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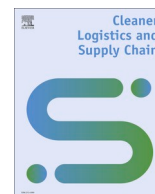
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The adoption of industry 4.0 practices by the logistics industry: A systematic review of the gulf region

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ARTICLE INFO

Keywords:

Logistics 4.0

Blockchain

Systematic literature review

Industry 4.0

Global supply chain strategies

ABSTRACT

Industry 4.0 is a global approach that involves digitising some of the manufacturing, retailing, warehousing, transportation, and industrial procedures of the logistics industry. This present review aims to systematically review the adoption of Industry 4.0 technologies in the Gulf Cooperation Council (GCC) region, with a focus on the logistics industry. The preferred reporting items for systematic reviews and meta-analyses (PRISMA) method were used to conduct a systematic review and comparative study of the GCC countries. The results indicate that the adoption of Industry 4.0 technologies by the logistics industries of the GCC countries is still at the nascent stage. This present review provides a general view of the present status of Industry 4.0 adoption by each GCC country. Therefore, it could serve as reference material for future studies that aim to develop the economic and market strength of the GCC region after taking into consideration the status of Industry 4.0 adoption by the logistics industries of these countries.

1. Introduction

As global reliance on technology has increased exponentially, technology-based disruptions are felt more keenly by industries all around the world. The Fourth Industrial Revolution (Industry 4.0) is still in its infancy and continues to grow at a rapid rate. Industry 4.0 was first introduced in 2011 at the Hannover Fair in Germany (Quin et al., 2017). It calls for the automation and digitisation of most industrial and manufacturing processes in order to facilitate operational autonomy and decentralisation, operational and cost efficiencies, risk management, and prompt decision-making (Upadhyay, 2020; Wong, et al. 2020). It consist of four main elements; namely, cyber-physical systems (CPSs), the Internet of things (IoT), big data, and smart factories (Hofmann and Rüsch, 2017; Dwivedi et al., 2021; Wamba and Queiroz, 2020).

Although Industry 4.0 is an evolving term and can include numerous practices, its four main elements summarise the principles of all these practices. For instance, CPSs can be used to control the physical systems of industrial processes by integrating computers and networks. This can be achieved using networking agents; such as actuators, sensors, control

processing units, and communication devices (Barreto et al., 2017). Meanwhile, the IoT employs smart technologies; such as artificial intelligence (AI) and cloud computing; to facilitate data exchange, communication between elements, and remote and instantaneous monitoring (Brous et al., 2020). Big data, on the other hand, is the both product and source of the autonomy of Industry 4.0 practices as connections between things and systems generate a great deal of data (Santos et al., 2017). For instance, as some practices require data for operations, the required data can be sent in its raw form then promptly processed and analysed to derive value (Shafiq et al., 2019). A smart factory utilises automation, software, and hardware to optimise its industrial processes as well as reduce reliance on manual labour. It can also be viewed as an amalgamation of the industrial and non-industrial aspects of industrial processes to achieve a dynamic organisation (Hozdić, 2015).

Cloud computing, AI, and blockchains are other Industry 4.0 technologies that have rapidly developed in recent years. Cloud computing allows users to access hardware from external points that feed data to servers, storage centres, applications, and services via the Internet

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<https://doi.org/10.1016/j.clscn.2022.100085>

Received 29 April 2022; Received in revised form 25 August 2022; Accepted 28 October 2022

Available online 8 November 2022

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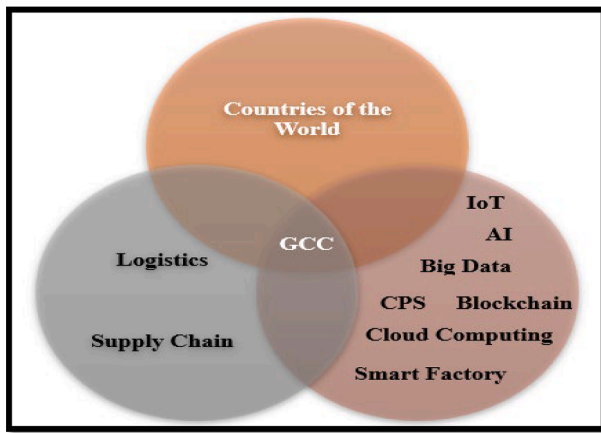


Fig. 1. Classification of keywords used in the search.

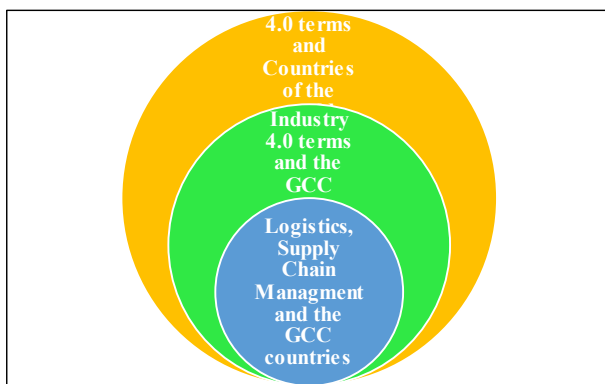


Fig. 2. Narrowing of the search criteria.

(Gupta et al., 2020). Meanwhile, blockchain uses data encryption and distributed storage to provide a secure and timely flow of information that is accessible to all and immune to human tampering (Kar-amchandani et al., 2020). The term AI consists of the words “artificial” (something man-made) and “intelligence” (the aptitude to think and understand) (Dwivedi et al., 2021). Therefore, AI can be defined as the creation of automated machines or systems that are capable of executing complex actions under the governance of reflexive procedures similar to that of humans (Mohammed et al., 2021).

The adoption of Industry 4.0 practices would enable real-time information sharing, goods and cargoes tracking, improved transport handling, and accurate risk management in the logistics industry (Ghouri and Mani, 2019). Some characteristics can distinguish the four generations of the Industrial Revolution. IR 4.0 can be explained as the current automation and data exchange in manufacturing technologies. IR 3.0 is characterised by electronics, IT, and industrial robotics for advanced automation production processes, while IR 2.0 is characterised by mass production with machines powered by electricity and combustion engine. IR 1.0 is the biggining of mechanical production powered by steam or water (Hidayatno et al., 2019; Sharma and Singh, 2020). According to Hofmann and Rüsch (2017), the logistics industry could two Industry 4.0 practices; specifically, physical supply chains and digital data value chains. The former can be used to automate sub-systems; such as transportation (autonomous trucks), turnover handling (robots), and order processing (smart contracts and blockchain technology); while the latter can be used to deliver structured data of the entire physical supply chain for processing and use. Together, these two practices should provide customers with three main benefits; availability, digital integration, and digital servitisation. Availability can be achieved by making products and services accessible to customers

around the clock via autonomous delivery while digital integration can be achieved by providing transparency and traceability of goods along the supply chain. Meanwhile, digital servitisation can be achieved by providing value-added digital services that go beyond the distribution of products and physical services.

As the world around us becomes increasingly digitalised, the GCC region is developing industrial practices to keep up with the latest trends and applications. This present review aimed to systematically answer the following questions.

Q1. Which studies evidence of the adoption of Industry 4.0 practices in the GCC region?

Q2. Which studies evidence of the adoption of Logistics 4.0 practices in the GCC and what is their primary focus?

Multiple studies were reviewed to answer the proposed review questions. Therefore, this present review highlights the latest Industry 4.0 and Logistics 4.0 trends of the GCC region. It is believed that the findings of this present review provide a clear picture of the current stage of the Fourth Industrial Revolution in the GCC region, especially in the logistics and supply chain industries.

2. Research methodology

2.1. PRISMA-based systematic literature review

This present review was conducted using the preferred reporting items for systematic reviews and meta-analyses (PRISMA). The scheme, which was developed by a team of 29 scientists, researchers, and reviewers in 2005, proposes a 27-item checklist with which to conduct an evidence-based, transparent, and systematic literature review (Liberati et al., 2009). The review process is a flowchart that consists of four steps; identification, screening, eligibility, and inclusion. All the relevant articles are first identified and compiled before duplicate articles are removed. The remaining articles are then screened to determine if they meet the review criteria. Articles that fail to meet the review criteria are excluded. The remaining articles are then reviewed to determine if they are eligible and meet the inclusion criteria before the ineligible resources are removed. The final stage outlines the final number of articles that will be included in the review (Moher et al., 2009).

The beauty of PRISMA is that it offers a great opportunity to confront emerging topics and a replicable research procedure that depicts the entire review process (Lagorio et al., 2016). Therefore, this method was chosen as it could answer the review questions with a continuous literature path that provides an understanding of the current and globally renowned terms and industrial trends. It also offers a means of tracking the Industry 4.0 practices of the GCC region in a systematic and evidence-based manner (Kon et al., 2021).

2.2. Literature review criteria

Industry 4.0 is an emerging topic and its presence in the GCC region presents great investigative opportunities. As there is a gap between the present industrial practices of the GCC region and the expectations of the Fourth Industrial Revolution, the region has to decrease this gap to optimise its economy. Therefore, this present review provides an overview of the current state of Industry 4.0 and Logistics 4.0 adoption in the GCC countries. The search criteria included the presence of Industry 4.0 elements and trends in the GCC region, particularly in the logistics industry. Peer-reviewed articles were also included by searching three sets of keywords (Fig. 1). The first set of keywords comprised every country in the world and was classified according to continent. The second set was created by reviewing a few relevant studies to shortlist terms that best describe general Industry 4.0 practices. The third set of keywords only comprised two terms; logistics and supply chain. These were paired with the second set to search Logistics 4.0 practices.

Table 1
PRISMA method of this present review.

PRISMA Stage	No. of Articles	Method
Identification	Articles identified via database search (n = 6631) (Fig. 3).	Title contained a combination of the first and second set of keywords.
Screening	Articles relevant to the GCC region (n = 215 + 101 = 316) (Figs. 4 and 5). Articles excluded as they were not relevant to the GCC region (n = 6315).	Title contained a combination of a GCC country and the second set of keywords (215 articles) and the third set of keywords (101 articles).
Eligibility	Articles that may contain evidence of Industry 4.0 and/or Logistics 4.0 practices in the GCC region (n = 134) (Fig. 6). Articles excluded as they that did not contain evidence of Industry 4.0 and/or Logistics 4.0 practices in the GCC region (n = 182).	Titles, abstracts, and conclusions of the 316 screened articles were skimmed.
Inclusion	Articles that contained in-text evidence of Industry 4.0 and/or Logistics 4.0 practices in the GCC region (n = 35 + 6 = 41) (Fig. 7). Articles excluded as they that did not contain in-text evidence of Industry 4.0 and/or Logistics 4.0 practices in the GCC region (n = 93).	Full texts of the 134 eligible articles were read. Thirty-five articles discussed Industry 4.0 while six discussed Logistics 4.0 in the GCC region.

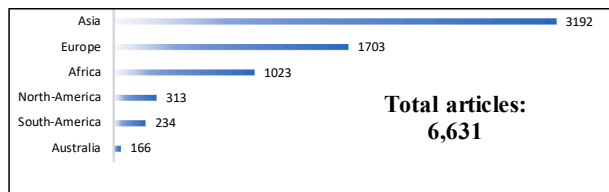


Fig. 3. Distribution of Industry 4.0 articles published by continents.

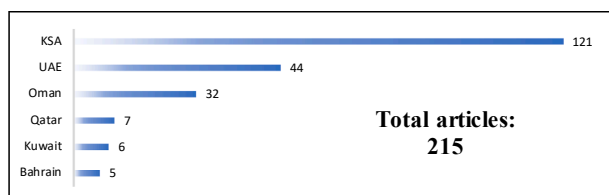


Fig. 4. Distribution of Industry 4.0 articles published by GCC countries.

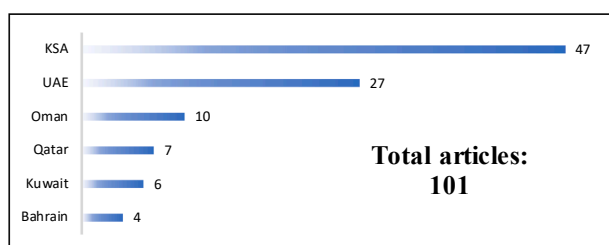


Fig. 5. Distribution of Logistics 4.0 articles published by GCC countries.

Google Scholar was used to search for peer-reviewed articles that answer the questions of this present review. The search period ranged between 2011; when Industry 4.0 was first introduced to the world; to

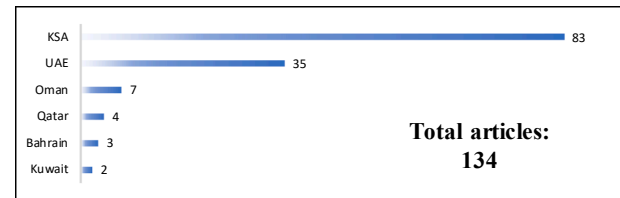


Fig. 6. Distribution of Industry 4.0 and Logistics 4.0 articles published by GCC countries in the eligibility stage.

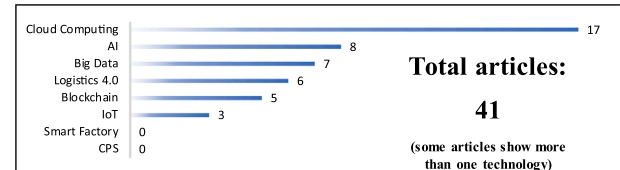


Fig. 7. Classification of Industry 4.0 articles included in this present review.

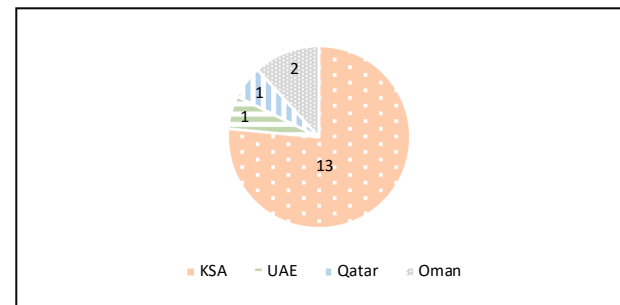


Fig. 8. Classification of articles on cloud computing.

2021; when this review was conducted. The search process involved three main steps: (i) pairing the first and second sets of keywords, (ii) pairing the GCC countries and the second set of keywords, and (iii) pairing the GCC countries and the third set of keywords (Fig. 2). The eligibility criteria included in-text evidence of Industry 4.0 and/or Logistics 4.0 practices in the studied countries while studies on countries other than the GCC countries (i.e., Oman, Bahrain, Kuwait, Qatar, the Kingdom of Saudi Arabia (KSA), and the United Arab Emirates (UAE)) were excluded.

2.3. Methodological framework

The PRISMA framework was used once the inclusion and exclusion criteria have been defined. Table 1 presents the scheme that was followed. The first step entailed resource identification. The terms “Industry 4.0” and “Fourth Industrial Revolution” yielded 9860 articles published between 2011 and 2021. A total of 570 articles were excluded as the titles were duplicates. The paired keyword combinations were then searched in the remaining 9290 articles, of which only 316 articles contained all of the shortlisted keywords. These remaining articles were then screened for eligibility by skimming the titles, abstracts, and conclusions. Articles that did not meet the eligibility criterion; i.e., evidence the presence of Industry 4.0 and/or Logistics 4.0 activities; were excluded. Only 134 articles satisfied this eligibility criterion. The full-texts of these 134 articles were then read to determine if they contained in-text evidence. Only 41 articles (Appendix 1) satisfied this criterion and were included in this present review. A summary of the included articles is provided in the subsequent section.

Table 2
Adoption of blockchain practices in the GCC region.

Country	Blockchain Adoption
KSA	- The Saudi Central Bank (SAMA) uses a blockchain solution to preserve the fluidity of the country's banks. - The government partnered with the IBM Corporation and Elm; a state-owned IT company; to provide commercial services using blockchain. - The King Abdelaziz City of Science and Technology teaches blockchain practices.
UAE	- Dubai's Foodwatch platform was implemented using blockchain. The Roads and Transport Authority (RTA) uses a blockchain solution for vehicle lifecycle management. - Dubai issues and inspects scientific degrees using blockchain solutions. - The launch of an initiative to perform 50 % of all government transactions using blockchain by 2021 (Al Barghuthi et al., 2019). The Dubai Blockchain Initiative was launched in 2018 (Petratos et al., 2020; Sherimon et al., 2020).
Qatar	- Ooredoo Corporate; a telecommunications company; launched an initiative to provide blockchain services to customers. - The Commercial Bank partnered with R3; a software firm; to create blockchain solutions for services such as developing smart contracts.
Kuwait	- The Kuwait Petroleum Corporation uses blockchain solutions for security and market growth purposes. - The Kuwait Finance House uses blockchain practices to optimise customer services and achieve its vision. The implementation of a blockchain-based email system (Sherimon et al., 2020).
Bahrain	- The General Directorate of Traffic uses a blockchain solution to create and manage vehicle registration. - The University of Bahrain uses blockchain-based software to issue awards and verify certificates.
Oman	- Launched a blockchain initiative in 2017. - Bank Dhofar uses blockchain solutions and programmes.

Table 3
Industry 4.0 adoption in the GCC region.

	Big Data	IoT	Cloud Computing	AI	Blockchain	CPSs	Smart Factories
The KSA	•	•	•	•	•		
The UAE	•		•	•	•		
Qatar			•		•		
Bahrain		•		•	•		
Kuwait					•		
Oman			•		•		

2.4. Analysis of the review

The first and second steps of the PRISMA method yielded a number of peer-reviewed articles that contain Industry 4.0 terms. It also showed the distribution of articles published by each continent (Fig. 3) and GCC country (Figs. 4–6). Out of all the Industry 4.0 articles published between 2011 and 2021, 48 % were from Asia, which indicates their efforts to adopt Industry 4.0 practices. Europe and Africa had published 26 % and 15 % of all the Industry 4.0 articles, respectively. As the Industry 4.0 concept was born in Europe, it explains further efforts to research it. Africa, on the other hand, is a growing market that is known for its abundance of natural resources, which explains its research into Industry 4.0 practices. North America, South America, and Australia only published 5.0 %, 3.5 %, and 2.5 % of all the Industry 4.0 articles, respectively. These paltry numbers as well as their world market stature could indicate their satisfaction with their current industrial practices and, therefore, a lack of initiative to research Industry 4.0.

Fig. 4 shows the distribution of articles published by the GCC region that contain Industry 4.0 terms and trends. The KSA, the UAE, and Oman published 56 %, 20 %, and 15 % of the articles, respectively. This indicates the significant commitment that the KSA and the UAE have towards revolutionising their respective industrial practices. Oman, on the other hand, has put considerable effort into researching industrial innovation as its 2040 vision involves revolutionising the industry. Meanwhile, Qatar, Kuwait, and Bahrain published 3 %, 3 %, and 2 %, respectively. Fig. 5 presents the distribution of articles published by the GCC region that contain Logistics 4.0 terms and trends. The countries were ranked similar to that in Fig. 4, with the KSA, the UAE, Oman, Qatar, Kuwait, and Bahrain having published 46 %, 27 %, 10 %, 7 %, 6 %, and 4 % of the articles on Logistics 4.0 practices in the GCC region, respectively.

In the eligibility stage, 134 articles potentially contained evidence of Industry 4.0 and Logistics 4.0 practices in the GCC region. Fig. 6 shows the distribution of these articles, with the KSA publishing 62 % of all the articles followed by the UAE (26.1 %), Oman (5.2 %), Qatar (3 %), Bahrain (2.2 %), and Kuwait (1.5 %).

3. Finding and analysis

The findings of this review were classified according to the six Industry 4.0 technologies currently practised in the GCC region: (i) cloud computing, (ii) big data, (iii) blockchain, (iv) artificial intelligence, (v) Internet of things, and (vi) Logistics 4.0. Fig. 7 shows the distribution of articles published according to the six-abovementioned terms.

3.1. Big data and Internet of things (IoT) in the GCC

Based on the findings, big data is currently practiced in the KSA (Alam et al., 2021; Almutairi, 2021; Mukthar and Sultan, 2017; Qaffas et al., 2021; Zaki et al., 2020) and the UAE (Faccia et al., 2019). Some Saudi institutions of higher learning use big data and cloud computing to create analytical frameworks with which to optimise their syllabi and learning experiences (Mukthar and Sultan, 2017). According to Almutairi (2021), schools are at the forefront of big data adoption in the KSA as they realise that it can be used to improve overall performance by optimising resource and fund allocation, student enrolment, and academic performance. The country's banking sector has also adopted big data. At present, it is used to analyse customer service feedback and cash flow as well as help managers make prompt decisions (Zaki et al., 2020). Meanwhile, the NEOM smart city uses a combination of big data and IoT. Both have been equipped to achieve their respective purposes, where big data networks interpret and classify the information received from IoT sensors. Some of the benefits of implementing big data and IoT include tracking energy usage to provide cost-effective energy consumption and connecting government programmes with strategic planning (Alam et al., 2021). The KSA also uses big data and IoT to optimise its healthcare practices (Qaffas et al., 2021). Meanwhile, several organisations in the UAE use big data in accounting software packages; such enterprise resource planning (ERP) and accounting information systems (AIS) (Faccia et al., 2019). Bahrain also uses IoT in several activities; such as smart cities, agriculture, appliance automation, and waste reduction (Abdulla et al., 2020a).

3.2. Cloud computing in the GCC

The KSA.

As seen in Fig. 8, 13 articles addressed the adoption of cloud computing in the KSA. According to these articles, several sectors in the KSA; such as the education, commercial, telecommunications,

government, and healthcare industries; have adopted the use of cloud computing. As several education institutions have adopted cloud computing, it is a popular research area in the country. The benefits of cloud computing; such as e-learning; have enabled education institutions to achieve milestones and overcome learning obstacles. As such, experts predict that cloud computing will become the fifth most important component of life in the KSA after gas, electricity, telecommunications, and water (Almutairi, 2020). The government has also launched the Cloud First initiative to realise the e-University goal of the KSA's 2030 vision (Ali, 2020). In the 2016/2017 academic year, at least 29 government universities adopted cloud computing to enhance their teaching capabilities (Alenezi, 2019). King Abdullah University and the University of Taibah were among these institutions (Ghazzawi et al., 2017). More specifically, the security information office of King Abdullah University uses cloud computing to protect their information assets while the University of Taibah benefited from the adoption of cloud computing as it provides faster remote access to software and hardware in the event of a failure and for maintenance purposes. Moreover, the cloud of the University of Taibah is backed up by private servers, thereby making it a hybrid system, as university officials believe this is the best way of saving data.

Attempts have been made to optimise the government practices for both citizens and government entities alike. For instance, a government training organisation adopted Google App Suite's cloud services in 2017 (Mreea et al., 2017). A 2017 study revealed that 44 % of the companies in the public sector had implemented or intended to implement cloud services (Ghazzawi et al., 2017). Furthermore, the government collaborated with CloudSigma and Hewlett-Packard Enterprise (HPE) to establish cloud services in order to achieve its Virtual Vision. These services are also open to companies as they offer a bundle of high-performance services such as cloud support services, public and private networks, storage, and connectivity. The government also successfully implemented cloud services through its e-government programme, "Yesser", which effectively reduced costs and unified government units (Aldieef and Khan, 2019).

In 2010, two government-owned telecommunication companies began searching for a way of providing cloud services to companies in the KSA (Alsanee and Barth, 2014). By 2018, three companies were able to successfully deliver cloud services to the KSA market. More specifically, under the brand name of Mobily®, the Etihad Etisalat Company provides virtual machine-ware (VMware) cloud services that deliver virtualisation software that decentralises computer hardware units by dividing them into separate virtual computers. Additionally, AWAL IT Services; a subsidiary of the Saudi Telecom Company (STC); may have partnered with HPE, the International Business Machines (IBM) Corporation, Cisco Systems, Inc., and Dell Technologies to provide cloud services to its customers. The STC also partnered with the Oracle Corporation to offer platform as a service (PaaS) and software as a service (SaaS) cloud services (Arif et al., 2018). It then went on to partner with the National Information Centre and Elm; a state-owned IT company; in 2019 to reshape government services using cloud computing (Alyoubi et al., 2019).

The KSA is an active market for state-of-the-art innovations and technological solutions. For instance, a large number of IT companies began adopting cloud computing in 2016, back when cloud computing in the KSA was at a nascent stage (Ghazaleh and Ahmad, 2017). In 2013, a Saudi telecommunications company aligned itself with an enterprise-class cloud software named Virtustream to provide small and medium enterprises (SMEs) in the KSA with cloud computing using protected, dependable, and high-speed network connections (Al-Tameem and

Mohammad, 2014). Moreover, the King Faisal Specialist Hospital successfully integrated cloud services by adopting private cloud solutions. This was a feasible option for the hospital as it already had the infrastructure required to implement cloud practices. However, the hospital outsources its cloud service needs to another organisation as it lacks skilled IT personnel (Alharbi et al., 2016).

3.2.1. The UAE, Qatar, and Oman

In the UAE, the adoption of cloud computing services enabled staff and faculty members of the Higher Colleges of Technology (HCT) to more efficiently share documents amongst themselves across 17 campuses (Allam et al., 2018). Meanwhile, the Carnegie Mellon University in Qatar offers undergrads a single semester course on cloud computing (Rehman and Sakr, 2011). In Oman, on the other hand, several leading companies in the oil and gas sector adopted cloud computing services for security, storage, and network interface purposes (Al-Mascati and Al-Badi, 2016). Furthermore, the Omani government launched "G-cloud" in 2014, which is funded by its e-government initiative, to facilitate and optimise inter-agency document sharing. The initiative, which is owned by the Information Technology Authority of Oman, has helped the government achieve its e-government goals at the lowest cost (Alzadjali and Elbanna, 2019).

3.3. Artificial intelligence (AI) in the GCC

The UAE (Alhashmi et al., 2019; Ghandour and Woodford, 2019; Halaweh, 2018; Shamout and Ali, 2021), the KSA (Alam et al., 2021; Ashehri, 2019; Basri, 2020), and Bahrain (Abdulla et al., 2020b) were all found to utilise AI technologies. In 2017, the UAE initiated its vision to make the country adopt AI technologies by 2031. By 2019, a Microsoft AI statement stated that UAE corporations and companies were leading the country's adoption of AI practices (Shamout and Ali, 2021). The UAE was also the first country to appoint an AI state minister (Halaweh, 2018). It has also successfully implemented AI practices in the healthcare industry to facilitate early detection and chronic disease management (Alhashmi et al., 2019). Meanwhile, the city of Dubai adopted AI practices by launching a self-driving vehicle on its streets as part of the UAE's initiative to convert a quarter of the vehicles in the country to self-driving vehicles by 2030 (Ghandour and Woodford, 2019).

In the KSA, a few new businesses and SMEs use AIs to create marketing solutions (Basri, 2020). A part of the country's 2030 Vision is to increase market adoption of AI practices. There is also a push to educate students using AI, IoT, and blockchain via an alliance between the Ministry of Technology and the Ministry of Education (Ashehri, 2019). Furthermore, NEOM city has heavily adopted the use of AI and robotics to the extent that the number of robots exceeds the number of people in the city. These robots are used for security, cleaning, and delivery purposes (Alam et al., 2021). Meanwhile, Bahrain has adopted the use of AI for banking solutions, mostly in the form of chat bots, which optimises customer-bank interactions (Abdulla et al., 2020b).

3.4. Blockchain in the GCC

The GCC's adoption of blockchain practices is admirable. For instance, the region is the first to utilise blockchain for value-added taxation (VAT) (Ainsworth and Alwohaibi, 2017). Most of the findings on the adoption of blockchain practices in the GCC were obtained from Al Hilali and Shaker (2021) while the rest were from Ainsworth and Alwohaibi (2017), Al Barghuthi et al. (2019), Petratos et al. (2020), and Sherimon et al. (2020). Table 2 provides a summary of the adoption of

blockchain practices in the GCC region.

3.5. Logistics 4.0 in the GCC

The UAE (Abudaqa et al., 2020; Bvepfepfe et al., 2019; Khan, 2019), the KSA (Elgendy, 2021; Yousif Alsharidah and Alazzawi, 2020), and Oman (Taderera et al., 2018) were all found to utilise Logistics 4.0, which is the implementation of Industry 4.0 technologies in logistics. In the UAE, several Abu Dhabi-based SME retailers use intelligent information systems; such as a Customer Relations Management (CRM) and Enterprise Resource Planning (ERP); for supply chain management (Abudaqa et al., 2020). The UAE has also adopted the use of Industry 4.0 technologies; namely, cloud computing, blockchain, AI, IoT, big data, and wireless technologies; in its supply chain practices (Bvepfepfe et al., 2019). Furthermore, managers at several UAE corporations use big data analytics to make prompt and efficient logistics-based decisions (Khan, 2019).

In the KSA, on the other hand, a number of organisations use big data analytics in their supply chain management practices. The managers of these organisation extol the handiness of big data analytics in achieving efficient logistics practices (Elgendy, 2021). A number of private organisations have also successfully used AI solutions for supply chain management (Yousif Alsharidah and Alazzawi, 2020). Meanwhile, Oman uses cloud computing solutions for local logistics via an e-government platform that links all ends of its supply chains to government entities (Taderera et al., 2018).

The Logistics Performance Index (LPI) is commonly used to measure the performance of a country's logistics practices in six categories; customs, infrastructure, global shipping, competency, traceability, and timeliness; between 2012 and 2018. The worldwide LPI ranking of GCC countries is as follows: #14 the UAE, #30 Qatar, #46 Oman, #52 the KSA, #54 Bahrain, and #59 Kuwait. In comparison to logistics powerhouses; such as the Hong Kong Special Administrative Region of the People's Republic of China, which ranks 9th worldwide; the GCC region has shown great initiative. The timeliness LPI of the UAE (4.23) is better than that of China (4.18). Moreover, if the LPI of Hong Kong is excluded from that of China, China's rank decreases to #27 worldwide. This indicates that the UAE outperforms the logistics performance of China in all categories when Hong Kong is excluded. The global shipping LPI of Qatar (3.62) is also better than that of China (3.57). The LPI of the GCC region also outperforms that of India, which is ranked #42 worldwide. More specifically, both the UAE and Qatar outperform India in all LPI categories while Oman outperforms India in three categories; namely, infrastructure, global shipping, and timeliness (The World Bank, 2018).

3.6. Limitations and recommendations for future studies

One of the limitations of this present review is that it only retrieved articles from the Google Scholar database. Although Google Scholar contains most academic publications, other forms of publishing; such as magazines, reports, and corporate newsletters; should also be taken into consideration as technology-related developments are often disseminated via these channels. Furthermore, this present review does not thoroughly examine the technical aspects of Logistics 4.0 and Industry 4.0. This review was also limited to corporations that operate in and initiatives that are currently in effect in GCC countries only. However, several GCC corporations and initiatives operate in other countries; such as Turkey and the European Union.

Therefore, future studies may consider retrieving articles from all forms of publishing; e.g. online databases, magazines, newsletters, and news to name a few; to investigate each GCC country separately and more comprehensively. Representatives should also be consulted to better understand the technology acquisition and utilisation processes of an institution as well as the extent of their technology adoption by constructing models and frameworks. Future studies may also conduct cost-benefit analyses to understand the phenomena of Industry 4.0 and Logistics 4.0 in GCC countries.

4. Conclusions

As Industry 4.0 has begun to severely disrupt the market, government officials have to either ride the wave or be left behind in today's market. This present review successfully used the PRISMA method to answer the following two questions:

- Q1. Which studies evidence the adoption of Industry 4.0 practices in the GCC region?
- Q2. Which studies evidence the adoption of Logistics 4.0 practices in the GCC and what is their primary focus?

In order to answer these questions, the criteria required to satisfy these questions were first outlined. This entailed dividing the review criteria into sets of keywords, using the Google Scholar to compile peer-reviewed articles that satisfied the review criteria, and using the PRISMA method to include articles that answered the review questions.

In conclusion, GCC countries; namely, the KSA, UAE, Qatar, Kuwait, Bahrain, and Oman; are still in the early stages of adopting Industry 4.0 and Logistics 4.0 technologies and solutions. Table 3 lists the Industry 4.0 technologies; i.e., big data, IoT, cloud computing, AI, blockchain, CPSs, and smart factories; that each GCC country has adopted. This present review is the first to utilise the PRISMA method to review Industry 4.0- and Logistics 4.0-related topics. It also provides a broad overview of the where the GCC stands in the face of a global issue. The GCC region may benefit from the findings of this review as it provides information on the origin, practices, and implementation status of the Fourth Industrial Revolution in the region. It may also serve as a stepping-stone for future studies that aim to develop the economy and market strength of the GCC region as it provides knowledge of the status of Industry 4.0 adoption in the region.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank Mr. Abubaker Omer, Research Assistant for assisting us in completing this research project.

Appendix A

Table A1

Summary of forty-one articles on Industry 4.0 adoption in the GCC region.

Article Title	Primary Focus	Country	Method	Contribution
(Rehman and Sakr, 2011) Teaching the cloud - Experiences in designing and teaching an undergraduate-level course in cloud computing at the Carnegie Mellon University in Qatar	Teaching cloud computing to undergraduate college students	Qatar	Literature Review	Outlines a cloud computing course for undergraduate college students
(Alsanea and Barth, 2014) Factors Affecting the Adoption of Cloud Computing in the Government Sector: A Case Study of Saudi Arabia	Cloud computing in the government domain	The KSA	Quantitative Analysis	Identifies factors affecting the adoption of cloud computing by government bodies
(Al-Tameem and Mohammad, 2014) The Impact of Cloud Computing on Saudi Organizations: The Case of a Telecom Company	Cloud computing in the telecommunications industry	The KSA	Qualitative Analysis	Provides knowledge and practical suggestions for the successful adoption of cloud computing by telecommunications companies
(Ghazzawi et al., 2017) A Technical Feasibility for Adoption of Cloud Computing in King Abdulaziz University, Saudi Arabia	The adoption of cloud computing by the King Abdulaziz University	The KSA	Observation Analysis	Compares King Abdulaziz University before and after the adoption of cloud computing
(Alharbi et al., 2016) Strategic Value of Cloud Computing in Healthcare Organisations Using the Balanced Scorecard Approach: A Case Study from a Saudi Hospital	Cloud computing in the healthcare industry	The KSA	Literature Review	Provides guidelines for the successful adoption of cloud computing by hospitals
(Al-Mascati and Al-Badi, 2016) Critical success factors affecting the adoption of cloud computing in oil and gas industry in Oman	Cloud computing in the oil and gas industry	Oman	Quantitative Analysis	Provides the top five factors affecting the adoption of cloud computing by oil and gas companies in Oman
(Ainsworth and Alwohaibi, 2017) The First Real-Time Blockchain VAT - GCC Solves MTIC Fraud	Blockchain VAT	The GCC region	Qualitative and Quantitative Analysis	Outlines how the GCC successfully modified and implemented the EU VAT to solve critical problems in the region
(Mukhtar and Sultan, 2017) Big Data Analytics for Higher Education in Saudi Arabia	Big data analytics at institutes of higher learning	The KSA	Literature Review	Identifies the application and challenges of big data adoption at higher learning institutes in the KSA
(Ghazzawi et al., 2017) An Investigation of the Most Critical Security Vulnerabilities in Cloud Computing in Saudi Arabia	Security liabilities of cloud computing in the medical, commerce, and academic industry and counter measures	The KSA	Systematic Review	Identifies the most eminent cloud computing security vulnerabilities of the KSA
(Mreea et al., 2017) Cloud computing financial and cost analysis: A case study of Saudi government agencies	Financial indicators and cost variables of cloud computing for government bodies	The KSA	Cost Analysis	Identifies the best financial indicators and cost variables of using cloud computing in the public sector
(Halaweh, 2018) Artificial intelligence government (Gov. 3.0): The UAE leading model	AI in the government sector	The UAE	Literature Review	Discusses the positive outcomes of the government's adoption of AI
(Arif et al., 2018) Improving Cloud Computing Adoption in Saudi Business Organizations - A Novice to Expert Case	Adoption of cloud computing by businesses	The KSA	Literature Review	Defines the factors affecting the willingness of businesses to adopt cloud computing
(Taderera et al., 2018) Analysing Oman Supply Chain Practices versus Global Best Practices	Cloud computing in the logistics industry	Oman	Observation Analysis Qualitative Analysis Literature Review	Provides the logistics industry with recommendations for the successful adoption of cloud computing
(Faccia et al., 2019) Accounting information systems and ERP in the UAE	Big data solutions in the accounting industry	The UAE	Qualitative Analysis	Identifies the limitations of the ERP software used in the accounting sector
(Alzadjali and Elbanna, 2019) New infrastructure technology and smart institutional interventions: The case of implementing government cloud computing in Oman.	The adoption of cloud computing by the Ministry of Health	Oman	Qualitative Analysis	Identifies the factors that drove the adoption of cloud computing
(Alenezi, 2019) The role of cloud computing for the enhancement of teaching and learning in Saudi Arabian universities in accordance with the social constructivism theory: A specialist's point of view	Benefits of adopting cloud computing for universities	The KSA	Quantitative Analysis	Proves that the adoption of cloud computing enhances university practices
(Aldieef and Khan, 2019) Data exchange in heterogeneous databases in KSA using cloud computing	Big data analytics and cloud computing	The KSA	Observation Analysis IT Design	Created an interface capable of processing a large amount of diverse data
(Alyoubi et al., 2019) The Impact of Cloud Computing on Decision Support System in Adopting Knowledge Management in Saudi Organizations	Cloud computing for managers	The KSA	Qualitative Analysis	Outlines the benefits of using cloud computing, knowledge management, and decision support systems in organisations
(Allam et al., 2018) Deploying Cloud Computing in Higher Education - A UAE Case Study	Cloud computing for institutes of higher learning	The UAE	Qualitative Analysis	Proves the efficacy of using cloud computing at higher learning institutes
(Alhashmi et al., 2019) Implementing Artificial Intelligence in the United Arab Emirates Healthcare Sector: An Extended Technology Acceptance Model	AI in healthcare	The UAE	Modelling Qualitative Analysis	Identifies the main factors driving the adoption of AI by the healthcare industry
(Ghandour and Woodford, 2019) Ethical issues in artificial intelligence in UAE	AI ethics	The UAE	Literature Review	Investigates the challenges of AI legalities and ethics
(Ashehri, 2019) Governance of artificial intelligence in KSA (NEOM as a model)	AI in smart cities	The KSA	Literature Review	Discusses AI as a part of everyday life and the government's efforts to employ adopt it
(Khan, 2019) Challenges with big data analytics in service supply chains in the UAE	Big data in the logistics industry	The UAE	Quantitative Analysis	Identifies the challenges of big data adoption in the logistics industry

(continued on next page)

Table A1 (continued)

Article Title	Primary Focus	Country	Method	Contribution
(Al Barghuthi et al., 2019) State of Art of the Effectiveness in Adopting Blockchain Technology- UAE Survey Study	Efficacy of blockchain	The UAE	Quantitative Analysis	Confirms the adoption of blockchain for supply chains and financial transactions
(Bvepfepfe et al., 2019) Adoption of Emerging Technologies in Supply Chain Operations for Cost Reduction and Enhancement of Shareholder Wealth: A Case Study of UAE Organization	IoT, AI, and blockchain in the logistics industry	The UAE	Qualitative Analysis	Confirms the adoption of IoT, AI, and blockchain by logistics organisations
(Basri, 2020) Examining the impact of artificial intelligence (AI)-assisted social media marketing on the performance of small and medium enterprises: Toward effective business management in the Saudi Arabian context	AI in social media marketing	The KSA	Quantitative Analysis	Proves that the use of AI for social media marketing increases the profitability of SMEs
(Abdulla et al., 2020b) Artificial Intelligence in Banking sector: Evidence from Bahrain	AI in the banking industry	Bahrain	Qualitative Analysis	Lists the AI solutions that most banks employed
(Zaki et al., 2020) Analysing the role of big data in activating social responsibility, supporting the sustainable development of Saudi banks	Big data in the banking industry	The KSA	Observation Analysis	Defines components that optimise big data adoption for banking practices
(Abdulla et al., 2020a) Implementing Internet of Things in Small Businesses of Bahrain	Status of IoT adoption by SMEs	Bahrain	Qualitative Analysis	Identifies factor affecting the adoption of IoT by SMEs
(Almutairi, 2020) A review of cloud computing in education in Saudi Arabia	Cloud computing in the education industry	The KSA	Qualitative Analysis	Identifies key challenges affecting the adoption of cloud computing by the education industry
(Petratos et al., 2020) A Blockchain Technology, Sustainability and Business: A Literature Review and the Case of Dubai and UAE	Blockchain sustainability	The UAE	Literature Review	Discusses the framework for blockchain adoption and defines areas in the market where blockchain is most impactful
(Sherimon et al., 2020) An integrated blockchain model for managing job recruitment for ministries in Sultanate of Oman	Blockchain in government ministries	Oman	Design and Observation Analysis	Outlines the blockchain framework that was used to inform residents of job vacancies
(Abudaqa et al., 2020) Impact of supply chain integration and intelligent information systems in achieving supply chain innovation: A study of retail trading SMEs in Abu Dhabi, UAE	Blockchain in the logistics industry	The UAE	Qualitative Analysis	Confirms that SMEs have weak tendencies of implementing ERP and CRM
(Yousif Alsharidah and Alazzawi, 2020) Artificial Intelligence and Digital Transformation in Supply Chain Management A Case Study in Saudi Companies	AI in the logistics industry	The KSA	Quantitative Analysis	Confirms the use of AI for logistics solutions
(Ali, 2020) Cloud computing adoption at higher educational institutions in the KSA for Sustainable Development	Cloud computing at institutes of higher learning	The KSA	Literature Review	Outlines the benefits and challenges of using cloud computing solutions at higher learning institutions
(Al Hilali and Shaker, 2021) Blockchain Technology's Status of Implementation in Oman: Empirical Study.	Adoption of blockchain in the GCC region	Oman	Qualitative Analysis	Assesses blockchain adoption generally in the GCC region and specifically in Oman
(Alam et al., 2021) Big Data for Smart Cities: A Case Study of NEOM City, Saudi Arabia	Big data in NEOM City, KSA	The KSA	Observation Analysis	Describes big data classifications and usage in NEOM City
(Qaffas et al., 2021) The Internet of Things and Big Data Analytics for Chronic Disease Monitoring in Saudi Arabia	Big data and IoT in the healthcare industry	The KSA	Data Mining Observation Analysis	Develops a framework for hypertension detection in senior patients
(Almutairi, 2021) Role of Big Data in education in KSA	Big data analytics in the education industry	The KSA	Quantitative Analysis	Identifies factors affecting big data adoption
(Shamout and Ali, 2021) The strategic pursuit of artificial intelligence in the United Arab Emirates	The UAE's AI vision	The UAE	Literature Review	Describes the country's National Artificial Intelligence Strategy 2031
(Elgendy, 2021) The mediating effect of big data analysis on the process orientation and information system software to improve supply chain process in Saudi Arabian industrial organizations	Big data in the logistics industry	The KSA	Quantitative Analysis	Provides manufacturing firms with recommendations for the successful adoption of AI in their logistical practices

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