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Clustering Analysis of Logistics Performance in Saudi Arabia: A Roadmap to Cloud Computing and IoT & Blockchain Solutions

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Abstract

The exponential growth is observed in improving levels of logistics services globally. Since 2007, the World Bank has adopted a project to assess global logistics services through a measurement index that collects its data from countries' responses worldwide. Given the Kingdom of Saudi Arabia's geographical position, the Kingdom of Saudi Arabia (KSA) seeks to benefit from this position by diversifying its financial resources as one of the goals of the Kingdom's Vision 2030. Also, improving service levels helps improve global trade because 12% of the global neighbors pass through KSA. Thus, this paper aims to analyze the levels of logistics services in KSA, identify weaknesses and provide solutions to improve logistics services. This research provides a framework for an integrated system built in the cloud computing building to increase the efficiency of logistics performance. The proposed integrated logistics information system helps to improve the performance of logistics services and can reduce their cost.

Disciplinary: Business & Management (Logistics & Supply Chain), Information Technology.

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1 Introduction

The logistics services sector is an essential sector worldwide linking global trade. This sector is changing dynamically and rapidly because it reflects the levels of change in global trade growth, especially with e-commerce. The development of information and communication technology technologies such as cloud computing (CC) and the Internet of things (IoT) will contribute to

changing various aspects of logistics services. This impact is increasing with the increasing concerns and risks surrounding cybersecurity and changes in governments' strategies and policies.

Responding to the explosive growth in international trade increases, and logistics service providers are making more support to customers, especially at the international level. A critical challenge in managing international trade is the effective regulation of logistics services between partners. This challenge is becoming increasingly important, with 82% of logistics service providers expecting the cost of transporting goods across borders to rise. (Eyefortransport, 2019)

World Economic Forum 2017 (WEF, 2017), participants in the forum extracted eight trends that will have the most significant impact on the future of the logistics industry and supply chain management: (Ittmann, 2018)

1. Collaborative business models.
2. Digital transformation of supply chains
3. E-commerce drives demand chains.
4. Logistics infrastructure and property.
5. Lack of logistical skills
6. Reorganizing of global value chains
7. Risks of Supply chains and recovery strategies. (resilience)
8. Sustainability of supply chains

Considering the logistics industry's challenges and supply chain management, especially the changing environment, the logistics services industry still needs to develop performance to gain competitive advantages. Also, this is needed to contribute to achieving effective participation in support of the Kingdom's National Transformation Program. Logistics services play a critical role in growing things and integration within a country and within the world. The logistics services and supply chain management within the economy provide access to the target levels to support trade and maintain life aspects. This sector does not play an essential role in facilitating trade within the state. It plays a more critical role in the global trading system across the state's borders. Therefore, the logistics services industry is one of the essential components of Total development in the world. The Saudi economy seeks through Vision 2030 to build a diversified economy based on diversified resources, not just oil. This transformation imposes tremendous pressure on the country's logistics and supplies chain management industry to contribute to the national transformation program. At the same time, the main requirement is in providing reliable and high-quality logistics services with keeping their costs under control. With logistics services, costs increase dramatically. It has been observed that companies focus on logistics performance standards such as economic cost, efficiency, carbon footprint, and safety. Many companies seek to build sustainable and environmentally friendly logistical systems, regardless of the time, effort, or cost (Benotmane, 2018). The main objective of logistics development is to maximize the benefits such as reducing logistical costs, reducing the final cost of products, increasing transit potential, and thereby improving the state's competitive position (Janno et al., 2020).

One of the most important aspects of data mining is the study and analysis of things' behavior. The data collected on things reflect facts that reside in the pattern's objects' behavior, strengths, and weaknesses. Data clustering techniques play an essential role in exploring and interpreting tacit knowledge. In today's world, data grows not daily but instantaneously. Large data sets can be identified containing little or no background information to help identify interesting patterns with clustering. clusters with identical properties grouped using repetitive techniques. (Arora et al., 2016)

From a practical perspective, clustering plays a prominent role in data mining applications in different domains. Data clustering represents the main research topic in several fields, such as machine learning and pattern recognition. Clustering is a data mining technique used for discovering data structures in the collected data from real-world events.

Clustering targets organize a data set into more clusters. Similar Data points belonging to one cluster, whereas dissimilar data points belonging to different clusters. Clustering is an unsupervised learning technique. It means creating groups of objects (clusters) based on their features or characteristics. Items that belong to the same group are similar, while the other items belong to other groups. The main advantage of clustering is finding exciting patterns of enormous data sets with minor background knowledge (Nanda et al., 2010).

This research aims to analyze the performance of the logistics services of SA of Saudi Arabia as an example of the countries of the world. To identify the weaknesses and challenges that face them and then develop a proposed framework to support logistics performance.

2 Models of Logistic Performance Evaluation

The leading Measuring Models to measure country-level logistics systems' effectiveness include (Beysenbaev & Dus, 2020)

1. The World Bank Model, The Logistics Performance Index(LPI)
2. The World Economic Forum, The Global Competitiveness Index "Basic requirements" subindex "Infrastructure" pillar (GCII), and
3. The Agility Logistics Company, The Agility Emerging Markets Logistics Index (AEMLI)

The World Bank (WB) publishes The LPI of countries every two years. It uses the following six indicators for calculating the LPI: (Arvis, et al., 2018)

1. Ability to track and trace consignments.
2. quality and Efficiency of logistics services
3. Easy to arrange international shipments at competitive prices.
4. Clarity of the efficiency of logistics operations.
5. Repeat shipments arrive at a specified or expected time.
6. Quality of infrastructure related to trade and transport
7. Moreover, based on six indicators, the world bank calculates the following indicator overall:
8. Logistics performance index: Overall score
9. Logistics performance index: Percent of the highest performer

The WB does scoring-based (1 to 5, 1=highest performer) surveys while determining the LPI. Scores (1=low to 5=high) show that countries with near-five scores have high logistics performance. On the other hand, countries with low logistics performance have a score close to one. (Ulutaş & Karaköy, 2019; Arvis et al., 2018).

The LPI represents an international scale for measuring the logistics sector's efficiency in the world's countries. This measure is based on two axes. The first is the compilation of data on six key performance indicators in one aggregate measure. The second axis is calculated using the Principal Component Analysis (PCA), a standard statistical method to reduce the dataset's dimensions. The input data for the PCA represent country scores averaged based on data provided by responding countries. Estimates are normalized by subtracting the sample mean and dividing by the standard deviation before PCA. International LPI is the result of calculating the weighted average of the six measurement indicators. The measurement scores for each of the original six indicators are multiplied in the weights of their components and multiplication outputs are collected. Since weights are the same for all six components, the global performance index is close to the weighted arithmetic mean indicators. (Beysenbaev& Dus, 2020)

3 Literature Review

The World Bank's interest in logistics studies worldwide has begun since 2007; many scientific studies and research based on World Bank data have started to analyze logistics services in countries. Orhan (2019) used the World Bank's 2018 data set to conduct a comparative study of Turkey's logistics services compared to EU countries, showing Germany ranked first in the order of logistical performance, and the most crucial standard was defined as a customs standard.

Kısa and Ayçin (2019) assessed the logistical performance of OECD countries using World Bank 2012-2018 dataset. The study demonstrated that the most important criteria for assessing logistics performance are the quality of logistics, infrastructure, and international shipping.

Yıldırım and Mercangöz (2020) assessed the logistical performance of OECD countries from 2010-2018. The most crucial criterion in logistics performance assessment is infrastructure, followed by the importance of tracking and tracking, which confirms the use of Information and communication technology methods.

Işik et al. (2020) focused on the logistical performance of eleven selected Eastern and Central European countries and through data analysis and classification. Timing was the most important factor for evaluation, while infrastructure represented less critical performance standards.

Gül Senir (2021) compared the logistical performance of EU and Turkey countries with an integrated model using the World Bank 2018 Logistics Performance Index data.

4 Clustering Analysis Using K Means

Cluster analysis of data is one method of machine learning based on the absence of a semantic characteristic that the machine learns from, so it is classified as unsupervised learning. Data clustering is a technique to group elements into distinct groups. Elements in one cluster are

very identical, and others in the different cluster(s) are relatively different. Cluster analysis of data contributes to dividing elements into similar characteristics based on their properties' values. (Oyelade, et al., 2019)

In data analysis, cluster analysis is used to find any hidden patterns that cannot be directly distinguished. Data Sets can be designated in many groups based on shared characteristics. Cluster analysis essentially depends on keeping identical elements within one cluster but others belonging to other groups or clusters. clustering paradigms include different types to categorize data and to discover cluster' common characteristics. (Bindra & Mishra, 2017)

Clustering analysis aims to discover a set of patterns from the natural grouping(s). We use the cluster analysis results to study and analyze each group of elements' characteristics and know what distinguishes it from other groups, to provide offensive strategic solutions that contribute to modifying the element's properties' values. This motivates to transfer the element from its group to a better or target group. Also, it provides preventive strategies to prevent the decline of the element's condition lead to move to a lower or not desirable group.

We can summarize the purposes of data clustering analysis in three main goals (Jain, 2010)

1. Natural classification: This is very important to determine things' identity and the degree of similarity or relationship between them.
2. Structurally fundamental: This should be a structural basis for understanding data perception, generating hypotheses, detecting anomalies, and identifying salient features.
3. Compression: This is also important to organize and summarize data through clustered prototypes

4.1 K-Means Algorithm

K-Clustering algorithm is one of the division-based clustering algorithms. It adopts an iterative, heuristic process for repartitioning data objects and retrofitting collection centers. The algorithm's basic idea is: Assume a set with element objects and the number of groups to be created (Arora et al., 2016).

K-means Algorithm

- Input: N Data points, K no of clusters
- Output: clusters

Procedure:

1. Select k points randomly from N data points as an initial centroid for each cluster.
2. For each centroid k
3. For each data point i
4. Assessment of the Distance Dki
5. Calculate the Dki minimum previously calculated block distance for each data point i.
6. Update the cluster midpoint value to the data point means to obtain a new cluster.
7. Repeat steps 2 to 6 if there is no change in the cluster value. Go to step 8
8. stop and print the results.

5 Analysis Logistics Performance in KSA

5.1 A Brief Overview of Saudi Arabia (SA)

KSA has the largest economy in the Middle East. It contributes about 38 per cent of GDP and has 21% of the population in the region. In 2016, KSA announced its vision for 2030. The most important pillar of its vision is to become the preferred logistics hub in the region. It is ideally centrally located in the Middle East and the world for effective communication routes among three continents of Asia, Africa, and Europe. Also, it is located directly on the trade route between Asia and Europe, through which 12% of container trade passes annually. SA has begun to diversify its economy, particularly the non-oil economy. It is rapidly embarking on an ambitious path to become the world's leading logistics hub (see Figure 1). (Ministry of Transport, KSA, 2020).

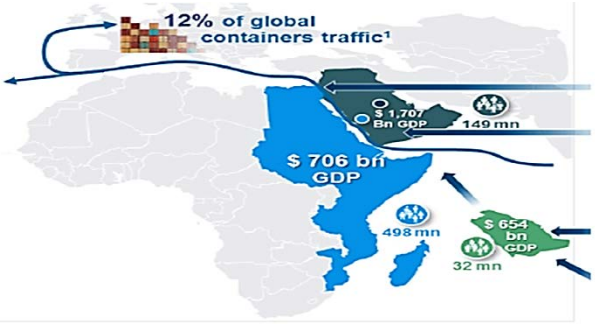

Figure 1: KSA Map for Logistics (Ministry of Transport, KSA, 2020)

5.2 Overview of Logistics Performance using World Bank Dataset

The research uses World Bank data, as the data includes readings from 160 countries for 2007-2018 for the variables of the logistical performance measurement model. In Figure 1, data for the year 2018 are presented regarding a comprehensive index to measure countries' logistics performance. Figure 2 reflects the competition between countries in the logistics sector is intense.

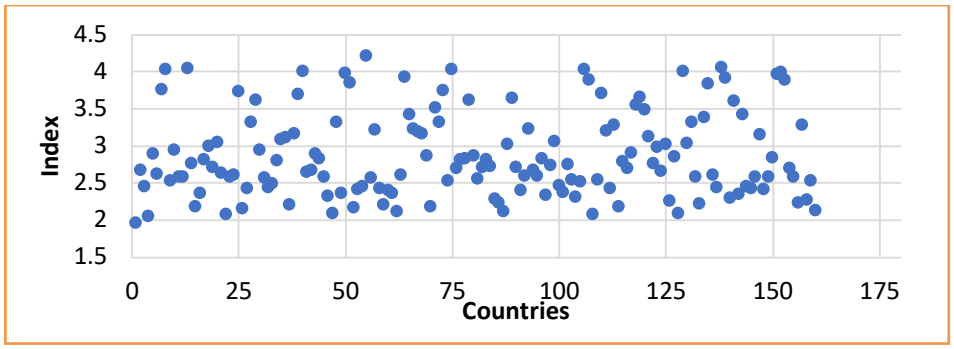

Figure 2: Logistics performance readings among the world's countries (2018).

The logistics sector's performance in SA during the 11 years has varied in ranking among the world's countries. However, the performance percentage is almost close (Figure 3). Further, SA had 41st rank in 2007, but it became in the 55th rank in 2018. SA has been consistently in the performance percent of highest performer. Figure 1 shows the countries that follow SA for each of the six editions of the survey. However, in the ranking, it lost 14 positions among the world's countries. This situation put significant responsibilities significantly as the KSA's ambitions, in light of the 2030 Vision towards a diversified economy, increase these responsibilities.

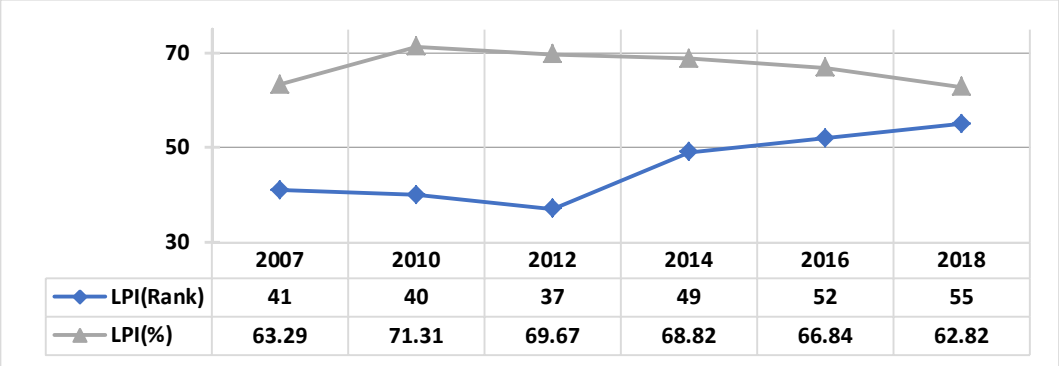

Figure 3: Logistics performance index (Rank & %) for Saudi Arabia.

Table 1 shows the scores and levels achieved by the Kingdom in all performance indicators during the years covered by the World Bank studies.

Table 1: The scores and Ranks of Saudi Arabia for the Logistics Performance indicators 2007–2018.

Year	Track and trace consignments		Competence and quality of logistics services		competitively priced international shipments		The efficiency of the clearance process		scheduled or expected time		Quality- of related infrastructure		Logistics performance index: Overall		Logistics performance index	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	%	
2007	3.02	43	2.88	51	2.93	50	2.72	45	3.65	39	2.95	38	3.02	41	63.29	
2010	3.32	42	3.33	32	2.80	82	2.91	43	3.78	45	3.27	33	3.22	40	71.31	
2012	3.21	42	2.99	47	3.10	42	2.79	51	3.76	34	3.22	35	3.18	37	69.67	
2014	3.15	54	3.11	48	2.93	70	2.86	56	3.55	47	3.34	34	3.15	49	68.82	
2016	3.25	49	3.00	54	3.23	48	2.69	68	3.53	53	3.24	40	3.16	52	66.84	
2018	3.17	46	2.86	57	2.99	56	2.66	66	3.30	67	3.11	43	3.01	55	62.82	

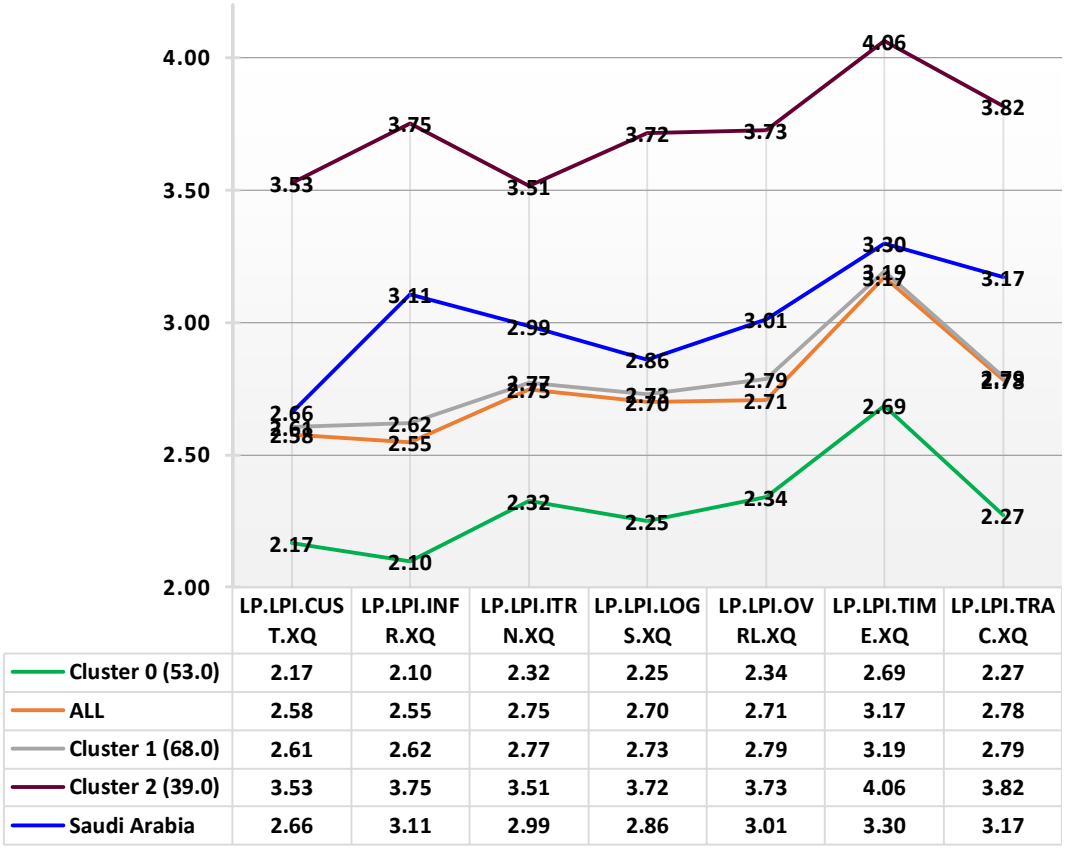

Figure 4: Clustering of logistics performance index

5.3 Clustering Analysis of Logistics Performance

Using the K means method as one of the clustering techniques (used Weka 3.8.4. as a data mining tool), the world's countries were divided into the logistics performance into 3 clusters. It is noticed from Figure 4 displays the reading of 2018. The first cluster is the pioneers in logistics, as there are promising countries. The third cluster is the Countries that strive to survive in the field (the logistics industry). SA is considered one of the promising countries that seek to reach the cluster of pioneers. This target can be achieved that through their competitive advantages. Whereas SA has characterized in terms of the geographical location is in the middle of the world. As well as it has the lengths of the coasts, and it owns the infrastructure of land roads and airports. Based on figure 4, SA achieves higher values in infrastructure 3.11, shipment tracking 3.17, and time 3.30 rather than in other performance measures. However, the evaluation does not achieve the Kingdom's ambitions in this regard.

5.4 A Comparison between Saudi Arabia and Its Neighbors

Due to the importance of geographical location in providing logistical services, Table 2 shows a comparison between neighboring countries' ranking concerning Saudi Arabia. It is clear from the figures in the table that SA comes in the fourth position, after the Emirates (UAE), Qatar, and Oman. SA is superior to the rest of the other neighboring countries. It is worth noting that the coasts that SA has in its possession help it to achieve an advanced position. In addition to its enormous economic capabilities and infrastructure, It has a 70 SAR Billion logistics market size and 240 million Tons of Cargo handled by seaports, according to 2017. Also, it owns 1500 KM Length of new railways and 27 airports. (https://investsaudi.sa/en/sectors-opportunities/transport-logistics/)

Table 2: logistics performance rank 2018 for Gulf and East Africa countries

Country	LP.LPI.OVRL.RK	Country	LP.LPI.OVRL.RK
United Arab Emirates	11	Egypt	67
Qatar	30	Kenya	68
Oman	43	Sudan	121
Saudi Arabia	55	Madagascar	128
Bahrain	59	Yemen, Rep.	140
Kuwait	63	Somalia	144

5.5 Impacts of ICT on LPI

The ability to track and trace the commodity index is a key indicator of the World Bank's logistics performance assessment model. The ICT development index calculated by the International Telecommunication Union(ITU) is used. In Figure 5, SA values for 2007-2018 still range from 40-60%. This position confirms weaknesses that need to be improved.

For Saudi Arabia to improve its competitive position, SA needs to develop an integrated system that helps it to address weaknesses and achieve several goals, the most important of which

1. Reduce the cost of logistics.
2. Reduce the time of logistics.
3. Enhance the quality of logistics.
4. Enhance the security and control of logistics.

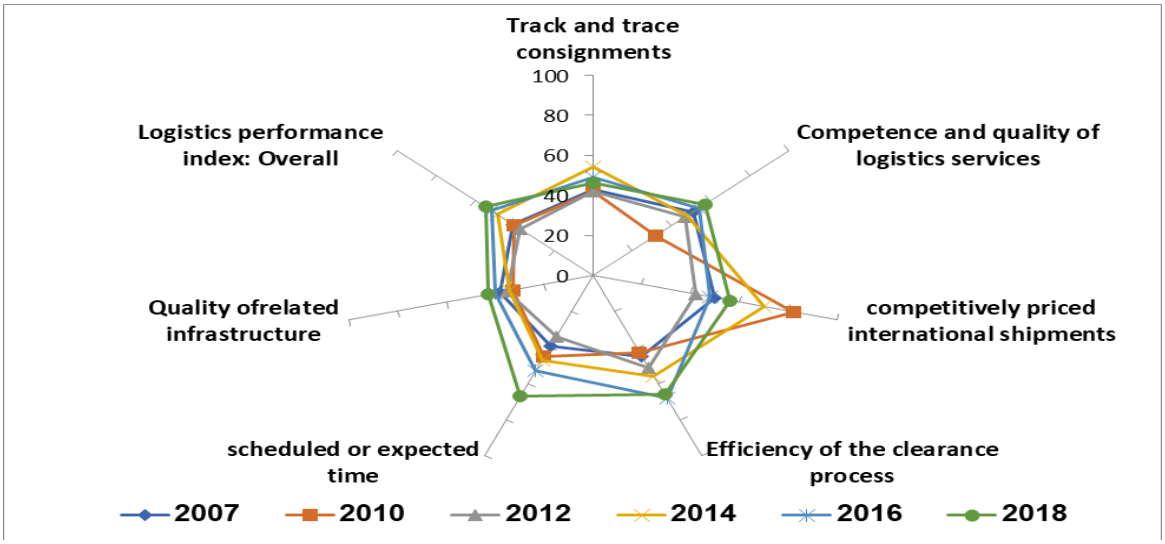

Figure 5: Logistics performance index for SA.

6 Suggested Integrated System based on Cloud Computing, Blockchain, and IoT

A low level of business cooperation is one of the critical problems in the logistics industry. Lack of Information leads to lower logistics and high logistics costs, thus reducing customer satisfaction. The integration of logistics and information technology addresses this problem and creates valuable activities. The use of cloud computing technology contributes to developing a dynamic integration framework for service-oriented collaborative logistics resources. (Gao et al., 2012). Li & Wu et al. (2012) proposed a cloud-based logistics information system. This system includes user profiles which consist of three parts: user basic data, user history, and user short time browsing action.

The Chinese Small & Medium Logistics Services providers (SMLSPs) find in Cloud Computing an opportunity to obtain world-ranked inexpensive IT capabilities. Cloud Computing adoption is an excellent chance to enhance supply chain management integration, green collaboration, and sustainability. Cloud computing environments help them meet the increasing demands of their customers for high-quality, cost-effective green services. The investigated Chinese SMLSPs are attracted to Cloud Computing to gain competitive advantages and improve customer services through low costs and green benefits (Subramanian et al., 2014).

Omega Inc. (2015) introduced "Telogis" as a shipment tracking system to

1. Maximize customer satisfaction levels.
2. Enhance the tracking and reliability of the shipment.
3. Monitor driving behaviors on the road.
4. Improve customer delivery sequences (thoughtful track planning).
5. Preventing loss or theft while handling and managing the shipment.

Due to cloud computing and network technology support for logistics, logistics patterns have changed functional morphology and resource allocation, with service integration and logistical resource sharing features. This confirms the strategic alignment between information and communication technology and business processes. This alignment has been achieved mainly in

the cloud logistics model to achieve centralized management of dispersed resources and dispersed management of central resources. ICT-based cloud logistics services help shape a new operating method for the logistics industry that delivers better results than traditional development methods. Cloud computing brings multiple advantages, including collecting all distribution centers, making full use of idle resources, and improving resource use in the cloud.

The relationship between organizations in supply and logistics chains has become increasingly complex, becoming a multi-layered, multi-dimensional, and multi-layered network. Due to the reasons for the privacy of Information, information exchange problems, and the governmental procedures control, the institutions' links are also characterized by randomness and ambiguity. Consequently, all of this confirms the importance of cooperation between private and governmental institutions and private enterprises. (Zhang et al., 2017). With new ICT applications such as cloud computing, the Internet of things, and other tracing intelligent devices, organizations improve their operational efficiency and customer service (Ali et al., 2019).

Blockchain can be successfully used to solve issues related to collaboration and interoperability, marketing and protocol, security and supervision, and global value chain governance. As well as e a blockchain-based can be used in collaborative production to share knowledge and ideas in design, implementation, and optimization production (Ouyang, 2019)

Wang (2020) introduced an IoT-based intelligent logistics system to provide a dynamic coordination environment between users and order-picking robots-based cloud technology. This system consists of three layouts: an intelligent platform based on an IoT, a multi-objective optimization model, and cloud technology. This research assures that IoT technology enhances customer satisfaction and outperforms traditional logistics methodologies.

6.1 Roles of Cloud Computing

Logistics service providers face many challenges because logistics service seekers need special services that require more flexibility, reasonable cost, transparency, and fast performance. Also, the enormous demand for resources, diversity of resources, demands an account, and contracts lead to logistical service suppliers facing the following problems: (Benotmane et al., 2018)

1. Lack of investment funds to expand information technology.
2. Inadequate manpower to run required IT
3. The complexity of developing IT components and integrating them into the existing ones.
4. Lack of IT expertise

Cloud computing solutions are achieving many new benefits to logistics providers. The cloud computing environment helps build an integrated information system to connect purchases, warehouses, and Content Management systems (CMS). So, cloud computing contributes to improving the supply chain and thus rapid access to resources and sharing all Information: (Benotmane et al., 2018) (Alyoubi et al., 2019)

Many logistics professionals view the cloud computing environment as a suitable environment for optimizing their operations. IT resources are flexible and dynamic; These resources are provided as an online service to users. The cloud computing environment includes many strategies such as infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS). Therefore, the use of a cloud computing environment in the field of logistics and supply chain management may achieve the following advantages: (Benotmane, 2018)

1. Without the need for massive investments in information technology solutions, companies can acquire one of the best services through monthly/annual fees.
2. Small and medium enterprises can access professional solutions with less investment in information technology.
3. Companies can drastically reduce the vast budgets they bear in exchange for hiring information technology specialists.
4. In the cloud computing environment, logistical systems contribute to better cooperation and control between partners in logistics services and supply chains and provide better services..

6.2 Roles of Blockchains

Blockchain is a recent ICT development, contributing to data management sharing between stakeholders. Blockchain is a block of sequential data, so it resembles a distributed ledger that contains shared data and is maintained by each node in the decentralized system. In a blockchain-based information system, connected and interactive nodes are stimulated through the P2P network through a stimulating mechanism to contribute to its computing power. All stakeholders can communicate effectively to conduct joint transactions, store and share associated data and publish transactions created during the period of participation between them. Therefore, a blockchain-based information system represents a distributed computerized ledger to achieve information exchange and asset management. Creating and sharing value. (Ouyang L. Y.-Y., 2019)

6.3 Roles of the Internet of things (IoT)

IoT represents the network of physical embedded devices, sensors, software, robotics, and actuators. IoT provides integration in communications, information processing, and control through various logistics provider systems. Using the IoT extends into all transportation methods such as Trucks, vehicles, ships, planes, roads, all other infrastructure, and all stakeholders such as the driver, client, and user). IoT enables the logistics systems components to connect and exchange data in real-time with high accuracy. All these IoT capabilities create opportunities to integrate among logistics services providers, provide efficient best services, maximize economic benefits, and reduce human exertions. Dynamic interaction among logistics system components enables vehicle & Truck communication, smart parking, intelligent traffic control, electronic fees collection systems, logistic management, vehicle & truck control, and road assistance and safety. In logistics services management, IoT platforms can monitor cargo and assets' location via wireless sensors. Also, IoT can send specific alerts when harmful risks occur, such as damages, loss, delays, thefts. (Wang et al., 2020)

6.4 Layers of proposed integrated system Framework

Table 3 addresses the layers of the proposed system framework. It presents a description of each layer and its role in interaction within the proposed system as a brief description of the proposed framework for an integrated system based on the IoT and blockchain technology in the cloud computing environment.

Table 3: Integrated system framework layers

System Layers	Layers Description
Service layer	The cloud computing environment provides distributed infrastructures, computing, processing, and storage have available in the cloud. This layer is built on Web Services which provide quick access to system functions and tasks. This layer includes a proposed web service catalog to implement all system users' information interchange tasks and achieve communication among all logistics service providers' stakeholders.
Application Layer	This layer plays the main role in the functions of the proposed framework. This layer includes all procedures and business rules to monitor and control partners performance in providing logistical services, as well as government controls and procedures. Stakeholders (companies, individuals, or government units) carried out All operations and procedures related to logistical services through this layer. The operations in this layer include logistics services costing and pricing as well as tracking the movement of shipments and trucks and calculating government taxes and fees.
Data Layer	Logistics services providers access data to perform various treatments on data. The primary function of this layer is to manage data. This layer includes all data of logistics services such as governance rules of logistics, logistics service processes data, Basics Data of Logistics services providers, and Government unit's data.
Network Layer	This layer contributes to effective communication and interconnection between the components of the system. After digital identity authentication, the components of the system, the connected devices, the Internet of Things components, as well as the blockchain become a reliable contract that exchanges data among them. There are many blockchain-based digital identity authentication systems already. In the P2P blockchain network, all nodes are equal peers connected to flat topology, which means that there is no hierarchical central structure. Accordingly, logistics services are becoming more and more readily available in an environment subject to government controls and rules. So, Individuals or SMEs can freely access the network and provide logistics services regardless of their capacity restriction.

7 Conclusion

Using the World Bank data to study Saudi Arabia's logistical performance and compare it with the countries of the Middle East region, the Kingdom of Saudi Arabia needs to improve performance levels in several discussions, the most important of which was tracking trucks and shipments. Despite SA its prominent global geographical location and strong economy, it is still not classified in logistics services among the leading countries. However, it represents a promising market in this field, and to achieve this, SA needs to build an integrated information system that links between the government and the private sector. For this system to achieve the desired goals, it is preferable to rely on modern Information and communication technology such as cloud computing and participatory data management through blockchain and the Internet of things. The proposed integrated logistics information system in this paper helps to improve the performance of logistics services and can reduce their cost. In future work, the proposed integrated system still needs to be further studied and improved.

8 Availability of Data and Material

Information is available upon request to the corresponding author.

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