The Mediating Role of E-purchasing in the Relationship between IoT Technology and Supply Chain Responsiveness[1]

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ABSTRACT

The study investigates the impact of integrating Internet of Things (IoT) technology with e-purchasing on enhancing the responsiveness of supply chain applied to a sample of companies in the food industry sector in developing countries. Four hypotheses were developed to achieve this goal, and a questionnaire was designed to collect primary data relevant to the study. Using Cronbach's alpha, the reliability of the study variables was confirmed. Factor analysis was employed to verify the measures' construct and discriminant validity. Furthermore, Partial Least Square (PLS) analysis was used to examine relationships within the model and test the hypotheses. The results revealed a statistically significant positive impact of IoT technology combined with e-purchasing on supply chain responsiveness. Additionally, IoT technology had a statistically significant positive effect on the responsiveness of the supply chain. The analysis also showed a statistically significant positive effect of e-purchasing on supply chain responsiveness in the companies studied. Finally, the researcher concluded that there was no statistically significant effect of e-purchasing as a mediating variable in the relationship between IoT technology and supply chain responsiveness in the companies under study. Finally, these study offers numbers of recommendations Such as: Build and develop Internet of Things (IoT) technology in Egyptian industrial organizations, shift from focusing on the traditional purchasing concept to employing advanced systems and tools for implementing the concept of electronic purchasing, Integrate and utilize IoT technologies and electronic purchasing, enabling improved communication and coordination of systems across various stages of supply chains.

Keywords: *Internet of Things (IoT), E-purchasing, supply chain responsiveness.*

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1. INTRODUCTION

With the tremendous advancement in information and communication technology, particularly the Internet, which has impacted all aspects of life and various economic and social activities, global trends to improve and develop organizational performance and information systems have become closely linked to integrating technology. This shift arose after traditional systems failed to meet the requirements for transitioning to a digital knowledge society based on knowledge dissemination and easy access to information.

Technology integration into organizational processes and information systems has become essential, as it offers a transformative leap in operational aspects, enhances performance levels, and improves sustainability and competitive capabilities in both local and international markets. Consequently, organizations are increasingly interested in how to leverage and benefit from the analytical capabilities provided by Internet of Things (IoT) technologies to support all functions within the organization, especially supply chain management (Argyropoulou, Garcia, Nemati and Spanaki, 2024; Arunachalam, Kumar and Kawalek, 2018; Shoomal, Jahanbakht, Componation and Ozay, 2024; De Vass, Shee and Miah, 2018).

Today, IoT technologies have become one of the most important resources for organizations due to their ability to enhance responsiveness to competitive pressures and adapt to significant technological developments, particularly in supply chain management. This capability allows organizations to quickly respond to customer needs, increase operational flexibility, and improve competitive advantages, relying on IoT's data analytics capabilities. These capabilities can deliver immediate and accurate information to decision-makers in supply chain and operations management, supporting the sustainability of the supply chain while enhancing its capabilities and reducing uncertainty and risks. Additionally, IoT technologies help streamline operations, shorten production cycles, focus on manufacturing requirements, and improve the agility and responsiveness of the supply chain. Thus, ignoring or postponing engagement with this technology is no longer an option for organizations. They must acquire data analysis and processing tools to transform information into added value for

the customer (Haddud, Desouza, Khare, Lee, Desouza, and Lee, 2017; Raut, Mangla, Narwane, Dora and Liu, 2021; Waithaka and Kimani, 2021).

IoT technologies and e-purchasing are among the most important innovations that contribute to providing innovative solutions for enhancing supply chain performance. Their ability to improve real-time data collection and analysis facilitates accurate forecasting, boosting operational efficiency. According to Lee, Romzi, Hanaysha, Alzoubi and Alshurideh (2022), integrating IoT technology into the supply chain shows significant improvements in the responsiveness and flexibility of operations, enabling companies to adapt to rapid market changes and increase customer satisfaction. IoT technology allows for real-time tracking of shipments, products, and inventory, which leads to reduced delivery times and improved inventory management. Results from Wu and Chien (2016) indicate that companies relying on IoT in their operations can achieve a 20% reduction in distribution costs and a 15% increase in customer satisfaction. In this context, e-purchasing plays a vital mediating role, providing a platform that facilitates access to a wide range of suppliers and enhances the effectiveness of purchasing processes. According to a Deloitte study, organizations that rely on e-purchasing record a 25% increase in responsiveness to changing markets (De Vass et al., 2018; Lee et al., 2022).

The researcher believes integrating IoT with e-purchasing can improve supply chain responsiveness significantly, helping companies adapt to rapid market changes and enhance customer satisfaction. By providing accurate real-time data, these technologies enable companies to make informed decisions, improving storage and distribution processes within the supply chain. Companies that adopt this integration can experience increased responsiveness and noticeable improvements in operational efficiency, ultimately enhancing customer experience and loyalty. Considering the above, this study will explore the impact of IoT technology and e-purchasing, their roles in improving supply chain responsiveness, and their implications for business performance within organizations.

2. LITERATURE REVIEW

2.1 The Role of the Internet of Things (IoT) and Its Analytics in Supply Chain Management

Supply chains are currently facing many challenges in the uncertain and complex environment in which business organizations operate, which has forced them to transform into a smart supply chain by adopting advanced technologies in the field of the Internet, such as the Internet of Things (IOT) to support supply chain activities in tracking transportation operations, inventory control, and customer service, as well as improving the organization's developmental capacity. It is necessary to work on equipping it with a technological infrastructure that enables it to manage physical and information flows in an integrated manner across the parties of the chain to overcome these challenges. The role of digitization is no longer limited to changing the organization's operations and products only but has also extended to changing the entire supply chain operations (Abdel-Basset, Manogaran and Mohamed, 2018; Argyropoulou et al., 2024; Fatorachian and Kazemi, 2021).

The definitions of IoT vary widely. According to Chang (2016), IoT refers to a state in which large numbers of objects or devices embedded with sensors are interconnected via the Internet, capable of gathering various types of data about their surrounding environment, including temperature, light, sound, time, movement, speed, and distance. Tan and Sidhu (2022) defined IoT as a technology that allows any natural or man-made objects to connect and transmit data using a dedicated Internet Protocol (IP) address, with or without human intervention. It is a system of interconnected computing devices, mechanical and digital machines, objects, and people, all equipped with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction (Wamba, Gunasekaran, Dubey and, Ngai, 2018).

IoT is often described as connecting devices such as computers and smartphones to the Internet, but it can also extend to vehicles, kitchen appliances, and even heart monitors. As IoT grows in the coming years, more devices will join this network. Any independent device that can be monitored and controlled

remotely via the Internet qualifies as an IoT device. Nearly all products can become IoT devices with smaller and more powerful chips. All components that enable companies, governments, and consumers to connect to IoT devices—including remote controls, dashboards, networks, gateways, analytics, data storage, and security—are part of the IoT ecosystem (Meola, 2018).

Kim (2016) defined IoT as a network of interconnected electronic devices that can complete tasks with minimal human intervention. The ability of these devices to communicate and continuously exchange information enables intelligent decision-making, making organizational processes more efficient. Considering the previous definitions, the researcher defines the Internet of Things (IoT) as a technological concept that refers to a network of smart devices that automatically collect and exchange data. These devices utilize applications to interact with and respond to their environment. This network comprises three primary components: First, there are Smart Devices, which use sensors and communication technology to collect data. Second, applications refer to software that analyzes data and generates intelligent actions. Third, user Interfaces are the tools consumers utilize to engage with the device.

IoT technology enables the connection of devices and equipment to the Internet, facilitating the collection and analysis of vast amounts of real-time data. This connection enhances the significance of the data generated, thanks to its highly advanced automation and digitization processes, which help improve supply chain responsiveness through immediate tracking of shipments and products. This capability allows access to a wide range of data, information, applications, and tools that can be leveraged to create more efficient and effective economic value for all parties involved in the supply chain (Chae, Yang, Olson and Sheu, 2014; Moyano-Fuentes, Bruque-Cámara and Maqueira-Marín, 2019; Shoomal et al., 2024).

Tan, Zhan, Ji, Ye and Chang (2015) emphasized that an organization's ability to utilize big data based on IoT technology directly impacts its competitive and innovative advantage, provided that the necessary technological infrastructure is in place to support this technology. Jahani, Jain and Ivanov (2023) also illustrated how IoT technology and big data analytics enhances decision-making efficiency

by providing accurate and reliable insights into operations and procedures. This capability improves forecasting, reduces costs, and aids risk management by identifying potential risks in the supply chain, enabling companies to take preventive measures. Consequently, this enhances the efficiency of logistics operations and supply chain management within organizations.

Jeble, Dubey, Childe, Papadopoulos, Roubaud and Prakash (2018) highlighted the positive impact of the analytical and predictive capabilities of data generated from IoT technology on improving the environmental, social, and economic performance of sustainable supply chains. This improvement relies on enhancing organizational capabilities and decision-making flexibility. Meanwhile, Abu Al-Fotouh and Al-Basyouni (2019) confirmed that using IoT technology for resource monitoring and operations management can reduce waste and decrease energy consumption. Additionally, it improves supply chain efficiency by providing real-time information about product and inventory status, enabling better planning, and supporting the organization's competitive advantage.

On the other hand, Fernando, Chidambaram and Wahyuni (2018) found a positive impact on organizations' ability to manage their data securely and confidentially, which enhances predictive capabilities and decision-making resulting from IoT technology usage. Dubey, Gunasekaran and Childe (2018) interpreted the relationship between big data analytical capabilities derived from IoT and supply chain flexibility, showing that this technology positively impacts supply chain agility and operational flexibility. Furthermore, Al-Talib, Melhem, Anosike, Reyes and Nadeem, (2020) and Zhan and Tan (2020) concluded that companies leveraging IoT technology in their operations can achieve a 20% reduction in distribution costs and a 15% increase in customer satisfaction.

Zhou, Chong and Ngai (2015) aimed to identify IoT's role in improving supply chain efficiency and flexibility. Their results indicated that IoT technology enhances supply chain efficiency by providing interactive and real-time information, and it boosts supply chain flexibility by improving the ability to adapt to changes and challenges. Additionally, it helps improve customer service by providing accurate and timely information about shipments and deliveries, ensuring quick responses to customer demands.

Related to the impact of IoT Technology on Supply chain performance responsiveness, past studies revealed that IoT technology enables the availability of advanced sensors and software capable of tracking the location of shipments and products throughout the supply process in real time, which reduces delivery times and improves inventory management (Al-Talib et al., 2020). Also, IoT facilitates the collection of vast amounts of data, which can be analyzed to enhance forecasting and operational processes. IoT-based data assists companies in making informed decisions regarding operational efficiency (Wang, Gunasekaran, Ngai and Papadopoulos, 2016)

2.2 E-PURCHASING

E-purchasing is the process that allows companies to procure goods and services using Internet technology (Amaro and Duarte, 2013). It is also described as adopting technological systems in the purchasing stages, which involve defining demand, identifying sourcing options, conducting bids, auctions, and negotiations (Mutangili, 2019).

E-purchasing provides a platform that enables companies to compare prices and select the best suppliers, thereby enhancing the flexibility and responsiveness of the supply chain. Through the data collected from e-purchasing activities, organizations can analyze purchasing patterns and trends, improving their ability to make swift strategic decisions (da Costa, Gillespie, Cama-Moncunill, Ward, Condell, Ramanathan and Murphy, 2022).

In this context, e-purchasing plays a vital intermediary role, offering a platform that facilitates access to a wide range of suppliers and enhances the effectiveness of purchasing processes. According to a Deloitte study, organizations that rely on e-purchasing report a 25% increase in their responsiveness to a changing market (Fatorachian and Kazemi, 2021).

Mutangili (2019) emphasized that e-purchasing enhances the management of information and knowledge related to suppliers and improves control over supplier operations. Additionally, e-purchasing may lead to increased speed, quantity, and quality of information processing, especially with international suppliers. Some researchers, such as Tai, Ho, and Wu (2010), note that e-

purchasing positively impacts the performance of both buyers and suppliers. Implementing e-purchasing encourages information exchange and collaboration with suppliers, improving flexibility in introducing new products, responsiveness to market changes, and enhanced supply chain responsiveness.

Chirchir, Ngeno and Chepkwony (2015) aimed to identify the impact of e-purchasing on supply chain performance. The findings indicated that e-purchasing can increase supply chain efficiency. On another front, Tan et al. (2015) examined the impacts of technological and informational dimensions supporting e-purchasing processes within the supply chain on achieving supply chain flexibility and responsiveness. It concluded that information technology plays a positive role in achieving operational flexibility through information sharing among partners within the supply chain to facilitate e-purchasing processes.

Ghasemaghaei, Hassanein and Turel (2017) confirmed that organizational flexibility can be enhanced by leveraging information technology through e-purchasing, which positively contributes to responsiveness and decision-making by utilizing information to align the activities of individuals, managers, and supply chain partners. Finally, the results of Tiwari, Chan, Ahmad and Zaman (2019) indicated a positive correlation between e-purchasing systems and supply chain performance within organizations. Tai et al. (2010) supported this finding, indicating that e-purchasing positively affects the supply chain's responsiveness.

2.3 Improving Supply Chain Responsiveness

Improving supply chain responsiveness is a vital strategic goal for organizations amidst rapid changes in business environments. Integrating IoT and e-purchasing enhances efficiency and flexibility, allowing companies to adapt to market demands. IoT improves supply chain responsiveness by connecting sensors to accurately collect information regarding inventory levels, transit times, and shipment status, facilitating quick decision-making (Suresh, Sanders and Braunscheidel, 2020). Also, IoT improves supply chain visibility, enabling companies to track products from origin to end consumer (Argyropoulou et al., 2024; Lee et al., 2022). Furthermore, e-purchasing is critical in enhancing supply chain responsiveness by Allowing companies to access suppliers more quickly

and effectively, reducing purchasing times, and increasing responsiveness. Moreover, it facilitates supplier communication, enhancing collaboration and reducing information gaps (Govindan, Cheng, Mishra and Shukla, 2018; Lee et al., 2022; Mandel, 2018).

Interaction between IoT, e-purchasing, and Supply Chain Responsiveness

Several studies Haddud et al. (2017); Wang et al. (2016); Swafford, Ghosh and Murthy (2008) have shown that the integration of IoT technology with e-purchasing and internal organizational flexibility serves as an indicator of supply chain responsiveness through increased processing and operational management efficiencies. Shang, Zhang, and Chen (2012) aimed to clarify how to design an effective service structure combining devices, networks, and data to enable various applications, including e-commerce. The results indicated that IoT can enhance online shopping experience by improving customer interaction, personalizing offers, and better inventory management. Furthermore, integrating IoT into e-commerce increases efficiency, improves supply chains, and reduces operational costs.

Meanwhile, Abu Khashabah (2021) explored the impact of big data analytics capabilities on supply chain flexibility dimensions and operational agility. Conducted on various industrial organizations in sectors such as pharmaceuticals, textiles, ready-made garments, and food and beverages in Alexandria, Beheira, and Cairo, they found a positive impact of big data analytics capabilities (based on IoT technology) on supply chain flexibility dimensions. However, they did not affect operational agility within the studied organizations. The findings from De Vass et al. (2018) and Waithaka and Kimani (2021) indicated that when IoT is integrated with e-purchasing, notable improvements in supply chain responsiveness are achieved, affecting improved decision-making that data aggregated from IoT allows companies to make informed, timely decisions, facilitating planning and forecasting (Mutangili, 2019). Also, these integrations enhance the ability to adjust inventory and modify purchasing strategies based on changing customer demands (De Vass et al., 2018).

Considering this, the researcher believes integrating IoT with e-purchasing effectively improves supply chain responsiveness. Companies should invest resources in these technologies to enhance their competitiveness in the market.

3. PROBLEM OF THE STUDY

Today, companies face multiple challenges related to the efficiency and flexibility of their supply chains. On the one hand, the increasing demand for e-purchasing creates higher customer expectations regarding delivery speed and product quality. On the other hand, the Internet of Things (IoT) is a powerful tool for improving visibility in the supply chain, as it can collect and analyze real-time data to enhance processes (Suresh, Sanders and Braunscheidel, 2020).

The main problem lies in understanding how the technologies of IoT and e-purchasing can integrate to achieve better responsiveness in the supply chain. While some studies indicate the benefits of these technologies, there is a lack of empirical evidence demonstrating the direct relationship between them and their joint impact on supply chain performance (Bag, Wood, Xu, Dhamija and Kayikci, 2020; Mageto, 2021; Piera, Roberto, Giuseppe and Teresa, 2014; Tsang, Wu, Lam, Choy and Ho, 2021; Wu and Chien, 2016; Zhan and Tan, 2020).

Notably, most previous studies addressing the relationship between IoT, e-purchasing, and the improvement of supply chain responsiveness have been conducted in developed countries, with a scarcity of studies conducted in developing nations, particularly in the Egyptian context. Additionally, there remains variability in the results of previous studies regarding the impact of IoT and e-purchasing on supply chain performance responsiveness, with some studies indicating a positive effect of IoT (IoT) and e-purchasing on supply chain responsiveness, suggesting that integrating IoT with e-purchasing enhances the speed of supply chain performance (Argyropoulou et al., 2024; Dubey, 2018; Ghasemaghaei et al., 2017; Moyano-Fuentes et al., 2019; Wu and Chien, 2016; Zhan and Tan, 2020). In contrast, several studies have supported the absence of an impact regarding how these technologies influence all aspects of the supply chain, including demand forecasting, inventory management, and customer service (Zhou et al., 2015).

Based on the above, the study's problem is to address the research gap by developing and testing a model to analyze and understand the impact of IoT and e-purchasing on supply chain responsiveness in a few industrial companies operating in the food manufacturing sector in Alexandria Governorate.

4. RESEARCH QUESTIONS

The research questions are as follows:

- What is the impact of the Internet of Things (IoT) on e-purchasing in the companies under study?
- What is the impact of the Internet of Things (IoT) on supply chain responsiveness in the companies under study?
- What is the impact of e-purchasing on supply chain responsiveness in the companies under study?
- Does e-purchasing mediate the relationship between the Internet of Things (IoT) and supply chain responsiveness in the companies under study?

5. OBJECTIVES OF THE STUDY

The main objective of this study is to investigate and analyze the impact of the Internet of Things (IoT) and e-purchasing on improving supply chain responsiveness. This objective can be divided into the following sub-objectives, which are to determine:

- the impact of the Internet of Things (IoT) on e-purchasing in the companies under study.
- the impact of the Internet of Things (IoT) on supply chain responsiveness in the companies under study.
- the impact of e-purchasing on supply chain responsiveness in the companies under study.
- the impact of E-purchasing as mediates the relationship between Internet of Things (IoT) Technology and Supply chain responsiveness in the companies under study.

6. IMPORTANCE OF STUDY

The importance of this study is highlighted by its anticipated contributions as follows:

- Scientific Importance
    - This study's field is one of the important and contemporary areas currently being discussed at global, regional, and local levels, given the increasing significance of the impact of IoT and e-purchasing on improving supply chain responsiveness.
    - There is a scarcity of research and studies addressing the impact of IoT and e-purchasing on improving supply chain responsiveness in developing countries.
    - This study will contribute to opening avenues for future research based on its findings.
- Practical Importance
    - Assisting industrial organization managers in leveraging the impact of IoT and e-purchasing to improve supply chain responsiveness, considering changes occurring in the supply chain environment, thereby achieving better operational benefits for industrial organizations in Egypt by utilizing data derived from IoT to enhance purchasing decisions and inventory management.
    - This study will provide a set of recommendations that enable managers in organizations operating in the industrial sector in Egypt to improve their competitive position using their technological resources and seizing available opportunities by understanding how these new technologies can contribute to developing new business models that keep pace with the rapid changes occurring in the business environment.

7. LIMITS OF THE STUDY

The primary limitation of this study is its spatial focus on large organizations operating in the food industry located in Alexandria Governorate. The researcher chose the food industry for this investigation due to its operation within a dynamic environment characterized by noticeable changes in customer preferences and desires and continuous technological advancements in this sector. This aligns with Dixon's (2023) definition of a dynamic environment, marked by rapid and unstable changes in competitive conditions, product demand, and technological development.

8. THEORETICAL FRAMEWORK

Based on a review of the literature, the proposed model for this study is built upon several previous studies (Argyropoulou et al., 2024; Dubey, 2018; Ghasemaghaei et al., 2017; Moyano-Fuentes et al., 2019; Reddy and Reinartz, 2017; Shoomal et al., 2024; Vass, 2018).

Considering the above, the proposed variables for the study comprise three components: the independent variable, which reflects the Internet of Things (IoT); the mediating variable, which is e-purchasing; and the dependent variable, which represents supply chain responsiveness. Figure 1 illustrates the proposed model for the study.

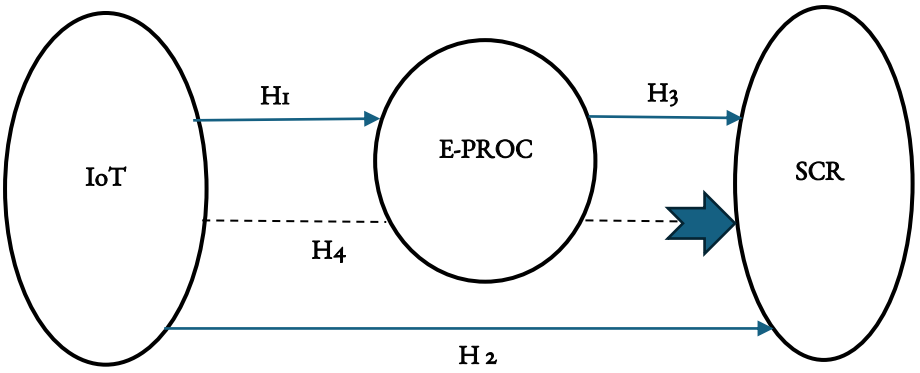

Figure 1: Model Employed

Based on the findings of several previous studies analyzing the relationship between the Internet of Things (IoT), e-purchasing, and supply chain responsiveness (Shoomal et al., 2024; Argyropoulou et al., 2024; Dubey, 2018; Ghasemaghaei et al., 2017; Moyano-Fuentes et al., 2019; Reddy and Reinartz, 2017; Vass et al., 2018; Zhan and Tan, 2020), the following hypotheses is posited.

Hypothesis 1: There is a statistically significant positive effect between the Internet of Things (IoT) and e-purchasing.

Hypothesis 2: There is a statistically significant positive effect between the Internet of Things (IoT) and supply chain responsiveness.

Hypothesis 3: There is a statistically significant positive effect between e-purchasing and supply chain responsiveness.

Hypothesis 4: E-purchasing mediates the relationship between Internet of Things (IoT) Technology and Supply chain responsiveness

9. RESEARCH METHODOLOGY

To achieve the study's objectives, the researcher adopted a descriptive-analytical approach aimed at describing the phenomenon, testing the study hypotheses, analyzing, and interpreting the collected data, and reaching conclusions that contribute to determining the impact of the Internet of Things (IoT) and e-purchasing on improving supply chain responsiveness. The study used two types of data collection sources: secondary sources that involved reviewing published literature, including books, theses, articles, research papers, and journals related to the study's topic. Additionally, the researcher used a questionnaire to gather primary data and information to test the study hypotheses.

The researcher employed a questionnaire method, supported by personal interviews, to facilitate clarification when delivering or collecting the questionnaires. This approach allowed for responding to any inquiries that participants might find necessary for answering the questionnaire. The questionnaire included 25 statements aimed at measuring the study variables, derived and developed from studies by Dubey (2018), Govindan et al. (2018), Moyano-Fuentes et al. (2019), Shoomal et al. (2024), Zhan and Tan (2020).

These measures were presented when testing the construct validity of the study variables. The researcher used a 5-point Likert scale for all questions, where (1) indicates strong disagreement and (5) indicates strong agreement, ensuring consistency in the questions and thus facilitating participants' responses.

The study population consists of Egyptian joint-stock companies in the food products sector listed on the stock exchange as of the beginning of the third quarter of 2023, totaling only 27 companies with trading activity (www.egx.com.eg) operating in the Alexandria Governorate. The researcher used a simple random sampling method to select a group of industrial companies' representative of the study population. The unit of observation and analysis comprised several managers working in production, marketing, warehousing, and supply management within the Arab Republic of Egypt. Using the following equation (Idris, 2009):

$$n = \frac{N(Z^2S^2)}{Ne^2 + Z^2Q^2}$$

Applying this equation, the sample size was determined to be 24 companies. The unit of analysis in this study is the factory rather than the company, which is consistent with several previous studies in this field. A total of 140 questionnaires were distributed, with 15 excluded due to incompleteness. This resulted in 125 valid questionnaires collected, representing approximately 89% of the total being distributed.

10. DATA ANALYSIS

Using the Smart PLS 3.0 software, the researcher employed several statistical methods to analyze the data collected from the responses of the study sample, including:

- Descriptive statistical methods such as mean and standard deviation to describe the study variables.
- Cronbach's alpha test to determine the internal consistency of the measurement scales for the study variables in the questionnaire. Construct validity was assessed using factor analysis to find the average explained variance.

- Smart Partial Least Square (PLS) analysis to evaluate the relationships within the model.

To test the study model, the researcher utilized the Smart PLS 3.0 software (Ringle et al., 2015) to assess the validity and reliability of the study variables. The data presented in Table 1 indicate that the values of Cronbach's alpha for the study variables range between 0.634 and 0.891. This suggests that the measurement scales for the study variables possess an acceptable level of reliability, given that reliability coefficients above 0.60 are considered satisfactory (Fornell and Larcker, 1981).

Table 1: Reliability and Validity of the Scales Used to Measure the Variables

Item Measures	Reliability Coefficient	Average Variance Extracted (AVE)	Loading Factor
Internet of Things (IoT)	0.862	0,878	
1. IoT technology helps provide aggregated data to companies, enabling them to make decisions based on accurate and timely information, facilitating planning and forecasting.			0.729
2. IoT technology enhances companies' ability to adjust inventory and change purchasing strategies based on changing customer demands.			0.787
3. IoT technology enhances supply chain visibility, enabling companies to track products from origin to end consumer.			0.800
4. IoT technology allows accurate data collection on inventory levels, transportation times, and shipment status, facilitating quick decision-making.			0.825
5. IoT technology helps companies improve inventory management efficiency with our suppliers.			0.642
6. IoT technology helps coordinate and organize supply chain operations to reduce non-value-added activities within the chain.			0,743
7. IoT technology helps companies adjust supply chain operations to reduce response time within the chain.			0.891
8. IoT technology helps companies quickly respond to introducing new types of products and services.			0.758
9. IoT technology helps companies offer a diverse range of products and services.			0.815

10. IoT technology helps companies discover unexpected changes in the physical flow of materials, inputs, and products across the supply chain.			0,634
11. IoT technology helps companies discover unexpected changes in market demand conditions.			0.824
12. IoT technology helps companies improve the process of making changes in product and service designs.			0.807
Electronic procurement (E-purchasing)	0.695	0,837	
13. Electronic procurement helps the company access suppliers faster and more efficiently, reducing procurement times and increasing response speed.			0.815
14. Electronic procurement makes it easier for the company to communicate with suppliers, enhancing collaboration and helping to reduce information gaps.			0.755
15. Electronic procurement helps the company reduce the cost of the procurement process compared to traditional procurement methods.			0.842
16. Electronic procurement provides the company with a platform that facilitates access to a wide range of suppliers and improves the effectiveness of procurement operations.			0.770
17. Electronic procurement helps improve our information sharing with suppliers.			0.830
18. Electronic procurement helps improve the exchange of product design information with suppliers.			0.803
19. Electronic procurement helps improve product quality.			0.771
20. Electronic procurement helps the company access suppliers faster and more efficiently, reducing procurement times and increasing response speed.			0.815
Supply Chain Response (SCR)	0.911	0.741	
21. Our supply chain response performance has helped us quickly respond to customer needs.			0.722
22. Our supply chain response performance has helped achieve customer satisfaction and increase their loyalty.			0.714
23. Our supply chain response performance has helped us adapt to market requirements.			0.654
24. Our supply chain response performance has helped reduce uncertainty and risks.			0.721
25. Our supply chain response performance has helped improve our competitive capabilities.			0.748

Source: Statistical Analysis Results of the Study Data.

The degree of validity for the scales used to measure the theoretical concepts of the study was determined based on the criteria outlined in Table 1. It shows that all factor loadings exceed 0.6 and have a high significance level at alpha = 0.001. The table indicates that the factor loadings range from 0,634 to 0.891. Additionally, the Average Variance Extracted (AVE) values for all variables are greater than 0.5, which is considered very suitable, as it exceeds the 0.5 thresholds proposed by Fornell and Larcker (1981). Regarding the validity examination, all these values were higher than the correlation coefficients between any two variables, indicating a high degree of discriminant validity. Both types of validity were achieved (Fornell and Larcker, 1981; Hair, Matthews, Matthews and Sarstedt, 2017).

Table 2: Correlation Coefficients and Discriminant Validity

	Internet of Things	E-purchasing	Supply chain Performance Responsiveness
Internet of Things	. 0.725**		
E-purchasing	. 0.554**	0.834	
Supply Chain Responsiveness	. 0.737**	0.612	0.854

Moreover, personal interviews were conducted with respondents from production management and heads of production departments. In addition, respondents filled out the survey questionnaire, focusing on specific dimensions necessary for improving the sustainability and flexibility of the supply chain and their impact on targeted performance. See Table 3.

Table 3: Description of Study Variables

Study Variables	Mean	Standard Deviation
Internet of Things	4.0656	0.7456
E-purchasing	3.7653	0.8454
Supply Chain Responsiveness	3.9868	0.7843

The results presented in Table 3 reveal that the average values for the concepts related to the study variables are closely aligned, ranging from 3.7653 to 4.065. This indicates a general agreement among respondents regarding these concepts.

Also, the standard deviations for the concepts are similar, ranging from 0.7456 to 0.8454. This suggests a relatively limited variation in the participants' opinions regarding these concepts.

To test the study model, the researcher utilized the Smart PLS 3.0 software (Ringle et al., 2015). Figures 2, 3, and 4 illustrate the results, which show statistical coefficients (t-values), while Tables 4 and 5 present the regression coefficients and the outcomes of the study model analysis.

Table 4: Results of Hypothesis Testing

Hypothesis	Relation	SE	t-value	Level of Significance	Decision
H1	(IoT) --> (E- PRCO)	0.925	18.365	0.000	Acceptance
H2	(IoT) --> (SCR)	0.328	2.706	0.001	Acceptance
H3	(E- PRCO) --> (SCR)	0.457	4.428	0.000	Acceptance

Note: t-values > 1.96** (p < 0.05); t-values > 2.58*** (p < 0.01)

Table 5: Results of Mediating Hypothesis Testing

Hypothesis	Direct Effect	Indirect Effect	Total Effect	SE	t-value	p-value	VAF	Decision
H4	(IoT) ----> SCR	(IoT) ----> (E- PRCO ----> (SCR)						
	0.328	0,036-	0,051	0,026	0.138	0,05	50%	Rejection

Note: t-values > 1.96** (p < 0.05); t-values > 2.58*** (p < 0.01)

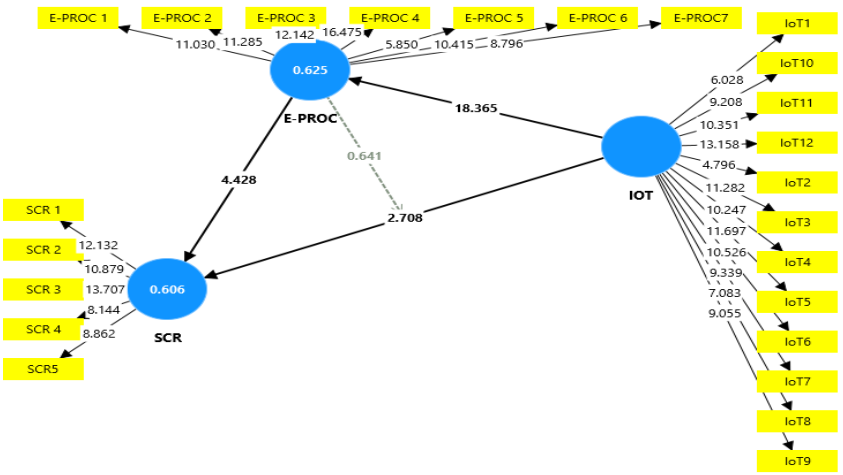

Figure 2: Results of Study Variables Analysis

Statistical Coefficients (t-values)

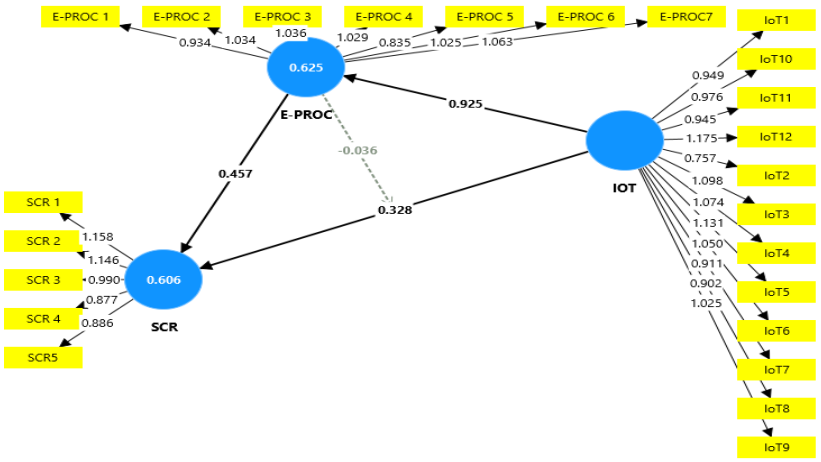

Figure 3: Results of Study Variables Analysis

Regression Coefficients

II. DISCUSSION

Hypothesis 1: There is a statistically significant positive effect between the Internet of Things (IoT) and e-purchasing.

The results in Table 4 indicate that the path coefficient between the two variables is 0.925, with a t-value of 18.365. This result shows a positive and significant relationship at a significant level of 0.000, which is less than 1%. This supports the acceptance of the first hypothesis, confirming the impact of IoT on e-purchasing in the studied companies. This finding aligns with previous research in this area (Seyedan and Mafakheri, 2020; Shoomal et al., 2024).

This result can be interpreted as IoT contributing to improved transparency in supply chains by providing accurate and up-to-date information about the status of goods and processes. Such improvements enhance the efficiency and effectiveness of e-purchasing operations. IoT can also increase the efficiency of e-purchasing by offering real-time, interactive data that supports accurate forecasting of future needs and product demand, thereby reducing waiting times and costs within e-purchasing channels.

Furthermore, integrating IoT technologies with e-purchasing can enhance communication and coordination between different stages of supply chains, facilitating the smooth flow of information and resources. This holistic approach ultimately leads to a more responsive and agile e-purchasing environment.

Hypothesis 2: There is a statistically significant positive effect between the Internet of Things (IoT) and supply chain responsiveness.

The results in Table 4 show that the path coefficient between these two variables is 0.328, with a t-value of 2.706. This result indicates a positive and significant relationship at a significant level of 0.000, which is less than 1%. Therefore, the second hypothesis is accepted, confirming the impact of IoT on supply chain responsiveness in the studied companies. This finding is consistent with several previous studies in this field (Argyropoulou et al., 2024; Raut et al., 2021; Seyeden and Mafakeri, 2020; Zhou et al., 2015).

This effect can be explained by the fact that IoT enhances the efficiency of supply chains by providing interactive, real-time information. It also improves supply chain flexibility by enhancing adaptability to changes and challenges. Furthermore, IoT contributes to increased transparency in supply chains by supplying accurate and updated information regarding the status of goods and operations. Finally, IoT aids in improving customer service by providing timely and precise information about shipping and delivery.

Hypothesis 3: There is a statistically significant positive effect between e-purchasing and supply chain responsiveness.

The results in Table 4 show that the path coefficient between these two variables is 0.457, with a t-value of 4.428. This indicates a positive and significant relationship at a significant level of 0.000, which is less than 1%. This finding supports the acceptance of Hypothesis 3, indicating that e-purchasing affects the responsiveness of supply chain performance in the companies studied. These findings align with several previous studies in this field (Dubey et al., 2018; Govindan et al., 2018; Moyano-Fuentes et al., 2019; Tan and Sidhu, 2022; Tiwari et al., 2019).

This effect can be explained by the fact that e-purchasing enhances the efficiency of supply chains by accelerating purchasing processes and reducing costs. Additionally, it improves the accuracy and timing of purchases, which minimizes waste and maximizes resource utilization. Furthermore, e-purchasing facilitates better management of information and knowledge related to suppliers, enhances control over supplier operations, and increases information processing speed, volume, and quality.

Hypothesis 4: E-purchasing plays a mediating role on the Internet of Things (IoT) and supply chain responsiveness.

The results in Table 5 indicate that the total effect value is 0.051, with a t-statistic of 0.769 and a significance level of 0.026, which is not statistically significant. Therefore, since the total effect is insignificant, there is no mediating role between the two variables.

Additionally, the path coefficient for the direct effect of the Internet of Things (IoT) on electronic purchasing is 0.925, while the path coefficient for the direct effect of electronic purchasing on supply chain responsiveness is 0.457. The path coefficient for the direct relationship between the Internet of Things (IoT) and supply chain responsiveness is 0.328. The indirect path coefficient, with electronic purchasing as a mediating variable between IoT and supply chain responsiveness, is -0.364, with a t-value of 0.138, which is also insignificant at a level lower than 0.05.

This suggests that electronic purchasing, as a mediating variable, does not significantly enhance the relationship between the Internet of Things (IoT) and supply chain responsiveness. This may be explained by the limited financial resources of the companies under study, which hinder their ability to establish an adequate technological infrastructure to integrate IoT technology with e-purchasing effectively. Consequently, companies cannot fully leverage IoT's potential in improving supply chain performance, and e-purchasing remains restricted to handling routine operations only without offering effective support for integrating and enhancing the flow of information and materials across the supply chain.

Overall, this research has contributed to advancing theoretical and managerial knowledge of the impact of IoT and e-purchasing on improving supply chain responsiveness especially since the study's field is one of the important and contemporary areas currently being discussed at global, regional, and local levels. Moreover, it expands the role of e-purchasing as a mediator particularly research and studies are scarce, addressing the impact of IoT and e-purchasing on improving supply chain performance in developing countries. The marketing and logistics team can focus on these aspects to improve supply chain responsiveness.

12. LIMITATIONS AND RECOMMENDATIONS

Considering the current study's findings and based on the researcher's interpretation and discussion of the results, the study offers two types of recommendations: practical recommendations and recommendations for future research.

12.1 PRACTICAL RECOMMENDATIONS

Recommendations	Implementation Requirements	Responsible Party(ies)	Success Indicators
1. Build and develop Internet of Things (IoT) technology in Egyptian industrial organizations	Develop a plan to enhance the existing databases and information. Connect the organization's databases with global databases.	Senior Management Information Technology Department	Degree of progress in planning for building and developing Internet of Things (IoT) technology. The amount of financial support provided by senior management to establish and develop IoT technology.
2. Shift from focusing on the traditional purchasing concept to employing advanced systems and tools for implementing the concept of electronic purchasing.	Introduce advanced statistical tools and methods for data analysis and generating useful information for decision-making in supply chain and operations.	Information Technology Department Supply Chain Manager Operations Manager	The number of modern statistical and mathematical tools used for data analysis. The number of users utilizing analysis methods and reporting information within the organization
3. Integrate and utilize IoT technologies and electronic purchasing, enabling improved communication and coordination of systems across various stages of supply chains.	Create training plans for employees and managers on leveraging the capabilities of Internet of Things technology. Allocate a sufficient budget for developing large databases for the organization.	Senior Management Supply Chain Manager Operations Manager IT Manager	The number of training programs in the field of information technology and databases Success indicators for employing databases and utilizing information technology within the organization

12.2 Recommendations for Future Research

The current study focused on testing the variables within the food industry sector. Therefore, it is recommended that future research examines these variables across other industrial sectors to identify similarities and differences that would allow for the generalization of the results and comparison with the current study's findings. Also, the current study limited its examination to the dimensions of Internet of Things (IoT) technology. Hence, future studies explore additional dimensions. Moreover, the researcher suggests that future studies should investigate a range of contextual factors, such as organizational structure, company size, market demands, and company strategy, alongside the current study's variables to enhance the model.

13. CONCLUSION

This study has advanced theoretical and managerial knowledge of IoT and e-purchasing's influence on supply chain responsiveness enhancement, which was accelerated by the increasing attention directed towards such a vital and trending subject at global, regional, and national levels. Since the impact of IoT and e-purchasing on supply chain performance improvement in developing countries, this paper aimed to expand the mediating role of e-purchasing.

Consequently, this research has confirmed that IoT significantly impacts e-purchasing within examined firms, including prior studies such as Seyedan and Mafakheri (2020) and Shoomal et al. (2024). Thus, it can be stated that IoT enhances the supply chain’s transparency by offering precise and real-time information regarding the goods’ status. Accordingly, consistent with earlier findings (Argyropoulou et al., 2024; Raut et al., 2021; Seyeden and Mafakeri, 2020), IoT advances the efficiency of e-purchasing, empowers product demand forecasting accuracy, and reduces waiting times and e-purchasing’s expenditures. Additionally, e-purchasing advances the efficiency of supply chains via quickening purchasing processes, which reduces waste and betters resource usage. Lastly, restricted financial resources of firms yield a non-mediating role of e-purchasing between IoT and supply chain responsiveness.

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الدور الوسيط للشراء الإلكتروني في العلاقة بين تقنية إنترنت الأشياء (IoT) وإستجابة سلسلة التوريد

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تبحث الدراسة في تأثير دمج تقنية إنترنت الأشياء مع الشراء الإلكتروني على تعزيز استجابة سلسلة التوريد بالتطبيق على عينة من الشركات في قطاع صناعة الأغذية في البلدان النامية. وقد تم تطوير أربع فرضيات لتحقيق هذا الهدف، وتم تصميم استبانة لجمع البيانات الأولية ذات الصلة بالدراسة. وباستخدام ألفا كرونباخ، تم تأكيد موثوقية متغيرات الدراسة. وتم استخدام تحليل العوامل للتحقق من بناء المقاييس وصلاحية التمييز. وعلاوة على ذلك، تم استخدام تحليل المربعات الجزئية الصغرى (PLS) لفحص العلاقات داخل النموذج واختبار الفرضيات. وكشفت النتائج عن تأثير إيجابي ذي دلالة إحصائية لتقنية إنترنت الأشياء جنبًا إلى جنب مع الشراء الإلكتروني على استجابة سلسلة التوريد. بالإضافة إلى ذلك، كان لتقنية إنترنت الأشياء تأثير إيجابي ذي دلالة إحصائية على استجابة سلسلة التوريد. وأظهر التحليل أيضًا تأثيرًا إيجابيًا ذي دلالة إحصائية للشراء الإلكتروني على استجابة سلسلة التوريد. وأخيرا توصل الباحث إلى عدم وجود تأثير ذي دلالة إحصائية للشراء الإلكتروني كمتغير وسيط في العلاقة بين تقنية إنترنت الأشياء واستجابة سلسلة التوريد في الشركات محل الدراسة.

وقدمت الدراسة عددًا من التوصيات، من بينها: بناء وتطوير تقنية إنترنت الأشياء (IoT) في المؤسسات الصناعية المصرية، والانتقال من التركيز على مفهوم الشراء التقليدي إلى تبني الأنظمة والأدوات المتقدمة لتطبيق مفهوم الشراء الإلكتروني، بالإضافة إلى دمج واستخدام تقنيات إنترنت الأشياء والشراء الإلكتروني بما يتيح تحسين الاتصال والتنسيق بين الأنظمة في مختلف مراحل سلاسل التوريد.

الكلمات الدالة : انترنت الأشياء، الشراء الالكتروني، استجابة سلسلة التوريد.

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