying it to a specific challenge or decision; unlike acquisition, it exclusively employs knowledge available within a firm (Holsapple & Joshi, 2004).

To speed up knowledge acquisition in companies, employees need to see that after acquiring knowledge, they gain personal value, additional responsibilities, personal accomplishment, and the recognition from others (Ho et al., 2007).

Knowledge Storage

Codification or documentation is a system for storing knowledge; it operates by codifying organizational memory (Badger et al., 2003). Organizational collective memory integrates all previous and present events, as well as culture, physical, and structure business environments (Alavi & Leidner, 2001).

There are two kinds of organizational memory: semantic memory and episodic memory. The semantic signifies wide-ranging explicit information, which encompasses customer, project, and industry knowledge, whereas the episodic reflects situational knowledge (Alavi & Leidner, 2001; Markus, 2001).

Because knowledge inside an organization remains personal until it can be saved within the organizational memory (Abdul-Malak et al., 2005), the shift to documentation may occur owing to a lack of personal networks, which are responsible for knowledge preservation and distribution. KMS's technological skills are thus required for codification, but they are not guaranteed success because social and technical impediments must be overcome (Kankanhalli et al., 2005).

Anantatmula (2009) divided documentation into five phases: assessing the scheme scope, establishing the ontology utilized and its restrictions, building a database of information, running the knowledge base, and making changes as knowledge evolves. Repositories are linked to KM's codification work, which attempts to reuse codified information through documentation and storage (Kankanhalli et al., 2005). There are two distinct kinds of repositories: document repositories and information repositories. Because information retrieval in documents differs from that in data, the methodologies must vary as well (Kubo et al., 2001).

Knowledge Sharing

The diffusion and transference of tacit and explicit information within an organization is referred to as knowledge sharing. To manage knowledge at all levels of organization, it is vital to convey it on an individual basis. This evolution, referred by Ipe (2003) as the procedure of ensuring knowledge availability inside an organization, encompasses the procedure of changing knowledge possessed by one person into a reduced form that others can perceive, incorporate, and use.

Knowledge sharing among individuals, groups, and organizations can become limited due to of the unwillingness or incapability of individuals, or there may exist cultural factors; these problems replicate topics of supremacy and faith, hence requiring an appropriate platform (Chen, 2009).

It is argued that everyone is responsible for information sharing, however there are two vital stakeholders in knowledge sharing which include contributors and seekers, both of whom are participating in the manner (Chang & Yang, 2008). If KMS does not foster the sharing of knowledge on both stages to encompass both searchers and contributors, it may result in an unsatisfying investment. Knowledge seekers' confidence Knowledge seekers gain trust during interactions with one another, making them more open to knowledge exchange. Knowledge providers that employ codification to externalize their knowledge assist others obtain information while benefiting from self-achievement (Chang & Yang, 2008). Knowledge contribution increases advantages while decreasing expenses, resulting in increased knowledge exchange among contributors (Kankanhalli et al., 2005). However, since experts are recognized for their personal successes, they may be hesitant to share what they know, especially if they perceive that it is this portable knowledge that is recognized (Kubo et al., 2001).

As a result, a fairness policy may be designed to guarantee knowledge contributors that their authority would not be diminished or altered as a result of sharing. This can motivate reciprocity strategies and sharing intentions. A recent study by Kersten et al, 2022, showed the important role of leadership in knowledge management, especially in boosting knowledge sharing and application. The study investigated the fundamental causes and ways for CEOs' organizational knowledge management, as well as their contributions to the advancement of these knowledge systems. The findings revealed that CEOs' intentions to stimulate knowledge processes among professionals are influenced by both internal (e.g., the CEOs themselves) and external (e.g., policy) contexts, with internal motivations having a greater influence. The investigation also acknowledged four strategies used by CEOs to encourage knowledge sharing and utilization: supporting organizational environments for the most effective knowledge processes; acknowledging and distributing knowledge holders; focusing on improvements; and knowledge-driven involvement in cooperative partnerships.

Knowledge Dissemination

Knowledge can be repurposed when knowledge providers and users exchange their experiences. When knowledge is intended to benefit persons who are drastically different from the knowledge developers, this is referred to as knowledge transfer (Markus, 2001). Accordingly, knowledge transfer is the process through which an individual or a collection of individuals shares knowledge and its impact on the involvements of others (Hewett & Watson, 2006). Knowledge transfer comprises knowledge transfer among individuals, transfer between individuals and explicit or groups, transfer within and among groups, and transfer from groups to workplaces; technology plays an important function in the transfer, particularly across geographical borders and in virtual teams (Anantatmula, 2009).

Knowledge transfer involves the process of disseminating knowledge within a firm, either through formal or informal networks, in order to improve performance and capacities (Braganza et al., 2009). Culture, laws, leadership, location, knowledge remoteness, the use of processes and needs, the obvious demand for knowl-

edge, the size of an organization, the perception of an individual's cognitive style, a lack in regular business operations, and technological standards all have an impact on knowledge distribution (Landaeta, 2008).

Knowledge Application (KA) or Utilization

Owing to the tacit characteristics of knowledge and the difficulty found in transferring it, the KBV claims that its implementation brings about the benefits of knowledge (Jugend et al., 2015). Knowledge utilization involves converting knowledge into actions that bring advantages to an organization. When organizations use relevant knowledge accurately, they decrease the probability of falling in failure, enhance efficiency, and interpret their organizational expertise into personified products continuously (Chen & Huang, 2009). Organizations can speed up the development of new products and the management of administrative and technological systems by applying knowledge. KA replies to the many kinds of knowledge available to an organization and employs knowledge that has been developed and distributed (Shujahat et al., 2017). According to Shujahat et al. (2017), KA is more important than other processes including created or shared information since knowledge is meaningless unless it is put to use. Sarin and McDermott (2003) show that KA empowers organizational members to achieve their goals.

It should be noted that current study evidence suggests that knowledge application is a significant activator of innovation and general performance, as well as an underlying achievement element for the increase of modern goods (Mardani et al., 2018). The basic goal of knowledge application is to use both internally and outside sourced knowledge to achieve organizational goals (Shin, Holden & Schmidt, 2001). According to Boateng and Agyemang (2015), application of knowledge refers to procedures within companies that allow organizations to utilize and impact knowledge in order to improve performance, produce new products, and build new knowledge assets.

Organizations can use knowledge integration strategies to tackle organizational problems by identifying the source of competitive advantage (Shin et al., 2001). This has become one of the basic characteristics of KM because its major goal is to guarantee that existing knowledge is used to benefit a business.

To summarize, information has substantial value for competitive advantage when it aids in boosting operational and innovation performance (Manesh et al., 2021; Cassia et al., 2020; Nonaka, 1994). Employee cognitive development and involvement in an organization can be aided by KM (Kolyasnikov & Kelchevskaya, 2020; Muniz et al., 2022). It may also promote worker collaboration to accomplish the targeted acheivements (Muniz et al., 2021), making it useful in the implementation of I4.0 technologies (Manesh et al., 2021; Abubakar et al., 2019).

Nevertheless, although KM has been considered for over twenty years, the investigation concerning KM in I4.0 is still in its infancy (Manesh et al., 2021; Cassia et al., 2020). This paper is an attempt to shed more light on this unique relationship.

Market Orientation

Expansion of the company's market performance arises if its market orientation is strengthened. Staff members gather data on clients, rivals, and their own sector of the market in addition to their understanding of the value or sector in which they are involved. Market orientation is a strong source of long-term competitive advantage since it is hard to imitate. The firm will concentrate on looking for growth prospects, and it cuts down on the time it takes to act on such chances. Additionally, market orientation is considered a key component of corporate culture that produces conflicting values, norms, artifacts, and behaviours, as well as offering a chance for competitive advantage for those that embrace it (Hadadian, 2014).

Market orientation describes the capacity of the organization to compete by foreseeing market demands and building lasting relationships with clients and suppliers. Key aspects of market orientation

include gathering information about consumers and rivals and disseminating such information throughout a firm's functional divisions. In organizations, the capacity to combine information and apply it to generate new knowledge is crucial to commercialization (Ghahroudi et al., 2019).

Market orientation is considered a strategy used by businesses to develop better behaviour and performance. A cultural viewpoint and a behavioural perspective are two perspectives on market orientation. The degree to which a company employs the idea of marketing strategy and techniques is known as market orientation. Customer value, competitive capability, and financial success are all indicators of market orientation. Market orientation also includes competitor orientation, consumer orientation, and operational coordination. The market orientation process is broken down into three parts: gathering information from consumers, sharing knowledge throughout the organization, and meeting both present-day and foreseeable future customer demands (Utomo et al., 2022).

The most successful organizational culture for producing the behaviours required to deliver higher value for customers and superior performance for the business is one that is focused on the market. Companies with a market-oriented organizational culture will base their plans for each business unit inside the organization on market desires and demands, as well as external fundamental necessities, to gauge the company's performance. With this knowledge, the selling organization can identify its potential clients and learn what their needs are today and, in the future (Suryani et al., 2021).

As a result, knowledge remains within a company's individual employees, which means that for this knowledge to benefit the business, effective internal knowledge-sharing procedures are required to transfer knowledge from the person to the corporate level. Organizations must also develop and acquire external knowledge in order to improve their performance. Adopting the procedure of voluntary knowledge-sharing with other SC actors such as customers and direct suppliers is a realistic means of gaining knowledge outside (Eslami et al., 2023).

Literature Review and Hypotheses Development

A recent extensive review of the literature done by Ribeiro et al., (2022), on KM and I4.0 on 41 works published between 2010 and 2021, has shown that there are three broad contexts, concerning KM and I4.0. The first theme is identified as Technology, which discovers infrastructure demands for application and its impacts on the creation of knowledge procedures; the second theme includes KM and learning, which enhances the significance of hard and soft traits, and suggests the necessity to explore enablers contribute to creation of knowledge and sharing; and lastly, Worker engagement, which reflects communicational, cultural and trust-related characteristics for a worker's development. Accordingly, this investigation may be seen to be attached to the second theme and where it looks into how KM can affect Industry 4 adoption in manufacturing and servicing organizations in Egypt.

This issue was studied in the literature by Sartori et al. (2022), Manesh et al. (2021), Cassia et al. (2020), Kolyasnikov & Kelchevskaya (2020), Núñez-Merino et al. (2020), and Feng et al. (2017). Most of the results of this research have generally supported the notion that KM is able to benefit in integrating technology and human-related features, enhance IT infrastructure strategy (Cassia et al., 2020), advance skill innovation, encourage collaboration (Abubakar et al., 2019), facilitate learning, boost product development, and aid the planning of process and control (Feng et al., 2017).

In addition, KM has been seen to specifically support the implementation of Industry 4 within a number of sectors; for example, Neumann and Evangelista, (2019) shed light on its application within the scope of the supply chain. Also, Sartori et al, (2022) proposed a conceptual model concerning KM in the setting of supply chain 4.0. Ardito et al, (2019) again confirmed that supply chain integration is favoured by the opportunity for higher data acquisition, storage, and knowledge elaboration.

Moreover, several studies have confirmed the relationship between a company's knowledge management and service innovation, confirming that Knowledge Management has positively influenced Service Innovation (Islam et al, 2017; Kariyapperuma, 2015). In addition, Arifiani et al., (2019) study confirmed the link between KM, and innovation for the telecommunication industry 4 in service organizations in developing countries such as Indonesia.

In Egypt, Shehata (2015) discovered a positive connotation between the six elements that comprise a KMS, especially the generation of knowledge, acquisition, codification, communication, the transfer, measurement, and perceived company performance in a study emphasizing the ICT sector. This investigation gives strong indication that KMSs are required to develop a firm's performance. However, the findings stated that respondents' age, gender, business type, and years spent experience have no major effect on perceived knowledge management performance as a result of KMS. In addition, a recent investigation of Qadri et al., (2021) revealed that knowledge generation, storage, as well as communicating all act in concert to moderate the links between organizational performance and organizational learning.

According to a study by Abusweilem and Abualoush (2019), KM processes (i.e., Creation of Knowledge, knowledge storage, and knowledge sharing) boost organizational performance. Zaim et al., (2019) study has investigated and confirmed the mediating influence of knowledge utilization on the link between KM and firm performance. The results of Ode and Ayavoo, (2020) established that creation of knowledge, storage and application have great significance, and can affect business innovation positively. The data also demonstrated that the application of knowledge influences the association between knowledge development, dissemination, firm innovation, and storage. The adopted results also suggest that knowledge management techniques donate to innovation in a structured manner, with knowledge application having a major effect on business innovation.

Areed, Salloum, and Shaalan, (2021) have provided a thorough assessment of 50 research-published articles and their main findings indicated that multiple KM processes contribute greatly to an innovative organization. Yet, it was discovered that knowledge exchange is the most important step for innovation.

From the literature presented above, this study assumes that KM practices will have a direct effect on Industry four adoption in manufacturing and service organizations working in Egypt; and hence proposes the following hypothesis:

H1: KM activities (Knowledge creation, acquisition, storage, sharing, dissemination, and application) are positively affecting Industry 4 adoption.

John (2016) examined how Gama Park in Santa Catarina, in the development processes of incubated companies, articulated market orientation, knowledge management and innovation. Findings illustrated that when in line with the goals of the organization, knowledge management, enhanced market orientation which resulted in innovation.

Similarly, Hussein et al. (2018) explored the impact of knowledge management behavior on the orientation of markets, as well as the mediating impact of the orientation of markets on the association between knowledge management behavior and business performance. The investigation revealed that knowledge management has a substantial impact on markets orientation. Because information sharing had no direct effect on firm performance, market orientation's mediating effect appeared to be totally mediating. The same result was obtained when testing different knowledge management activities (Ghahroudi et al., 2019; Ullah et al., 2019; Seifollahi and Arbabi, 2021; Dash, 2022; Khammadee, 2022; Setiyono et al., 2022).

From the literature presented above, this research claims that KM practices will directly influence market orientation; and hence proposes the following hypothesis:

H2: KM activities are positively affecting market orientation.

Companies attempt to satisfy consumer requirements using technology since market-oriented businesses have features that are customer-oriented. Customers need precise and timely service when ordering things. As a result, businesses adopt technology to enhance the sales process in an effort to satisfy client expectations. By deploying technological applications that offer several advantages, businesses not only meet the demands of their existing clients but also those of future customers (Utomo et al., 2022).

Asare et al. (2011) aimed to elaborate on the function of market orientation in B2B technology adoption. It was found that an organization's marketing channel orientation greatly influenced how an organization responded to requests from its trading partner to adopt B2B technologies. Also, Alford and Page (2015) examined the effects of the orientation of markets on the adoption of marketing technology by small businesses. It was discovered that there was a significant connection with the implementation of marketing technology, as well as a clear understanding of its opportunities, particularly in terms of promoting greater effectiveness market orientation and more engaged marketing while adhering to the concepts of efficient reasoning.

Herrero et al. (2018) illustrated the influences of market orientation on the adoption of SNS for the purpose of marketing in hospitality micro-enterprises. The data collected demonstrated that, despite having an impact indirectly through its impact on performance expectancy and social influence, market orientation profoundly affected the intention to utilize SNS as a mode of communication in microenterprises. This shows that, at its core, the aim to utilize technology to communicate in microenterprises was driven by changing client preferences and behaviors, necessitating a quick and successful response from firms to adapt to new market behaviors.

Konno and Schillaci (2021) recently revisited the theory concerning knowledge-creation to examine its usefulness to management of innovation in the age of Society 5.0 ("super smart society"). They assert that in modern society, social innovation involves exchanging intellectual capital that exceeds organizational boundaries. In order to accomplish this mission, they suggest an open innovation paradigm facilitated by key participants (academics, businesses, government, and user groups) based on the Socialization, Externalization, Combination, and Internalization (SECI) model. As each significant participant develops their own internal techniques to apply the SECI model, they should all identify the shared goal, which is symbolized by Sharing "Ba" (open place, dynamic context). Internal and external systems are so linked as a result.

Utomo et al. (2022) demonstrated the impact of market orientation on the use of fintech and online-based marketing technology. According to the findings, the orientation of markets had a major impact on the employment of fintech and online-based marketing technology.

The above-mentioned studies have shown that the orientation of markets has appeared to have a significant influence on technology adoption, yet little research has been concerned with the effect of market orientation on Industry 4.0 adoption. This means that there is a lack of information concerned with how market orientation could enhance the role of Industry 4.0, and this could be one of the current research contributions. Therefore, this research postulates that market orientation will have a direct effect on Industry 4.0 adoption as a means of technology; and hence proposes the following hypothesis:

H3: Market orientation is positively affecting Industry 4.0 adoption.

In addition, the following hypothesis could be developed:

H4: Market orientation significantly mediates the relationship between KM activities and Industry 4.0 adoption.

Research Methodology

The quantitative approach is used to examine the role of knowledge management in industry 4.0 adoption through the mediating role of market orientation. The hypotheses were developed from the theoret-

ical perspectives, where this research uses the descriptive explanatory design to describe the relationship between the research variables. The research framework with the research variables is illustrated in Figure 2.

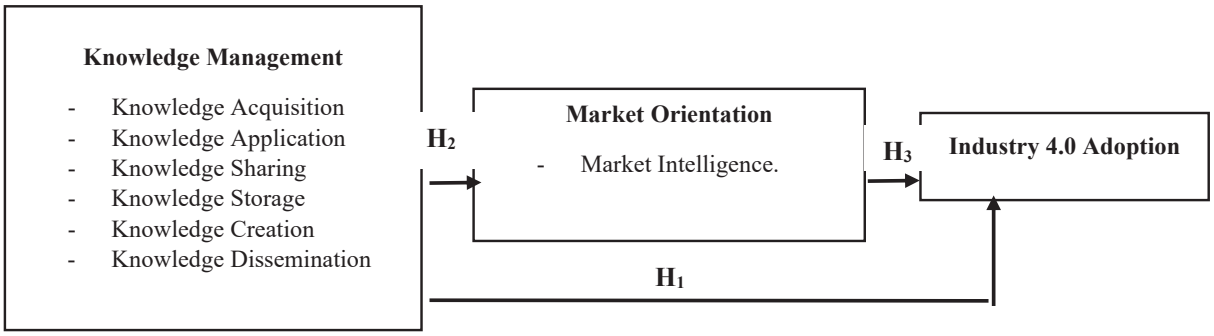

Figure 1: Research Model

Accordingly, the research hypotheses could be stated as follows:

- H1: KM activities (Knowledge creation, acquisition, storage, sharing, dissemination, and application) are positively affecting industry 4 adoption.
- H2: KM activities are positively affecting market orientation.
- H3: Market orientation is positively affecting industry 4.0 adoption.
- H4: Market orientation significantly mediates the relationship between KM activities and Industry 4.0 adoption.

The target population is defined as employees working in manufacturing and service sectors in the Egyptian context. Primary data was collected using questionnaire adopted from previous studies (see table 1). The research variables measurements are illustrated in Table 1. Respondents were asked to rate their agreement to each statement on a Likert 5 item scale where 1= strongly disagree to 5= strongly agree.

Table 1: Questionnaire Statements

Variables	Sample of Statements Used
KM (Knowledge Acquisition) (Yu et al., 2022)	My organization regularly acquires information about environment-friendly products and processes/services from external stakeholders (e.g., customers and suppliers).
KM (Knowledge Application) (Yu et al., 2022)	My organization ensures the application of acquired knowledge to produce environment-friendly products and services.
KM(Knowledge Sharing) (Yu et al., 2022)	People within our organization regularly interact with each other to discuss different environmental developments and share knowledge.
KM(Knowledge Storage) (Yu et al., 2022)	My organization has sufficient information about environment-friendly products and processes/services.
KM (Knowledge Creation) (Yu et al., 2022)	My organization uses existing information to create environment-friendly products and services.
KM(Knowledge Dissemination) (Chong et al., 2014) (Tortorella et al., 2022)	Our organization has processes for distributing knowledge throughout the organization. My firm works in partnership with international customers.
Market Orientation (Market Intelligence) (Zhang et al., 2022)	Our team's forecast of the market demand for this project is accurate.
Industry 4.0 Adoption (Sharma et al., 2022)	The system is unnecessarily complex.

Demographic variables. Seven main demographic variables were included: gender, Income level, Education level, sector (private versus public), organization type; organization size and adoption maturation level.

The non-probability sampling method was used, as there is no sampling frame could be reached for employees working in manufacturing and service sectors in Egypt. Convenient sampling is used as a beneficial type of non-probability sampling when trying to create a representative sample.

As there is no specific sampling frame for this research, and there is an infinite number of employees for different sectors, therefore, the sample size is calculated according to Saunders et al.'s (2016) 95% confidence level equation, implying that the minimum sample size for an infinite population is 385 observations. A number of 1200 responses were distributed, while only 843 responses were collected, with a response rate of 70.25%. A number of 177 responses were invalid or had missing responses. Therefore, 666 responses were considered in the analysis.

Table 2: Descriptive Statistics of Respondents Profile

Item	Category	Frequency (N=666)	Percent %
Gender	Male	432	64.86%
	Female	234	35.14%
Income Level	Less than 5000	59	8.85%
	5000 – less than 10000	168	25.23%
	10000 – less than 15000	164	24.62%
	15000- less than 20000	121	13.99%
	20000 or above	154	18.17%
Education Level	Bachelor's Degree	387	58.11%
	Master's Degree	192	28.83%
	Doctorate Degree	86	12.91%
Sector	Public	326	48.9%
	Private	340	51.1%
Type	Manufacturing	479	71.9%
	Service	187	28.1%
Size	Small	200	30.0%
	Medium	330	49.5%
	Large	136	20.4%
Maturation	Initial	331	49.7%
	Followers	308	46.2%
	Beacons	27	4.1%

Table 2 shows the respondents profile, where number of males are 432 respondents with a percentage of 64.86%, which is higher than the number of females, with 234 respondents with a percentage of 35.14%. In addition, respondents with income level between 5000 and 10,000 are the highest representing a number of 168 respondents with a percentage of 25.23%. The income level between 10,000 and 15,000 comes in the second rank, representing 164 respondents with a percentage of 24.62%. However, the list in income level is that less than 5000 with number of respondents of 59 and percentage of 8.85%. Regarding education, around half the sample under study have a bachelor's degree where 387 respondents belong to this group with a percentage of 58.11%, while respondents having a doctorate degree or the least with 86 respondents representing 12.91% of this sample under study. Employees in the private sector represent 340 respondents with a percentage of 51.1%, while employees in the public sector or 326 respondents with a percentage of 48.9%. In addition, employees belonging to the manufacturing sector represent 479 respondents with a percentage of 71.9% while those in the service sector represent 187 respondents with a percentage of only 28.1%. Moreover, employees in small enterprises represented 200 respondents with a percent of 30% of the sample under study, a number of 330 employees work in medium enterprises, while only 136 respondents representing 20% of the sample under study work in large business volume organizations. Regarding maturation, around half the sample under study work in organizations with initial maturation level with number of respondents equals 331 respondents; while the least in maturation level "the beacon" level with only 27 respondents representing 4.1% of the sample under study.

Results and Findings

In this section, the SEM analysis is conducted to test the research hypotheses for the research model. A preliminary step is to show the measurement model to test the model validity.

Validity and Reliability Analysis

Assessing the constructs validity, as shown in Table 3, the Average Variance Extracted (AVE) is found to be between 84% and 89% (AVE > 50%). Also, the factor loading is found between 0.752 and 0.934 (FL > 0.4). In addition, the most common reliability test, Cronbach's alpha, can be used to evaluate how consistently the statements form the corresponding construct. Alpha values range between 0.950 and 0.979 (Alpha > 0.7), indicating adequate reliability.

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) is a required step to confirm the factor structure extracted by the researcher as a measurement scale for each dimension before launching the structural equation model-

ling (SEM). AMOS 24 program was used and ML method was applied to show the factor loading for each variable and their model fit. Regarding the CFA using the covariance method, it had been illustrated using Figure 2 and the results had been shown as follows:

The model fit of the confirmatory factor analysis were computed, where it was found that the minimum discrepancy or chi-square divided by the degrees of freedom (CMIN/DF) was 1.677; the probability of getting as larger discrepancy as occurred with the present sample (p-value) was 0.000; goodness of fit (GFI) was 0.921 (> 0.900); adjusted goodness of fit index (AGFI) was 0.913 (> 0.900) - that evaluate the fit of the model versus the number of estimate coefficients or the degrees of freedom needed to achieve that level of fit; the Bentler-Bonett normed fit index (NFI) was 0.974 (> 0.900) and the Tucker-Lewis index or Bentler-Bonett non-normed fit index (TLI) was 0.988 (> 0.900) — which assess the incremental fit of the model compared to a null model; the comparative fit index (CFI) was 0.989 (> 0.900).

Also, the root mean square residual (RMR) was 0.026 (0.1) — which shows the amount by which the sample variances and covariances differ from their estimates obtained under the assumption that the model is correct; the root mean square of approximation (RMSEA) was 0.032 (<0.08) — which is an informative criterion in covariance structure modelling and measures the amount of error present when attempting to estimate the population (Hair et al., 2016).

Figure 2 shows the confirmatory factor analysis had been applied, where the factor loadings are shown on arrows implying good factor loadings (Factor Loadings > 0.4) for the confirmatory factor analysis. These factor loadings are shown in numbers using Table 3.

Table 3: Validity and Reliability

Variables	KMO	AVE	Cronbach's Alpha	Items	Factor Loading
Knowledge Acquisition	.917	87.813	.965	KAC1	.846
				KAC2	.869
				KAC3	.888
				KAC4	.892
				KAC5	.895
Knowledge Application	.896	83.466	.950	KAP1	.843
				KAP2	.841
				KAP3	.848
				KAP4	.818
				KAP5	.823
Knowledge Sharing	.872	89.666	.976	KSH1	.957
				KSH2	.899
				KSH3	.860
				KSH4	.892
				KSH5	.934
				KSH6	.838
Knowledge Storage	.886	84.490	.954	KST1	.869
				KST2	.881
				KST3	.808
				KST4	.893
				KST5	.774
Knowledge Creation	.879	87.615	.965	KCR1	.896
				KCR2	.848
				KCR3	.900
				KCR4	.896
				KCR5	.840
Knowledge Dissemination	.960	84.379	.979	KDS1	.830
				KDS2	.845
				KDS3	.870
				KDS4	.860
				KDS5	.813
				KDS6	.881
				KDS7	.791
				KDS8	.859
				KDS9	.871
				KDS10	.818
Market Intelligence	.868	87.321	.964	MI1	.847
				MI2	.873
				MI3	.858
				MI4	.879
				MI5	.909
Industry 4.0 Adoption	.932	85.983	.979	I4.0A1	.854
				I4.0A2	.805
				I4.0A3	.934
				I4.0A4	.887
				I4.0A5	.851
				I4.0A6	.912
				I4.0A7	.831
				I4.0A8	.752
				I4.0A9	.913

Table 4 shows that all factor loadings (FL); which represent the size of the loadings of items on their corresponding variables, are greater than or equal to 0.40, implying the fact that the constructs under study have adequate validity. Also, all the P-values are less than 0.05, showing the significance of the corresponding statements to their constructs. Also, it could be observed that the value of CR for all constructs is greater than 0.60. Therefore, composite reliability achieved the required level.

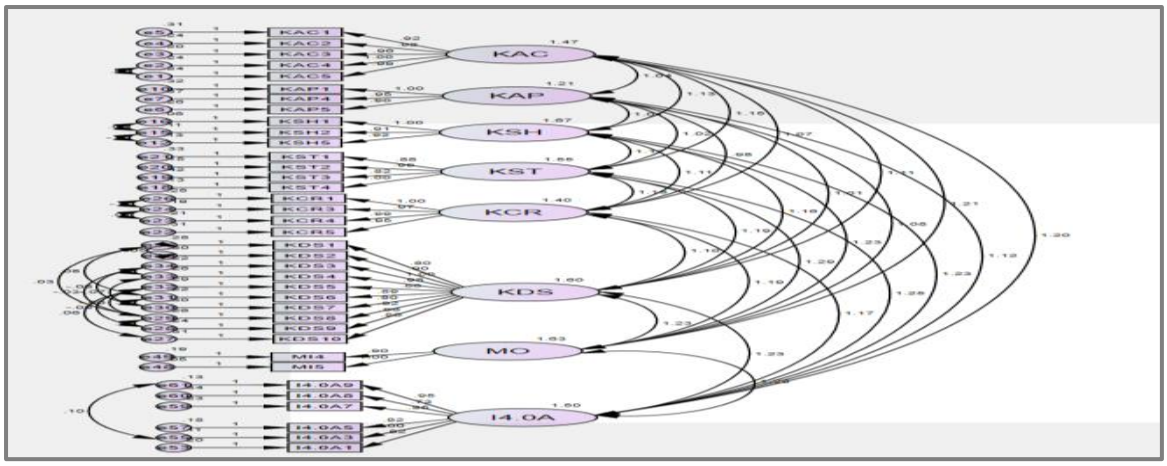

Figure 2: CFA for the Measurement Model

Discriminant Validity

Table 5 shows the discriminant validity of the research variables, where it could be observed that all square root of AVE values is greater than the correlations between the corresponding construct and other constructs. This means that the research variables have adequate discriminant validity.

Descriptive Analysis of Research Variables

Frequency statistics sum how many times each variable is repeated. In the following section, means, standard deviations and frequency statistics will be conducted on both; demographic data and the research variables. Table 6 shows the mean and standard deviation for the research variables. It could be observed that the responses are within the neutral zone.

Normality Testing for the Research Variables

The Kolmogorov-Smirnov test of normality, which assesses the normality assumption for samples larger than 50 observations, is one of the techniques used most frequently to confirm the normality of a data collection. If the P-value exceeds 0.05, the data are assumed to be regularly distributed. It is known as the exact normal test. With the research variables listed in Table 7, the Kolmogorov-Smirnov test was used to formally assess the normality assumption. Because all the associated P-values are lower than 0.05, it is obvious that the data under study is not normally distributed. An informal test is run to establish the approximate normality when the formal test's findings show that the data are not normally distributed. Table 7, which displays the

Table 4: Item Loading after Confirmatory Factor Analysis

			Estimate	S.E.	C.R.	P	Composite Reliability
KAC5	<---	KAC	.987	.020	48.958	***	.964
KAC4	<---	KAC	1.000				
KAC3	<---	KAC	.959	.022	44.476	***	
KAC2	<---	KAC	.916	.022	41.738	***	
KAC1	<---	KAC	.916	.023	39.099	***	
KAP5	<---	KAP	.901	.028	32.630	***	.912
KAP4	<---	KAP	.953	.031	30.935	***	
KAP1	<---	KAP	1.000				
KSH5	<---	KSH	.917	.016	58.718	***	.977
KSH2	<---	KSH	.906	.014	64.608	***	
KSH1	<---	KSH	1.000				
KST4	<---	KST	1.000				.952
KST3	<---	KST	.822	.023	36.202	***	
KST2	<---	KST	.991	.017	58.115	***	
KST1	<---	KST	.878	.021	41.785	***	
KCR5	<---	KCR	.953	.025	37.950	***	.958
KCR4	<---	KCR	.988	.024	42.018	***	
KCR3	<---	KCR	.970	.023	41.553	***	
KCR1	<---	KCR	1.000				
KDS10	<---	KDS	.856	.022	39.757	***	.979
KDS9	<---	KDS	.960	.021	45.668	***	
KDS8	<---	KDS	.920	.022	41.304	***	
KDS7	<---	KDS	.798	.024	33.798	***	
KDS6	<---	KDS	.892	.020	45.475	***	
KDS5	<---	KDS	.860	.021	40.722	***	
KDS4	<---	KDS	.985	.017	56.545	***	
KDS3	<---	KDS	1.000				
KDS2	<---	KDS	.905	.022	41.989	***	
KDS1	<---	KDS	.799	.020	39.364	***	
MI5	<---	MO	1.000				.966
MI4	<---	MO	.902	.017	54.511	***	
I4.0A1	<---	I4.0A	.818	.017	48.025	***	.975
I4.0A3	<---	I4.0A	1.000				
I4.0A5	<---	I4.0A	.818	.016	50.427	***	
I4.0A7	<---	I4.0A	.850	.018	47.089	***	
I4.0A8	<---	I4.0A	.732	.020	35.763	***	
I4.0A9	<---	I4.0A	.950	.007	142.375	***	

informal test for normality, reveals that skewness and kurtosis values are above ±1, demonstrating that the analyzed data are not normal.

Table 8 shows the SEM analysis for the impact of KM activities on Industry 4.0 adoption through the mediating role of market orientation. Regarding the first hypothesis testing the effect of KM activities on Industry 4.0 adoption, it was found that there is a significant positive effect of all KM activities on Industry 4 adoption as follows : Knowledge Creation (Estimate = 0.128 > 0; P-value = 0.001 < 0.05); Knowledge Acquisition (Estimate = 0.127 > 0; P-value = 0.000 < 0.05).; Knowledge Storage (Estimate = 0.146 > 0; P-value = 0.000 < 0.05); Knowledge Sharing (Estimate = 0.125 > 0; P-value = 0.000 < 0.05); Knowledge Dissemination (Estimate = 0.142 > 0; P-value = 0.000 < 0.05) and Knowledge Application (Estimate = 0.274 > 0; P-value = 0.000 < 0.05). It is also noticed that 83% of the variation in Industry 4.0 adoption is due to KM activities and Market Orientation (R2 = 0.830). Results revealed that the first hypothesis claiming that KM activities (Knowledge creation, acquisition, storage, sharing, dissemination, and application) are positively affecting industry 4 adoption is fully supported.

Table 5: Discriminant Validity of the Research Variables

	1	2	3	4	5	6	7	8
1. Knowledge Acquisition	(0.937)							
2. Knowledge Application	.810**	**(0.914)**						
3. Knowledge Sharing	.787**	.792**	**(0.947)**					
4. Knowledge Storage	.790**	.790**	.792**	**(0.919)**				
5. Knowledge Creation	.796**	.800**	.800**	.803**	**(0.936)**			
6. Knowledge Dissemination	.796**	.800**	.801**	.804**	.806**	**(0.919)**		
7. Market Intelligence	.831**	.820**	.832**	.832**	.839**	.836**	**(0.934)**	
8. Industry 4.0 Adoption	.853**	.860**	.853**	.852**	.852**	.854**	.880**	**(0.927)**

Table 6: Describing the Research Variables

Research Variable	N	Mean	Std. Deviation	Frequency				
				1	2	3	4	5
Knowledge Acquisition	666	3.1577	1.31529	106	112	120	227	101
Knowledge Application	666	3.2282	1.23928	82	116	126	252	90
Knowledge Sharing	666	3.1697	1.32292	112	100	116	239	99
Knowledge Storage	666	3.1547	1.27973	96	120	128	229	93
Knowledge Creation	666	3.1562	1.29995	106	105	129	231	95
Knowledge Dissemination	666	3.1682	1.27153	100	108	121	254	83
Market Orientation	666	3.4189	1.33328	51	171	78	180	186
Industry 4.0 Adoption	666	3.6727	1.27122	20	141	139	103	263

Table 7: Formal Testing of Normality

Research Variables	Kolmogorov-Smirnov			Skewness		Kurtosis	
	Statistic	df	Sig.	Statistic	Std. Error	Statistic	Std. Error
Knowledge Acquisition	.232	666	.000	-.313	.095	-1.099	.189
Knowledge Application	.247	666	.000	-.402	.095	-.915	.189
Knowledge Sharing	.242	666	.000	-.365	.095	-1.084	.189
Knowledge Storage	.229	666	.000	-.304	.095	-1.046	.189
Knowledge Creation	.231	666	.000	-.337	.095	-1.051	.189
Knowledge Dissemination	.250	666	.000	-.393	.095	-1.001	.189
Market Intelligence	.218	666	.000	-.284	.095	-1.273	.189
Industry 4.0 Adoption	.247	666	.000	-.342	.095	-1.288	.189

Regarding the second hypothesis testing the effect of KM activities on market orientation, it was found that there is a significant positive effect of all KM activities on Market orientation as follows: Knowledge Acquisition (Estimate = 0.181 > 0; P-value = 0.000 < 0.05,); Knowledge Creation (Estimate = 0.208 > 0; P-value = 0.000 < 0.05); Knowledge Sharing (Estimate = 0.114 > 0; P-value = 0.000 < 0.05); Knowledge Storage (Estimate = 0.264 > 0; P-value = 0.000 < 0.05);; Knowledge Dissemination (Estimate = 0.134 > 0; P-value = 0.000 < 0.05) and Knowledge Application (Estimate = 0.136 > 0; P-value = 0.005 < 0.05). It is also noticed that 77.4% of the variation in market orientation is due to KM activities (R2 = 0.774). Results revealed that the second hypothesis claiming that KM activities (Knowledge creation, acquisition, storage, sharing, dissemination, and application) are positively affecting market orientation is fully supported.

Regarding the third hypothesis testing the effect of market orientation on Industry 4.0 adoption, it was found that there is a significant positive effect of market orientation on Industry 4.0 adoption (Estimate

= 0.099 > 0; P-value = 0.010 < 0.05). Results revealed that the third hypothesis claiming that market orientation is positively affecting industry 4.0 adoption is supported. This also means that market orientation may play a mediation role between KM activities and Industry 4.0 adoption.

Regarding the fourth hypothesis testing the mediation effect of market orientation in the relationship between KM activities and Industry 4.0 adoption; market orientation significantly affects Industry 4.0 adoption as shown in the third hypothesis.

Table 8: SEM Analysis for the Research Variables

	Estimate	St. Estimate	S.E.	C.R.	P	R2
MO <--- KAC	.181	.172	.042	4.332	***	
MO <--- KAP	.136	.117	.049	2.794	.005	
MO <--- KSH	.114	.115	.034	3.372	***	
MO <--- KST	.264	.258	.042	6.331	***	.774
MO <--- KCR	.208	.192	.044	4.743	***	
MO <--- KDS	.134	.133	.036	3.696	***	
I4.0A <--- KAC	.127	.126	.037	3.438	***	
I4.0A <--- KAP	.274	.246	.043	6.333	***	
I4.0A <--- KSH	.125	.132	.030	4.226	***	
I4.0A <--- KST	.146	.149	.038	3.873	***	.830
I4.0A <--- KCR	.128	.124	.039	3.286	.001	
I4.0A <--- KDS	.142	.146	.032	4.438	***	
I4.0A <--- MO	.099	.103	.038	2.577	.010	

Also, it was found that all KM practices have a significant effect on industry 4.0 adoption in the presence of marketing orientation where: knowledge acquisition had a significant value of (P-value < 0.05); knowledge creation (P-value < 0.05); knowledge sharing (P-value < 0.05); knowledge storage (P-value < 0.05); knowledge dissemination (P-value < 0.05); and knowledge application (P-value < 0.05). Therefore, market orientation partially mediates the relationship between all KM activities and industry 4.0 adoption. This means that the fourth hypothesis claiming that market orientation significantly mediates the relationship between knowledge management activities and industry 4.0 adoption is partially supported.

The model fit indices; CMIN/DF = 1.677, GFI = 0.928, CFI = 0.989, AGFI= 0.913, and RMSEA = 0.032 are all within their acceptable levels. The SEM model conducted for the effect of the research model is illustrated in Figure 3.

Further statistical analysis were run to detect if the level of KM activities or the degree of technology 4 adoption; and market orientation, would differ according to organization size, maturation stage, sector or type. The following section will illustrate these further analyses results.

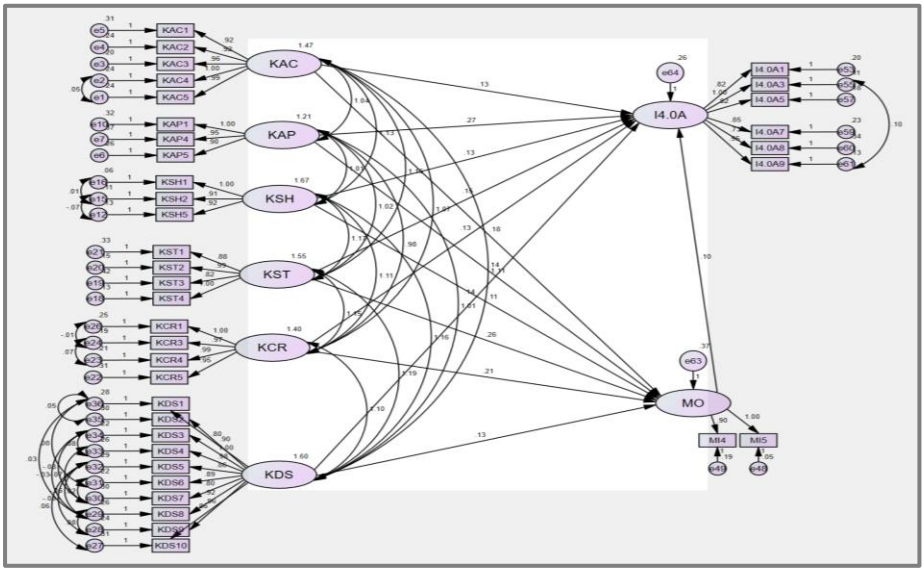

Figure 3: SEM Model

Table 9 shows the ANOVA test for each of the KM activities and I4.0 adoption according to size. It could be observed that there is a significant difference in KM activities, market orientation and I4.0 adoption according to size (P-value < 0.05). For example. Knowledge acquisition (P-value = 0.000 < 0.05), was highest in large organizations (Mean = 3.4926) and least in small organizations (Mean = 2.5400). Similar result was observed in all other KM activities.

Also, there is a significant difference in market orientation with different sizes of organizations (P-value = 0.000 < 0.05), where market orientation is the highest in organizations with large business volume (Mean = 3.7647) and the least in organizations with small business volume (Mean = 2.8150). Finally, there

is a significant difference in I4.0 adoption with different sizes of organizations (P-value = 0.000 < 0.05), where I4.0 adoption is the highest in large size organizations (Mean = 4.0368) and the least in small sized organizations (Mean = 3.1300).

Table 10 shows the ANOVA test for KM activities and I4.0 adoption according to maturation. It could be observed that there is a significant difference in KM activities, market orientation and I4.0 adoption according to maturation level (P-value < 0.05). For example there is a significant difference in knowledge acquisition with different maturation levels of organizations (P-value = 0.000 < 0.05), where knowledge acquisition is the highest in beacons (Mean = 4.2963) and the least in initials (Mean = 2.3233). Same results were indicated in all other KM activities understudy.

Table 10: ANOVA Test for KM Activities and I4.0 Adoption According to Maturation

Variables	Items	N	Mean	Std. Deviation	P-value
Knowledge Acquisition	Initial	331	2.3233	1.13139	0.000
	Followers	308	3.9545	.89400	
	Beacons	27	4.2963	.91209	
	Total	666	3.1577	1.31529	
Knowledge Application	Initial	331	2.4350	1.09455	0.000
	Followers	308	4.0097	.77622	
	Beacons	27	4.0370	1.01835	
	Total	666	3.2282	1.23928	
Knowledge Sharing	Initial	331	2.3293	1.12964	0.000
	Followers	308	3.9935	.89149	
	Beacons	27	4.0741	1.14105	
	Total	666	3.1697	1.32292	
Knowledge Storage	Initial	331	2.3293	1.09697	0.000
	Followers	308	3.9643	.85915	
	Beacons	27	4.0370	.80773	
	Total	666	3.1547	1.27973	
Knowledge Creation	Initial	331	2.3112	1.10775	0.000
	Followers	308	3.9870	.82696	
	Beacons	27	4.0370	1.22416	
	Total	666	3.1562	1.29995	
Knowledge Dissemination	Initial	331	2.3686	1.08855	0.000
	Followers	308	3.9545	.87559	
	Beacons	27	4.0000	1.03775	
	Total	666	3.1682	1.27153	
Market Orientation	Initial	331	2.5196	1.10182	0.000
	Followers	308	4.3052	.86802	
	Beacons	27	4.3333	.83205	
	Total	666	3.4189	1.33328	
Industry 4.0 Adoption	Initial	331	2.7795	1.05730	0.000
	Followers	308	4.5422	.73633	
	Beacons	27	4.7037	.72403	
	Total	666	3.6727	1.27122	

Table 9: ANOVA Test for KM Activities and I4.0 Adoption According to Size

Variables	Items	N	Mean	Std. Deviation	P-value
Knowledge Acquisition	Small	200	2.5400	1.23533	0.000
	Medium	330	3.3939	1.23376	
	Large	136	3.4926	1.32215	
	Total	666	3.1577	1.31529	
Knowledge Application	Small	200	2.6950	1.19125	0.000
	Medium	330	3.4364	1.18650	
	Large	136	3.5074	1.19874	
	Total	666	3.2282	1.23928	
Knowledge Sharing	Small	200	2.6650	1.22895	0.000
	Medium	330	3.3030	1.33425	
	Large	136	3.5882	1.20782	
	Total	666	3.1697	1.32292	
Knowledge Storage	Small	200	2.6050	1.21918	0.000
	Medium	330	3.3394	1.25718	
	Large	136	3.5147	1.16737	
	Total	666	3.1547	1.27973	
Knowledge Creation	Small	200	2.5500	1.30230	0.000
	Medium	330	3.3606	1.21801	
	Large	136	3.5515	1.18522	
	Total	666	3.1562	1.29995	
Knowledge Dissemination	Small	200	2.6350	1.16558	0.000
	Medium	330	3.3485	1.25590	
	Large	136	3.5147	1.22314	
	Total	666	3.1682	1.27153	
Market Orientation	Small	200	2.8150	1.24439	0.000
	Medium	330	3.6424	1.30210	
	Large	136	3.7647	1.24862	
	Total	666	3.4189	1.33328	
Industry 4.0 Adoption	Small	200	3.1300	1.17045	0.000
	Medium	330	3.8515	1.24471	
	Large	136	4.0368	1.23173	
	Total	666	3.6727	1.27122	

Also, there is a significant difference in market orientation with different maturations levels of organizations (P-value = 0.000 < 0.05), where market orientation is the highest in beacons (Mean = 4.3333) and the least in initials (Mean = 2.5196). Finally, there is a significant difference in I4.0 adoption with different maturations levels of organizations (P-value = 0.000 < 0.05), where I4.0 adoption is the highest in beacons (Mean = 4.7037) and the least in initials (Mean = 2.7795).

Table 11 shows the T-test for KM activities and I4.0 adoption according to sector. It could be observed that there is a significant difference in KM activities, market orientation and I4.0 adoption according to different sec-

tors (P-value < 0.05). All forms of KM activities were higher in private sector than in public sector. For example. There is a significant difference in knowledge acquisition with different sectors (P-value = 0.000 < 0.05), where knowledge acquisition is the highest in private sector (Mean = 3.4353) and the least in public sector (Mean = 2.8681). Similar results were obvious in all other forms of KM.

Also, there is a significant difference in market orientation with different sectors (P-value = 0.000 < 0.05), where market orientation is the highest in private sector (Mean = 3.7118) and the least in public sector (Mean = 3.1135). Finally, there is a significant difference in I4.0 adoption with different sectors (P-value = 0.000 < 0.05), where I4.0 adoption is the highest in private sector (Mean = 3.9676) and the least in public sector (Mean = 3.3650).

Table 12 shows the T-test for KM activities and I4.0 adoption according to organization type. It could be observed that there is an insignificant difference in KM activities, market orientation and I4.0 adoption according to different types (P-value > 0.05).

Table 11: T-Test for KM Activities and I4.0 Adoption According to Sector

Variable	Sector	N	Mean	Std. Deviation	P-value
Knowledge Acquisition	Public	326	2.8681	1.25186	0.000
	Private	340	3.4353	1.31653	
Knowledge Application	Public	326	2.9540	1.18232	0.000
	Private	340	3.4912	1.23729	
Knowledge Sharing	Public	326	2.9233	1.27350	0.000
	Private	340	3.4059	1.32815	
Knowledge Storage	Public	326	2.8344	1.24413	0.000
	Private	340	3.4618	1.23912	
Knowledge Creation	Public	326	2.8252	1.30918	0.000
	Private	340	3.4735	1.21053	
Knowledge Dissemination	Public	326	2.8497	1.24978	0.000
	Private	340	3.4735	1.21781	
Market Orientation	Public	326	3.1135	1.28518	0.000
	Private	340	3.7118	1.31449	
Industry 4.0 Adoption	Public	326	3.3650	1.22231	0.000
	Private	340	3.9676	1.24877	

Table 12: T-Test for KM Activities and I4.0 Adoption According to Type

Variable	Item	N	Mean	Std. Deviation	P-value
Knowledge Acquisition	Manufacturing	479	3.1065	1.30462	0.108
	Service	187	3.2888	1.33684	
Knowledge Application	Manufacturing	479	3.1900	1.22193	0.203
	Service	187	3.3262	1.28075	
Knowledge Sharing	Manufacturing	479	3.1566	1.30597	0.683
	Service	187	3.2032	1.36838	
Knowledge Storage	Manufacturing	479	3.0960	1.27871	0.058
	Service	187	3.3048	1.27344	
Knowledge Creation	Manufacturing	479	3.1023	1.28068	0.087
	Service	187	3.2941	1.34169	
Knowledge Dissemination	Manufacturing	479	3.1127	1.26086	0.072
	Service	187	3.3102	1.29102	
Market Orientation	Manufacturing	479	3.3653	1.32016	0.097
	Service	187	3.5561	1.36027	
Industry 4.0 Adoption	Manufacturing	479	3.6263	1.25770	0.132
	Service	187	3.7914	1.30109	

Discussion

This research aimed at studying the effect of KM on Industry 4 adoption. To achieve this aim, the paper investigated the effects of some KM activities, namely, Creation of Knowledge, Acquisition of Knowledge, Sharing of Knowledge, Storage of Knowledge, Knowledge Dissemination, and Knowledge Application on Industry 4.0 adoption in Egyptian manufacturing and service companies.

All studied KM activities (Creation of Knowledge, Acquisition of Knowledge, Sharing of Knowledge, Storage of Knowledge, and Knowledge Dissemination) were found to have positive significant effects on Industry 4.0 adoption (Estimates > 0; P-value < 0.05). Accordingly, the adopted result is consistent with the investigation of previous studies (e.g., Neumann and Evangelista, 2019; Sartori et al, 2022; Ardito et al, 2019; Shehata, 2015).

Moreover, it could be claimed that knowledge application is the most essential activity of knowledge management for Industry 4.0 adoption, as the corresponding standardized estimate is 0.274. Then comes knowledge storage and knowledge dissemination, with a standardized estimate of around 15%. Finally, Knowledge creation, Knowledge acquisition, and Knowledge sharing resulted in a close standardized estimate of around 13%.

It could be understood why that knowledge application is the most important activity in the KM process (compromising 27% of the effect on Industry 4 adoption). As claimed by many academic investigations, the principal attention of knowledge management is concerning the application of knowledge as it increases the relevancy of knowledge for the production of organizational value (Bhatt, 2001; Choi, Lee & Yoo, 2010).

Shujahat et al. (2017) pointed out that Knowledge application is more vital than other procedures like created knowledge or shared knowledge as knowledge appears to be insignificant until it has been applied. Ode and Ayavoo's (2020) study also argued that the associations between other KM practices (generation, diffusion, and storage) and business innovation can be mediated by the application of knowledge, claiming that if knowledge generation and diffusion are not applied effectively, they cannot produce desirable results.

Another interesting results was found showing that the level of KM activities; the degree of technology 4 adoption; and market orientation, all differ according to organization size, maturation stage, sector and organization type. To understand this findings one should refer to the literature that argue that particular knowledge management strategies should be implemented in line with conditions occurring in a particular business environment. For example, Kolyasnikov and Kelchevskaya (2020) demonstrated that firms use various approaches for accruing and providing knowledge consistent with their maturity stages and the scope of application of Industry 4.0. Also, Sartori et al, (2022) has proven that knowledge management in small and medium-sized firms does not have the same features, demands, and obstacles as knowledge management in large enterprises.

Consequently, researchers approved the efficiency of the theory concerning Dynamic capabilities (DC) which concentrates on the capabilities of a company to maintain its competitiveness (Qamar et al., 2019; Sánchez et al., 2019; Teece et al., 1997). In reference to DC literature, if a company does not own the correct skills to respond appropriately to the requirements of an active business environment, it may not automatically get a competitive edge despite having many resources (Teece et al., 1997). Furthermore, a firm's resource-based view (RBV) explains how certain firms outperform others because they have distinct organizational resources. Hence, companies with more unique resources and knowledge would outperform other firms with less capacity. This notion would explain why, in our sample, those larger firms, at a mature stage, and in private sectors would have higher KM practices and higher technology adoption.

Also, the study has confirmed the positive effect of KM on market orientation. This result is consistent with that found in previous studies (e.g., Zebal et al., 2018; John, 2016; Hussein et al., 2018; Ghahroudi et al., 2019; Ullah et al., 2019; Seifollahi and Arbabi, 2021; Dash, 2022; Khammadee, 2022; Setiyono et al., 2022).

Organizations become more capable of responding to market shifts and making more beneficial judgments regarding the allocation of precious resources to focus on the enhancement of their internal and external aspects concerning marketing by implementing integrated knowledge management programs. Additionally, Roblek et al. (2016) claimed that KM processes will allow marketing strategists to improve accuracy, acquire content that is relevant and valuable from customers, and constantly reply to them in real time, with the purpose of changing or enhancing customer behaviour.

Moreover, in line with other studies in the context of previous academic studies, (e.g., Herrero et al., 2018; Konno and Schillaci, 2021; Utomo et al., 2022), this research confirmed that Market orientation has a significant positive influence on Industry 4.0 adoption. Market orientation allows firms to accumulate and build market-based assets that open the way for successful performance. Therefore, managers should identify market-based assets which already exist in their organizations, analyze and discern their value, and fully utilize them when introducing new products and maintaining relationships with external stakeholders (Masa'deh et al., 2018).

Market orientation also employs a partial mediation function in the relationship between KM activities and Industry 4.0 adoption. This means that knowledge management activities have a direct effect on Industry 4.0 adoption, in addition to an indirect effect from the mediating role of market orientation. As organizations become more oriented towards the market, they can cope and adjust to the altering turbulent market contexts to boost their attractiveness and consequently attain organizational accomplishment (Zebal et al., 2018).

Conclusion and Recommendation

This research sheds light on the significance and benefit of the KM process in the adoption of Industry 4 technology in theoretical and practical ways:

First, it is vital due to more scholars are recognizing the need to classify and advance intangible assets including knowledge and intellectual capital to facilitate and boost the value of a firm.

Second, previous literature that have examined the connections between the management of knowledge and Industry 4 adoption take the perspective of a developed country (Alegre et al., 2013; Apak, Tuncer, Atay, & Kos, An, 2012; Donate & Guadamillas, 2011; Donate & Pablo, 2015; García-Álvarez, 2015). Few academics have looked at the association between management of knowledge and technology adoption in developing countries. A new investigation by Gaviria-Marin, Merigó, and Baier-Fuentes (2018) employs bibliometric analysis to show that a few investigations has centered on knowledge management-related difficulties in developing countries, particularly African ones.

Concentrating solely on the backdrop of developed countries distorts our comprehension of the character of evolving markets and the noteworthy ways in which market systems in developing countries differ from those in established markets. Accordingly, this work renders an empirical contribution by providing a basic comprehension of current KM practices used in Egyptian firms, specifically the impact of knowledge creation, acquisition, codification, sharing, transfer, and application, as well as their links to Industry 4 adoption. As a result, the findings of this study may assist managers in better understanding how and why KM procedures and operations are helpful in facilitating the adoption of Industry 4 technology, and through what processes this can occur.

In summary, through highlighting the importance of KM practices, especially knowledge application, and also through focusing on the market orientation as a mechanism for maximizing adoption, the present investigation provides much-needed guidance and insights to assist ICT managers boost advantage more from future KM initiatives. This study, in return, encourages organizations to test the effect of KM on corporate performance, which will ultimately expose the financial advance resulting from making use of KM and, hence, justifying its cost.

Research Limitations and future studies

There are a few conditions to consider when evaluating the findings of this study. First, self-report survey data might be subject to typical method variance, social desirability biases, and distortion of response due to self-defense inclinations. Second, the cross-sectional character of the data makes causal inference difficult. Only a specific scenario in the context of the sampling organizations polled could be analyzed, not their general conduct over time; so, future research ought to concentrate on a longitudinal study. Third, this research is restricted to the six major components of the KM systematic process.

However, KM alone is insufficient to ensure its effectiveness; the company must also focus on the Important variables for success for KM effectiveness, which, according to the Wong and Aspinwall, 2005 study, proposed 11 CSFs to serve as the foundation for KM adoption in the SME sector: culture; leadership and support; information technology; measurement; strategy and objective; organizational infrastructure; resources; processes and activities; human resource management; training and education; and motivational assists. Hence, future research is encouraged to engage in the model of other success factors besides KM, in order to comprehensively detect its effect on Industry 4 adoption.

Fourth, this research is limited to studying the effect of KTM activities on Industry 4.0 adoption through the mediating function of market orientation in the Egyptian context. New research could examine the same relationship in other developing countries. Another limitation is that this research considered only one dimension of market orientation, which is market intelligence. New research could address other features of market orientation like customer orientation, competitors' orientation, and so on.

Finally, this research collected data from the manufacturing and service sector in the Egyptian context, therefore this research was general for both sectors. New research could study each sector separately as well as conduct a comparative study between manufacturing and service sectors in the Egyptian context.

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