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The Impact of Implementing Technological Advances in the Supply Chain Activities on Achieving Supply Chain Sustainability: Testing the Moderating Role of Senior Management's strategic flexibility

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Abstract:

Purpose – Sustainability in the field of supply chains is one of the most crucial international issues, especially given the challenges that supply chains face in various parts of the world, as represented by the Russian-Ukrainian war and, before it, the Corona pandemic, in addition to the current global trend toward attention to sustainability in general and sustainable supply chains in particular, as represented by the Climate Conference that was held in the Arab Republic of Egypt in November 2022, Researchers discovered that supply chain technology will greatly aid in achieving sustainability in its three pillars: economic, environmental, and social, with a research gap in previous studies dealing with supply chain technology, particularly its application to businesses. As a result, the current study aims to bridge this gap by investigating the impact of using supply chain technologies on building sustainable supply chains, as well as investigating the moderating impact of senior management's strategic flexibility in strengthening the relationship between the independent variable (supply chain technology) and the dependent variable (sustainable supply chains) by applying to a group of 36 subsidiaries companies of the Food Industries Holding Company. It is worth noting that the Egyptian government-owned Holding Company for Food Industries is a subsidiary of the Ministry of Supply and Internal Trade.

Design/methodology/approach – In this study, the researchers implemented the practical aspect through in-depth interviews with the managers working at the senior management and middle management levels in the organizational structure of the company under study, which are 36 subsidiaries companies of the Holding Company for Food Industries, where a survey was distributed on a number consisting of 385 surveys. There are 327 valid surveys for statistical analysis from the study population, consisting of a set of questions prepared according to the five-point Likert scale for each variable of the study, as well as a set of descriptive questions. The data obtained from the participants were analysed using a structural equation modelling approach.

Findings – The study concluded that there is a positive, significant effect of all dimensions of supply chain technology (IOT, AI, Robotics, self-driving trucks and supply chain security) on the sustainability of supply chains, as well as the same effect on each of the dimensions of sustainability (economic, environmental and social). Furthermore, the statistical analysis confirmed that senior management's strategic flexibility has a significant moderating effect that positively affects the strengthening of the relationship between the variables of the independent and dependent studies. The study gives policymakers critical strategic guidelines for achieving sustainable supply chains while also assisting managers in improving sustainability practices at Egyptian Food Industries Holding Company.

Keywords: Technologies in Supply Chain, Internet of Things (IOT), Artificial Intelligence (AI), Robotics, Self-driving Trucks, Supply Chain Security, Sustainable Supply Chain, Strategic Flexibility, Structural Equation Modelling, Egyptian Food Industries Holding Company.

1. introduction:

As part of Egypt's Vision 2030, the subsidiaries of the Egyptian Holding Company for Food Industries are adopting sustainable supply chain management practices. This strategy is aligned with the 17 Sustainable Development Goals (SDGs) that were established by the United Nations in 2015. It is necessary to strike a balance between sustainable development and economic growth. It is a trade-off between the costs associated with implementing environmental, social, or resilient practices versus the benefits they provide. There is a growing concern about sustainability both internationally and domestically. As a result of its broad nature and application across a wide range of specializations, this topic is considered to be an interdisciplinary topic (Ahi and Searcy, 2013).

A business perspective on sustainability is used in this research to examine sustainability in the supply chain. Furthermore, it discusses how supply chain technology tools can assist in building sustainable supply chains, as well as how senior management can utilize its strategic flexibility philosophy to achieve this goal.

During the last few years, supply chain technologies and digital transformation have emerged as the most significant trends in sustainable logistics and supply chain management. As a result, practitioners face significant challenges, but they also have ample opportunities to gain competitive advantages at various levels. A major development in this regard is the automation of information and physical processes, as it may have a lasting impact on planning and controlling logistics systems at the strategic, tactical, and operational levels (Nitsche, B., 2021; Junge, A.L.; et al, 2019; Kersten, W., 2017). Using these technologies, companies in the supply chain can undergo a digital transformation that will enhance their performance and allow them to remain competitive as well as achieving more sustainability.

It is important to note that there are numerous motivating factors behind process automation, ranging from the desire to reduce costs and enhance productivity to the expectation that individuals within logistics networks will have greater autonomy over their decisions. In modern sustainable supply chain management, automation encompasses both physical flows and informatics; both are equally important, and each has room for improvement. In more detail, Nitsche et al. describe supply chain automation as "the partial or complete replacement of a human-performed physical or informational process by a machine. As part of this, you will be responsible for planning, controlling, and executing both the flow of physical goods within your firm as well as the flow of corresponding financial and informational information within your supply chain partners".

Similarly, to the rapid development of digital technologies in supply chain industries, sustainable performance has emerged as a critical goal for business survival and growth in the future from economic, social, and environmental perspectives (Kamble et al., 2020b). Sustainable Supply Chain Management (SSCM) is defined as "The voluntary integration of economic, environmental, and social considerations into coordinated supply chains based on key inter-organizational business systems for the efficient and effective management of material, information, and capital flows during procurement, production, and distribution for the purpose of meeting stakeholder requirements and improving the organization's profitability, competitiveness, and resilience in the short and long term" (A. Rajeev et al., 2017).

2- research problem:

Management practices must be implemented in the context of the supply chain that enhance the company's overall performance and supply chain, while also addressing social, economic, and environmental concerns (Alzaman, 2014; Amin and Zhang, 2014; Beske, 2012). Consequently, Supply Chain Management (SCM) should also focus on sustainability. Therefore, the problem with this study is how supply chain technology tools can be used to achieve sustainability in the supply chains of subsidiaries of the Egyptian Holding Company for Food Industries. Hence, the following questions can summarize the study's main problem:

1- What are the most significant and recent supply chain technologies?

2- What are the dimensions of a sustainable supply chain?

3- How does implementing supply chain technologies impact the sustainability of the supply chains of companies affiliated with the Egyptian Holding Company for Food Industries?

4- What's the moderating role of strategic inflexibility on the relationship between supply chain technologies and sustainable supply chain subsidiaries of Egyptian Holding Company for Food Industries?

2- Literature Review:

By reviewing former studies and conducting in-depth interviews with supply chain professionals, especially in the food industry, the experimenters set up that the following tools for supply chain technology have the topmost impact on supply chain sustainability Internet of Things (IOT), Artificial Intelligence, self-driving trucks as well as robots and supply chain security. thus, the study model was erected on these rudiments, and the management's strategic flexibility was used as a moderated variable to increase the effectiveness and efficiency of the model from a directorial and academic viewpoint. This section will cover previous studies of study variables.

2.1 Internet of Things (IOT)

Internet of Things (IOT) refers to a network that connects physical objects to online devices to provide location, identification, and control services. Currently, the Internet of Things is a significant component of supply chain management. The Internet of Things (IOT) was spotlighted by academic researchers, however. In developing nations, there was a clear gap in exploring and investigating its impacts on supply chain sustainability.

By connecting machines, products, individuals, and supply chain managers through the Internet of Things, Internet of Things (IOT) opens up a whole new world for supply chain practitioners (Li, B. and Li, Y., 2017; Banker, 2014 and DeGroote et al., 2013). In contrast to traditional technology, the Internet of Things allows the supply chain to be tracked with complete information (Zhou and Piramuthu, 2015). Additionally, it encourages process integration and information sharing, which increase the sustainability of the supply chain activites and promote more efficient and effective supply chain management (Li, B. and Li, Y., 2017: Abubaker ,et al 2017). Several advantages of Internet of Things (IOT) implementation in supply chain management are presented by Evtokdieva et al. (2020), including predictive analytics for demand forecasting, warehouse automation, and cost reductions. By taking the place of humans in the procurement processes, chatbots will lower transaction costs and shorten the time it takes for a sale to close. Using "Location Tracking" and the monitoring of sensitive commodities, intelligent transportation systems are able to keep an eye on and proactive control the flow of incoming and internal goods and materials (Barbara et al., 2022: Delgosha et al., 2021). Despite the many benefits of the Internet of Things, 47% of the respondents' sample acknowledged that the subsidiaries of the Holding Company for Food Industries are not interested in using Internet of Things (IOT) solutions for supply chain management, which has a detrimental effect on the sustainability of their supply chains.

With the wide variety of sensors available today, there are virtually no limits to what IOT can do in the food industry. Furthermore, a much wider range of software solutions are available for analyzing data. IOT installation makes it possible to manage the food supply chain more effectively at all points, from raw materials in the production to product distribution to clients and consumers. Furthermore, it facilitates data collection, enabling food firms to ensure high levels of traceability and safety throughout the supply chain. By doing so, we can reduce waste, costs, and even safety hazards which lead to more sustainability (Shashank, 2022).

2.2 Artificial intelligence (AI):

Making intelligent devices that function and respond like people is known as artificial intelligence (AI). The goal is to train machines to think critically, much like people do. The machines have followed instructions up to this point. However, artificial intelligence (AI) will enable machines to think and act like people. The food processing sector is using Artificial Intelligence (AI) to improve a variety of offerings, streamline processes, and improve consumer experiences and sustainable development fundamentals (Louise Manning et al.,2022; Mkrttchian, 2021; Cambra Baseca, Sendra, Lloret, & Tomas, 2019; Koksal & Tekinerdogan, 2019).

The growth of Supply Chain Management (SCM) is greatly enhanced by Artificial Intelligence (AI). The ability to make strategic, tactical, and operational decisions is one of the most powerful functions of artificial intelligence (Fakhreddin F. Rad et al,2022; Louise Manning et al.,2022). The most typical applications of artificial intelligence (AI) are at operational levels, such as forecasting, production, and warehouse operations. Artificial

Intelligence (AI) can boost Supply Chain Management (SCM) sustainability creation by achieving nearly accurate forecasts and reducing production costs (Mkrttchian, 2021). With the help of sophisticated tools, corporations can meet customer expectations, but as marketplaces get more competitive, they constantly need to think about their next move. Artificial intelligence technology's goal is to solve problems and fill in gaps that humans have created (Prakash, Rakesh, 2021). Artificial Intelligence (AI) is used to enhance the functionality of the supply chain. However, fewer than a small percentage of all possible AI approaches and algorithms are investigated and applied to SC processes (Youssra Riahi , Tarik Saikouk et al., 2021). Thanks to AI, systems can now automatically complete tasks and make creative decisions. Artificial intelligence (AI) and machine learning are being used by businesses to gain sustainability insight into supply chain management, logistics, and warehouse operations (Muhammad, Sulaiman et al ,2022; Kleineidam, J. 2020).

With artificial intelligence (AI), various foods can be processed by robotics or machines in the food industry. While the technology offers several advantages to the food industry, the prohibitive cost of deployment limits the market's expansion. The food industry has difficulties since the feedstock is rarely homogeneous. Food storage is typically carried out with the aid of manual labour. But with AI, this sorting process can be automated, which will ultimately save labour costs, speed up production, and increase yields (Antony, A., & Sivraj, P.; 2018).

This sector, for the most part, is a very high volume, low profit industry. Finding effective strategies to boost efficiency even slightly can mean the difference between a facility making a profit or a loss. Due to these functional limitations, many food processing companies are now using AI technology in order to improve the many components of their processes. This is fostering the expansion of AI in the local food and beverage industry (Khoroshailo, T. A., & Kozub, Y. A. ;2020). Despite the significance of AI, according to the survey's results, 77% of participants said that the Holding Company for Food Industries did not deploy AI technology in its supply chain.

All food businesses can gain from lower operational expenses, fewer risks and more sustainable activities. In this field, machine learning and AI tools hold significant potential for everything from visual inspections to monitoring crucial production machinery. Image recognition software can significantly lower the possibility of a reputation-damaging error in product quality or even a costly recall due to incorrect packaging (Kleineidam, J. ;2020).

2.3 Robotics

A large number of industries have adopted robots as part of their everyday operations. Over the past few years, the number of robots ordered and shipped has increased dramatically. Furthermore, many different varieties of robots have been developed for use in industries such as metal, electronics, and automobiles (Kurdiet et al., 2020). Although these are not the only types of robots developed, they are among the most common. Robots are available in many sizes, shapes, and styles and are used for a wide variety of purposes worldwide (Sullivan, M.; Simpson, W.; Li, W.,2021). Furthermore, robots and autonomous machines have ushered in a new age of technology. Future and sustainable business environments will be characterized by a wide variety of intelligent systems and autonomous robots (Mohamed Shamou et al., 2022).

The development of robots has progressed from automated systems with a single purpose to intelligent systems with multiple functions (Savela et al., 2018). In its simplest form, an autonomous robot is an intelligent machine that can perform specified tasks independently (e.g., without the influence or control of humans). As a result of technological advancements in recent years, people have become increasingly familiar with the role of robots in their daily routines (Gnambs & Appel., 2019). There has been concern expressed about the impact that autonomous robotics will have on the workforce and the employment situation by critics of the technology. In contrast, A Kurdiet al., 2020 argue that such systems will improve people's activities and well-being, and also provide businesses with a source of sustainable economic growth. Despite weighing the pros and cons of adopting autonomous robots in terms of technological, organizational, and environmental impacts, firms are uncertain about the value of adopting robots (Mohamed Shamou et al., 2022, Savela et al., 2018).

The use of automation in food manufacturing and processing has become more prevalent than traditional methods due to the cost-effectiveness of these solutions. Since manual labor is considered a traditional concept nowadays, more emphasis is being placed on robotized handling and manufacturing. A few examples include picking, placing, packaging, and palletizing. German researchers reported that the last two applications are the most commonly used (Jamshed et al., 2017; Buckenhüskes & Dppenhäuser, 2014). As part of the development of (International Association for Vegetation science) IAVs, business logic is improved and a higher level of technical capability is achieved. The use of IAVs has been found to be beneficial in many economic sectors, including management of production lines, inventory management in warehouses, and logistics support (Tsolakis, N., Bechtsis, D., 2017). Even though IAVs are popular, promoting digital transformation through their integration into the supply chain poses significant technical and financial challenges. Consequently, software simulation can be used to assess the operational efficiency and sustainability of IAVs (M.O.Okwu et al., 2020). In this manner, supply chain actors will be able to make projections and take appropriate actions as a result. Unfortunately, 84% of the sample confirmed that the subsidiary companies of the Holding Company for Food Industries lack the capability to apply robotics technology. In contrast, 90% of respondents emphasized that the application of robotics in supply chains will greatly aid in achieving dimensions of economic, environmental, and social sustainability. This technology helps reduce carbon emissions and production costs while reducing the percentage of resources wasted and save the society welfare which lead to more social sustainability.

2.4 Self-driving trucks

Founded on the concept of mobile entities made up of hardware and software applications, autonomous vehicles aggregate data in order to provide visibility, operational planning, and decision-making downstream of the sustainable supply chain (Christian V. et al,2020). In addition to providing sufficient computational processing power, such vehicles are typically equipped with the capability of handling operational tasks and optimizing daily supply chain activities (Bechtsis, D. and Tsolakis, N. 2018). For the transportation industry, the introduction of self-driving vehicles is expected to be a game changer and 90% of long-haul trucking may soon be self-driving. It is anticipated that the freight and supply chain industries, in particular, will undergo significant changes if newly developed technology is widely adopted. Globally, transportation contributes 14% to greenhouse gas emissions. 75% of these emissions are attributed to road transport. In addition, while road freight transportation occupies only 4% of the on-road fleet, CO2 emissions from road transport account for 30% of global emissions (M.O. Okwu et al., 2020). Consequently, in order to improve transportation efficiency, supply chain management initiatives should focus on the use of technologies. In this way, the carbon footprint of the industry will be reduced. As a result of computer-assisted driving, a reduction in carbon footprint will be achieved when fuel consumption is improved and emissions caused by inefficient human driving are eliminated (Maurer, Gerdes, Lenz & Winner, 2016). It has become increasingly imperative for supply chain actors to reduce the carbon footprint of their supply chains in light of governments committing to CO2 emission reduction targets and many EU states advocating tougher fuel efficiency standards (Rosenzweig & Bartl, 2015). In this context Self-driving trucks can also bring sustainable safety benefits, as every year hundreds of thousands of trucks are involved in accidents, resulting in thousands of deaths and injuries. Also, this type of vehicle does not get tired and therefore can travel at the least crowded times of the day. They will have data from advanced sensors and technologies on board that can warn them of road problems in a timely manner, which helps to achieve sustainability in transportation operations (Christian V. et al,2020). According to the sample, 100% of respondents confirmed that companies affiliated with the Holding Company for Food Industries do not have self-driving trucks, and 87% of respondents stated that self-driving trucks would make logistics services more sustainable by reducing accidents, noise, and greenhouse gas emissions.

2.5 Supply chain security

Considering that Supply Chain Security Management [SCSM] is a relatively unexplored field within Operations Management Research, there are very few introductory and tutorial papers available (Mona Jazinaninejad et al., 2022). In recent years, global sustainable supply chains have experienced increased security concerns, leading to the development of additional security initiatives, standards, and protocols. It has become an integral part of the supply chain management process to implement these initiatives. Additionally, 69% of respondents agree that Egyptian Holding Company for Food Industries is interested in implementing Supply Chain Security Management in all activities of its supply chain in order to enhance sustainability.

Globalization has introduced new challenges to supply chain security (SCS) management through the increase in international production, sourcing, marketing, and trading activities. There are a number of security risks associated with production facilities and logistics processes, in particular (Su et al., 2021). SCS incidents around the world have included terrorist attacks, prohibited weapon imports, and drug smuggling. There is a significant impact on public safety, national security, as well as economic prosperity as a result of these incidents. As a result of supply chain security incidents, supply chain partners have suffered economic losses as well as productivity losses (Xun et al., 2022; Lu et al., 2017; Tang 2006).

Despite the prominence of SCS in the literature, few formal definitions can be found. The following definition is appropriate for this study (Alizera, 2009; Closs and McGarrell, 2004): "The process of securing supply chain assets including products, facilities, equipment, and information from theft, destruction, or terrorism, as well as preventing unauthorized contraband, personnel, or weapons of mass destruction from entering the supply chain". According to the previous definition, supply chain security can be viewed from two perspectives: a soft and a rigid perspective(Arup Roy ,2012). A difficult aspect of security is the theft of physical assets (facilities, equipment, and personnel) or damage to property. "Soft aspects" refer to intangible vulnerabilities, which in the previous definition are defined as information theft.

As a result of these concerns, international organizations, nations, industry associations, and companies have adopted legislation and established international, national, industry, and company standards (Arup Roy ,2012) also many of the principles of supply chain and logistical solutions applied today have been developed in an era when sustainability, safety and security were not essential determinants and therefore increased attention in particular to the determinants of safety in supply chains in various industries to ensure sustainability in all its elements and achieve the principles of sustainable development at the level of global supply chains (Su et al., 2021). A relevant example is the ISO 28000 standard, which was introduced by the International Organization for Standardization (ISO) (Xenophon & Guanyi; 2017).

There is a fundamental relevance of supply chain security to the food industry since the products traded are consumed by people, posing a significant threat to a person's life and well-being (Judith et al., 2009). Various practices are employed to reduce the risk of foodborne illness in food security management. The issue of food safety is a concern beyond intentional acts such as terrorism or adulteration of products. The consequences of these worries, however, are equally devastating. Food handling protocols and standard operating procedures, for example, must be followed to prevent illness and possibly death, which threatens the very existence of the organization (Xenophon & Guanyi; 2017).

2.6 Supply chain sustainability:

Climate change issues have been addressed in the last few decades by moving towards sustainable development. It is essential for businesses to promote sustainability by developing efficient strategies towards the transition from fossil-fuel consumption to the use of renewable resources (Mona Jazinaninejad et al., 2022; Sansaniwal et al., 2017). It is defined as the integration of economic, environmental, and social considerations into key interorganizational business systems in order to meet stakeholder requirements and improve profitability, competitiveness, and resilience over time, organizations must be able to effectively manage materials, information, and capital flows associated with procurement, production, and distribution" (Ernesto Mastrocinque et al., 2022; Ahi and Searcy, 2013). It is critical to emphasize sustainability in terms of its environmental, social, and economic dimensions, since the impact of community activities on resource depletion, contamination intensification, waste management, and energy consumption can be evaluated through the environmental dimension. As for the social aspect, it shows where active units within society are putting their energy into resolving issues related to poverty, unemployment, income inequalities, education, and workforce health. The concept of economic sustainability describes community efforts to improve economic conditions and achieve financial goals (Negar and Seyed, 2020; Jayanti, 2020).

The use of technology in supply chains can positively influence sustainability triple bottom lines, for example by removing environmentally harmful and low-quality products from shelves (Satya et al., 2019; Mello et al., 2017). As an example, autonomous transportation affects logistics in three ways. Their economic impacts come from reducing various types of costs, their environmental impacts come from reducing industrial pollution to the environment, and their social impacts come from ensuring that workers are safer and healthier at work (Zulfiquar N. Ansari, et al.2017; Bechtsis et al., 2016).

In the food supply chain, sustainability is a growing concept (Genovese et al. 2017). It involves a variety of initiatives, such as reducing food waste by modifying consumer behavior, implementing proactive strategies to enhance sustainability, strengthening national food safety control systems and improving the food system to increase farmers' income (Zhu et al. 2018; Glover et al. 2014).

2.6.1 Environmental aspects:

Over the past few decades, companies have been striving to improve their environmental performance. The supply chain has been an integral part of this effort (Andrea, 2013). There has been a major focus on the environmental aspects of supply chain management over the past two decades. Environmental sustainability is a critical component of the triple bottom line, and it has recently been prominently featured in the news due to the effects of climate change and rising energy prices. The terms "environment" and "sustainable development" have been used interchangeably by researchers and managers to a certain extent. During the early days of sustainability, this misunderstanding was particularly prevalent. When a brand-new paradigm is introduced, this is a common occurrence. As viewpoints have begun to converge, we are now seeing a more uniform understanding of sustainability and its application under the triple bottom line (Craig and Liane, 2011). In many countries, organizations are required to meet specific environmental impact thresholds, such as the release of toxic chemicals (Ahi and Searcy, 2015). Measures related to reducing or avoiding hazardous/harmful/toxic materials are commonly used. The second most commonly cited metric is water consumption, followed by energy consumption, recycled materials, life cycle analyses, and environmental penalties. The literature has frequently cited measures related to energy efficiency, air emissions, and greenhouse gas emissions (Mastos and Gotzamani,2022).

This study focuses on the food supply chain due to its significant environmental impacts. According to Beamon (2008), there has been limited research conducted on the food processing industry as a result of the complexity of the supply chain and the absence of adequate research on issues such as waste, resource re-use, and greenhouse gas emissions (Andrea et al., 2017).

2.6.2 Social aspects:

Sustainability in social terms essentially refers to how businesses take care of the health, safety, and well-being of their workforce, which is closely related to their supply chains (Ahmadi et al., 2017; Mani et al., 2020). There are several commonly identified social performance measures in the literature, including product safety, accident rate, training rate, health and safety, employee contributions, benefits, loyalty, turnover rate, corporate image, screening of human rights (suppliers and contractors), and community involvement. (Tajbakhsh and Hassini,2015; Reefke and Trocchi,2013; Erol et al., 2011). As part of the social aspect of sustainability, production type and method are aligned with social needs both within and outside the organization (Büyüközkan and Berkol, 2011).

Food supply chains (FSC) commonly investigate and measure social sustainability (Malak et al., 2019). When food systems are viewed as food supply chains, each stage, defined as a process by which a food product is transformed, is examined in relation to the stakeholders involved (Hong et al., 2018). Different actors are involved in the Food Supply Chain, as they add value to the process of producing, aggregating, processing, distributing, consuming, and disposing of food products harvested from agriculture, forestry, and fisheries. In addition to interacting and influencing each other, FSC stakeholders also have an impact on the natural, economic, and social environments in which they operate (E. Desiderio et al., 2022).

2.6.3 Economic aspects

The economic performance of a business is the most critical factor that must be improved. A company's success is measured by how well it achieves its financial objectives. Economic performance can be measured using a variety of indicators, including productivity, delivery time, product quality, sales and market share, customer loyalty, flexibility, profit rate, and investment yield (Mastos and Gotzamani, 2022; Santiteerakul et al., 2015). It is possible for economic incentives to be hidden behind a variety of environmental and social measures, particularly in the economic dimension (Ahi and Searcy, 2015). Using environmentally friendly materials, for example, may result in higher procurement costs (Beske et al., 2015). The most frequently cited indicator of economic performance is quality. Quality measures can be defined as the quality of the goods supplied by suppliers or the quality of the production process (Rao and Holt, 2005). Sales, market share, and profit are the second most common measures, followed by delivery time and customer satisfaction (Mastos and Gotzamani, 2022).

2.7 Strategic flexibility:

The inflexibility of supply chain strategies adopted by organizations is the cause of many supply chain failures. Although there is substantial research that indicates that strategic flexibility is positively associated with supply chain performance. An organization's flexibility refers to its ability to monitor and adapt to changes in the work environment in all aspects which lead to more sustainability in supply chain activities (Tong Kooi, Teo.2020; Durrah, et al. 2016).

In order to maintain strategic flexibility, an organization must be able to respond to opportunities and threats in a manner that is in keeping with the market's reaction speed and reaction tactics (Grewal & Tansuhaj, 2001). In addition, Reyesil et al., (2015) defined strategic flexibility as the ability to adjust tactical capabilities in accordance with an organization's strategy; in other words, how would the company be able to adjust its market share, adapt quickly to market trends and variables, and deal with other crises dynamically in order to focus on its strategic goals? (Jubouri and Baghdadi, 2015). The statistical findings indicated that strategic flexibility played an instrumental and positive role in Egyptian Food

Industries Holding Company achieving supply chain sustainability and effective supply chain implementation.

Resources and capabilities flexibility refers to the ability of an organization to manage its material and human resources effectively to meet customer requirements and to cope with environmental, economic and social changes (Zeebar and Siron,2017). In order to achieve long-term supply chain sustainability, organizations should use a variety of administrative systems that allow them to allocate and use material resources efficiently and optimally (Wheelen et al,2014).

Operational flexibility also refers to an organization's ability to expand without incurring an unacceptable increase in quality or costs, and a feature of operational flexibility includes the organization's ability to control the size, quality, and technology of operating energy in the organization in response to changes in customer desires and needs, as well as the ability to manage costs. So using this lean production strategy in such a way that this expansion does not result in an increase in costs that jeopardizes its competitive position, enhance its corporate social responsibility and allow organizations to remain sustainable (Renton and Richard, 2019: Yu 2012, Li et al 2011).

3- Hypotheses Development and Conceptual Framework

There are a number of studies, as can be seen from the reviewed articles, that examine the relationship between SC activities and environmental sustainability practices. Other studies have investigated the impact of SC practices on a firm's financial sustainability. However, only a few studies have explored the link between environmental sustainability and a firm's financial performance. As far as the authors are aware, there has been no study that has analyzed the relationship between supply chain technologies, management strategic flexibility, and sustainable supply chains. In order to fill this gap in the literature, the following conceptual framework has been developed (Figure 1).

H1: there is a positive significant impact of implementing technologies in supply chain on achieving supply chain sustainability (Environmental, Economic and Social).

H2: Management Strategic flexibility moderates the relationship between implementing technologies in supply chain and achieving supply chain sustainability, such that the relationship is stronger when Management Strategic flexibility is high.

H3: there is a positive significant impact of implementing IOT tools on achieving economic sustainability.

H4: there is a positive significant impact of implementing IOT tools on achieving environmental sustainability.

H5: there is a positive significant impact of implementing IOT tools on achieving social sustainability.

H6: there is a positive significant impact of implementing AI tools on achieving economic sustainability.

H7: there is a positive significant impact of implementing AI tools on environmental sustainability.

H8: there is a positive significant impact of implementing AI tools on achieving social sustainability.

H9: there is a positive significant impact of implementing Robotics on achieving economic sustainability.

H10: there is a positive significant impact of implementing Robotics on achieving environmental sustainability.

H11: there is a positive significant impact of implementing Robotics on achieving social sustainability.

H12: there is a positive significant impact of implementing Self driving trucks on achieving economic sustainability.

H13: there is a positive significant impact of implementing Self driving trucks on achieving environmental sustainability.

H14: there is a positive significant impact of implementing Self driving trucks on achieving social sustainability.

H15: there is a positive significant impact of implementing Supply Chain Security on achieving economic sustainability.

H16: there is a positive significant impact of implementing Supply Chain Security on achieving environmental sustainability.

H17: there is a positive significant impact of implementing Supply Chain Security on achieving social sustainability.

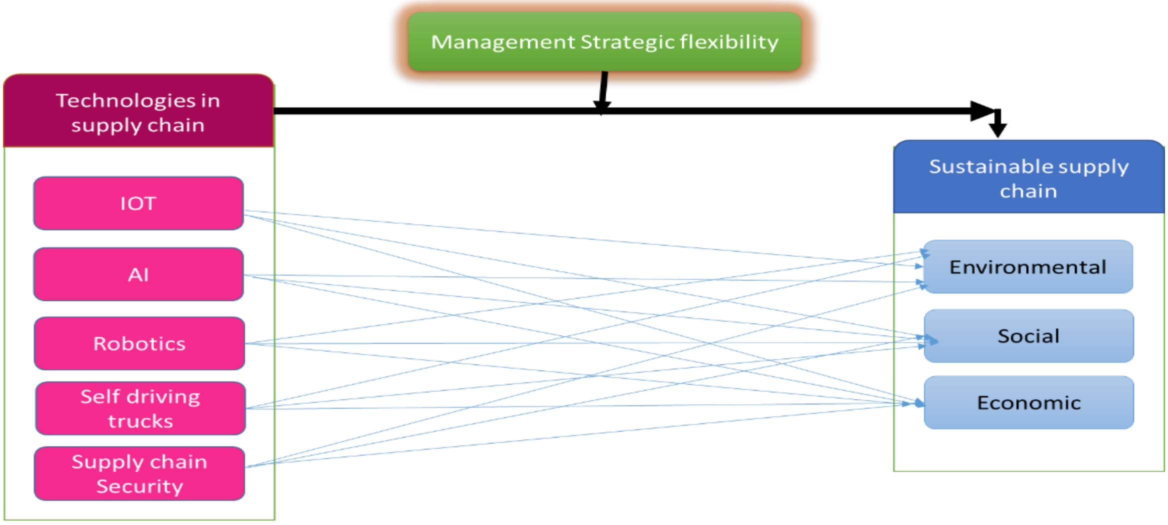

Figure 1: Conceptual Framework (Main Hypotheses)

4- Research Methodology

The current study is primarily based on the observational descriptive design, which entails librarian surveying concerning previous research to construct a theoretical foundation for the proposed research, as well as descriptive research strategies and a field survey framework for data collection using a scientific questionnaire.

4.1 Data Collection and Sample

The questionnaire method was used in this study to obtain data for model testing using the post-positive perspective. As a result, non-probability sampling, specifically the purposive sample approach, was used in this investigation. To include the purposive sample technique into the data collection procedure, the study was confined to the managers working at the senior management and middle management levels in the organizational structure of the company under study, which are 36 companies affiliated with the Holding Company for Food Industries. The sampling approach was selected for gathering data for the employees' field study because of the enormous size of the employee's base, the timing, and cost factors that all operate as research restrictions. Following the act of big numbers, the sample size was tested and calculated (385 participants), assuming a confidence level of 95% and a margin of error of 5% (Sekaran, U.; Bougie, R.,2016)

A questioner was used to collect data, and a Likert scale of five points ranging from strongly disagree (1) to strongly agree (5) was used to analyse every attitude item. We received 323 replies, with 380 being selected for further analysis., the data gathering lasted about twelve months (from December 2021 to November 2022). The statistical package for social sciences (SPSS) and the smart partial least squares (Smart-PLS) software version 3.2.7 were used to conduct the data analysis.

4.2 Measures:

The Partial Least Squares (PLS) technique was used to examine this research model, which was done with the Smart-PLS 3.2.7 program (Ringle, Wende, & Becker, 2015). Reflective constructions (Anderson & Gerbing, 1988; Ramayah, Lee, & In, 2011) advocated a two-step analytical technique, which was followed by the current study. As a result, a measurement modelling test for validity and reliability of the constructs was done, proceeded by a structural model inquiry (i.e., testing of hypotheses) (Ramayah, Jasmine, Ahmad, Halim, & Rahman, 2017). To test the relevance of the path coefficients and the loadings, a bootstrapping method was used (Hair et al., 2017).

As indicated in Table (1), some prior studies are considered to acquire the measurements of included variables and the items' number. The study involved three sorts of variables; Supply chain technologies, as the independent variable, Sustainable supply chain as the dependent variable, and Strategic flexibility as the moderating variable. The questions were developed and revised using literature as a guide, and the replies were scored on a Likert scale of five points.

Table 1: The measures used in the study

Variable	Number of items	Reference
Supply chain technologies	**31**	(Barbara et al., 2022: Xun et al.,2022; Youssra Riahi , Tarik Saikouk et al., 2021: Sullivan, M.; Simpson,W.; Li,W.,2021: M.O.Okwu et al., 2020)
Sustainable supply chain	**16**	(Mona Jazinaninejad et al., 2022 ; Negar and Seyed, 2020; Jayanti and Gowda, 2014)
Strategic flexibility	**7**	(Tong Kooi, Teo.2020; Zeebar and Siron,2017:Wheelen et al,2014)

5- Statistical Data Analysis

The study hypotheses were examined using the SmartPLS 3.2.7 software and the partial least squares structural equation modeling (PLS-SEM) technique. PLS-SEM is effective for measuring the strength of structural and complicated relationships between model constructs, determining the interaction impact of moderating variables, and assessing the theoretical validity of variable relationships (Chin et al., 2003). Common method bias (CMB) was detected through Harman's single-factor test; the percentage of the factor's explained variance was below the threshold of 50% (MacKenzie and Podsakoff, 2012). The results of the normality statistics show that the values of Skewness and kurtosis for all the constructs of the model were within the range of ±2, therefore the variables were normally distributed (Trochim & Donnelly, 2006; Gravetter & Wallnau, 2014).

5.1 Assessing the Measurement Model

To establish the validity of the model's constructs, the measurement model was evaluated for reflective and latent variables (see figure 2). Factor loadings, Cronbach's Alpha, Joreskog rho (rho_A), composite reliability (CR), average variance extracted (AVE), and discriminant validity were used to assess construct validity (Hair & Lukas, 2014).

Table 2: Measurement model assessment

Construct	*Item*	*Loading*	*Cronbach's Alpha*	*rho_A*	*CR*	*AVE*
IOT	IOT1	0.832	0.93	0.932	0.943	0.673
	IOT2	0.801				
	IOT3	0.869				
	IOT4	0.828				
	IOT5	0.813				
	IOT6	0.812				
	IOT7	0.813				
	IOT8	0.792				
AI	AI1	0.766	0.881	0.884	0.91	0.629
	AI2	0.803				
	AI3	0.864				
	AI4	0.708				
	AI5	0.799				
	AI6	0.81				

Robotics	ROB1	0.921	0.906	0.91	0.931	0.729
	ROB2	0.886				
	ROB3	0.81				
	ROB4	0.853				
	ROB5	0.792				
Self-driving trucks	SDT1	0.863	0.825	0.875	0.873	0.549
	SDT2	0.872				
	SDT3	0.837				
	SDT4	0.79				
	SDT5	0.421				
	SDT6	0.536				
Supply chain security	SCS1	0.674	0.785	0.783	0.853	0.538
	SCS2	0.755				
	SCS3	0.786				
	SCS4	0.751				
	SCS5	0.696				
Strategic Flexibility	SF1	0.76	0.872	0.877	0.903	0.577
	SF2	0.767				
	SF3	0.863				
	SF4	0.738				
	SF5	0.765				
	SF6	0.511				
	SF7	0.858				
Environmental	ENV1	0.641	0.841	0.854	0.882	0.557
	ENV2	0.668				
	ENV3	0.761				
	ENV4	0.784				
	ENV5	0.79				
	ENV6	0.816				
Social	SOC1	0.601	0.86	0.882	0.9	0.647
	SOC2	0.835				
	SOC3	0.87				
	SOC4	0.873				
	SOC5	0.81				
Economic	ECO1	0.84	0.918	0.919	0.939	0.754
	ECO2	0.85				
	ECO3	0.915				
	ECO4	0.877				
	ECO5	0.858				

Table 2 displays indicators' loadings, as well as the constructs Cronbach's Alpha, rho_A, CR and AVE. All values of outer loading were above 0.4 (Hair et al., 2017), therefore no items were removed from the model. The table also shows that Cronbach's Alpha, rho_A, and CR values were above the requirement (0.70) proposed by Hair et al. (2017). The convergent validity of reflective measurement models is also measured through AVE values that should be above 0.5; therefore, the convergent validity in table (2) is established. Table (3) shows the results of discriminant analysis through HTMT values. The HTMT approach is "the ratio of the between-trait correlations to the within-traits correlations". HTMT values should be lower than 1 (Gaskin et al., 2018). Following these guides, the discriminant validity is established.

Table 3: Discriminant validity

Construct	***AI***	***Economic***	***Environmental***	***IOT***	***Robotics***	***Self-driving trucks***	***Social***	***Strategic Flexibility***
Economic	0.532							
Environmental	0.655	0.841						
IOT	0.897	0.495	0.598					
Robotics	0.848	0.597	0.624	0.805				
Self-driving trucks	0.817	0.753	0.853	0.848	0.919			
Social	0.586	0.802	0.934	0.462	0.597	0.705		
Strategic Flexibility	0.74	0.731	0.712	0.617	0.596	0.581	0.789	
Supply chain security	0.475	0.588	0.843	0.352	0.37	0.613	0.708	0.467

5.2 Assessing the Structural Model

Examining the structural model includes path coefficients, collinearity diagnostics, coefficient of determination (R^2), effect size (f^2), predictive relevance (Q^2), and goodness of fit criteria. The interaction impact was then examined as part of the moderation analysis. Prior to analyzing the structural model, the collinearity between constructs was examined using variance inflation factors (VIF), and found that all values were less than the threshold of 5 (Hair et al., 2017).

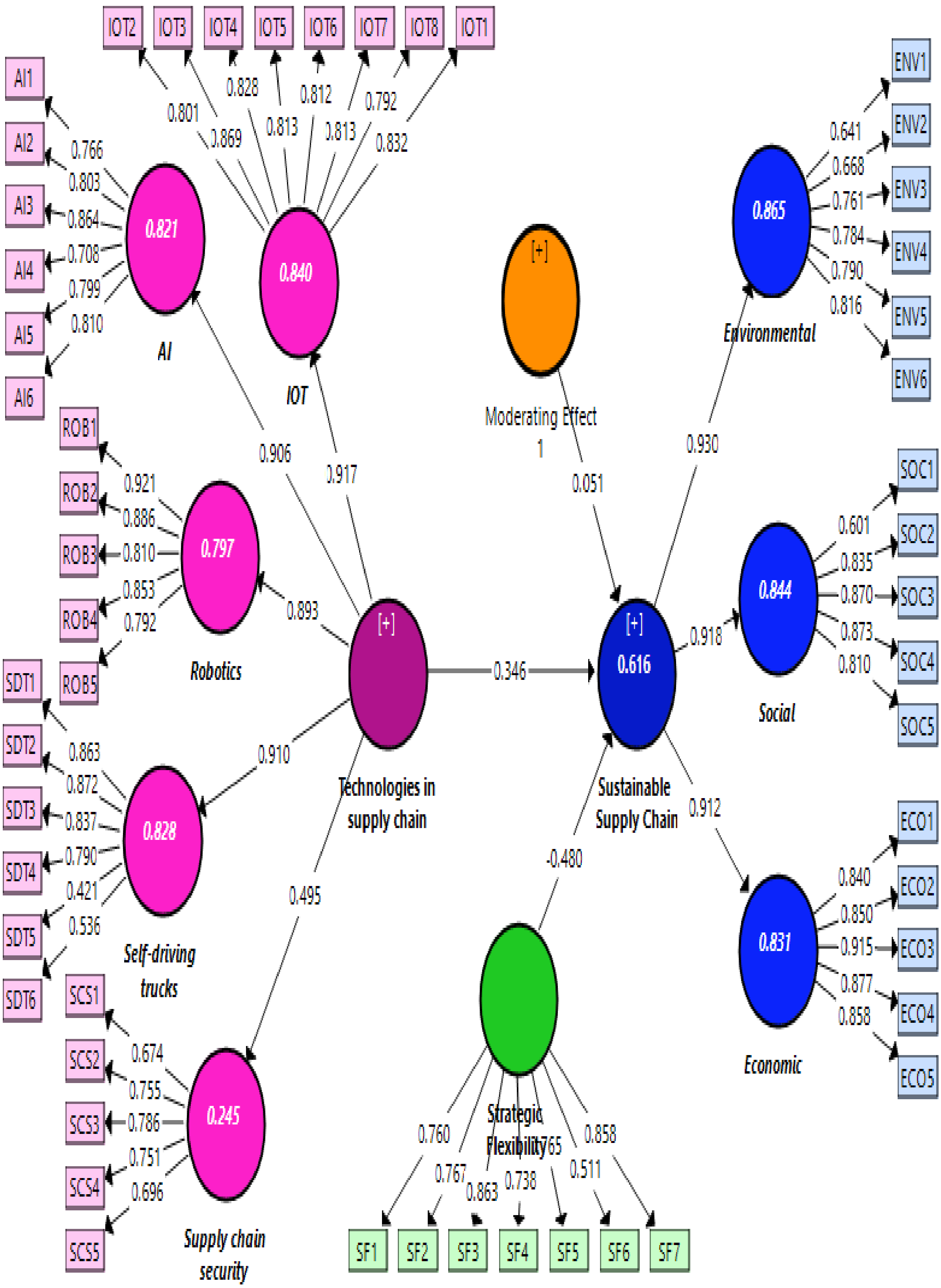

Figure 2: Measurement Model Assessment (Factor Loading)

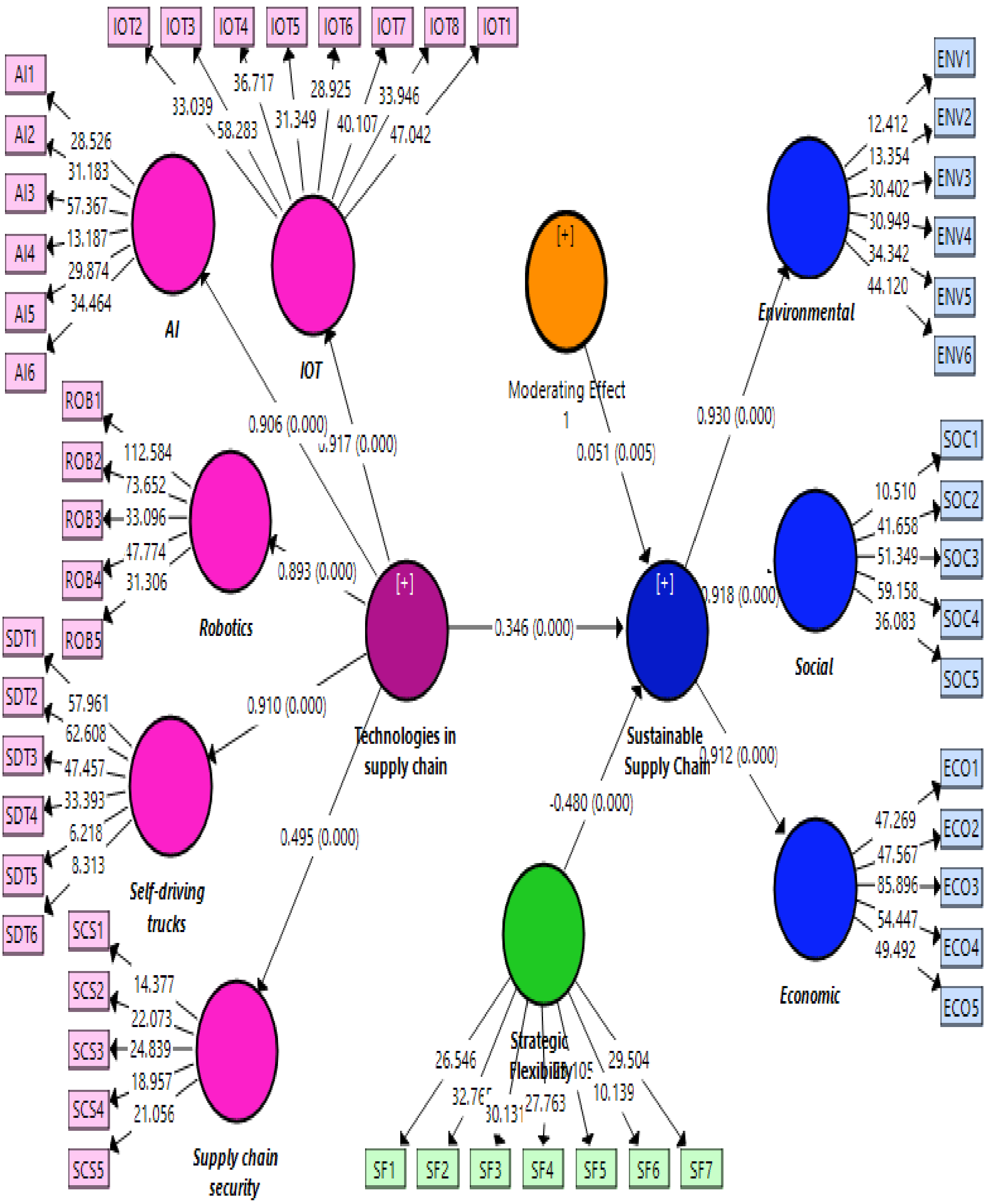

Figure 3: Structural Model Assessment (Main Hypotheses)

Table 4: Results of structural model assessment

Path	*B*	*t-value*	*P-value*	*95% Bis Corrected CI*		*R Square*	*R Square Adjusted*	*Effect Size*	*Remark*
				LB	*UB*				
Main Hypotheses									
H1: *Technologies in supply chain -> Sustainable Supply Chain*	0.346	6.39	0***	0.231	0.441	0.616 b	0.612	0.169b	Supported
H2: *Moderating Effect 1 -> Sustainable Supply Chain*	0.051	2.85	0.005**	0.017	0.086				Supported
Sub-Hypotheses									
H3: *IOT -> Economic*	0.466	9.096	0.000***	0.36	0.555	0.217 b	0.215	0.278b	Supported
H4: *IOT -> Environmental*	0.552	10.819	0.000***	0.443	0.645	0.305 b	0.302	0.438c	Supported
H5: *IOT -> Social*	0.48	11.251	0.000***	0.394	0.56	0.231 b	0.228	0.3b	Supported
H6: *AI -> Economic*	0.483	8.571	0.000***	0.359	0.582	0.233 b	0.231	0.304b	Supported
H7: *AI -> Environmental*	0.574	10.14	0.000***	0.452	0.674	0.329 b	0.327	0.491c	Supported
H8: *AI -> Social*	0.556	11.052	0.000***	0.448	0.646	0.31 b	0.308	0.449c	Supported
H9: *Robotics -> Economic*	0.559	11.873	0.000***	0.46	0.648	0.313 b	0.311	0.455c	Supported
H10: *Robotics -> Environmental*	0.574	12.845	0.000***	0.476	0.652	0.329 b	0.327	0.491c	Supported
H11: *Robotics -> Social*	0.578	13.512	0.000***	0.487	0.655	0.334 b	0.332	0.501c	Supported
H12: *Self-driving trucks -> Economic*	0.682	19.58	0.000***	0.601	0.742	0.465 b	0.464	0.871c	Supported
H13: *Self-driving trucks -> Environmental*	0.741	24.233	0.000***	0.669	0.793	0.549 b	0.547	1.216c	Supported
H14: *Self-driving trucks -> Social*	0.65	17.307	0.000***	0.56	0.713	0.422 b	0.421	0.731c	Supported
H15: *Supply chain Security -> Economic*	0.5	9.331	0.000***	0.387	0.599	0.25 a	0.247	0.333b	Supported
H16: *Supply chain Security -> Environmental*	0.73	27.106	0.000***	0.664	0.776	0.533 b	0.532	1.143c	Supported
H17: *Supply chain Security -> Social*	0.59	11.168	0.000***	0.473	0.681	0.348 b	0.346	0.533c	Supported

**P < 0.001, ***P < 0.001; LB= Lower Bound, UB=Upper Bound, CI= Confidence Interval. f^2 thresholds: a > 0.02 (weak effect); b > 0.15 (moderate effect); c > 0.35 (strong effect); R^2 thresholds: a > 0.19 (weak), b > 0.33 (moderate), c > 0.67 (high). References for cuttof values
Chin (1998); Hair et al. (2017).

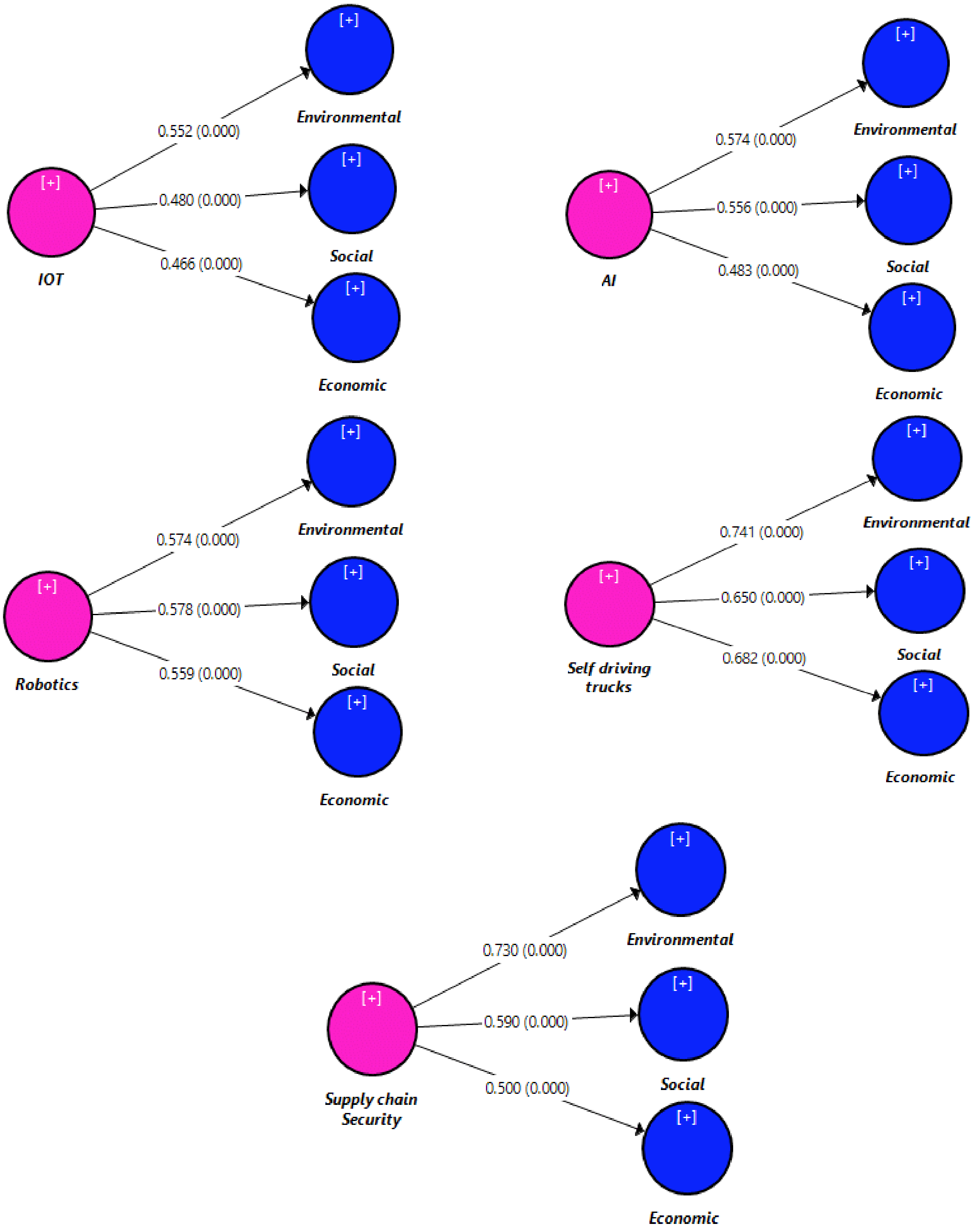

Figure 4: Structural Model Assessment (Sub-Hypotheses)

Figure (2) show the reseach model with the estimated path coefficients along with the corresponding p-values. The results of the first hypothesis in table (3) show that; *Technologies in supply chain* has statistically significant positive effect on *Sustainable Supply Chain* since ($\beta = 0.346, \mathrm{t} = 6.39, \mathrm{P} < 0.001, 95\%\ \mathrm{CI\ for}\ \beta = [0.231{,}0.441]$), so that the first hypothesis is accepted. There were about 62% of the variation in *Sustainable Supply Chain* is explained by the variation in *Technologies in supply chain* with moderate Cohen's effect size (f^2 =0.169). Moreover, *IOT* has statistically significant positive effect on the dimensions of *Sustainable Supply Chain;* as for *Economic* ($\beta = 0.466$), for *Environmental* ($\beta = 0.552$), and for *Social* ($\beta = 0.48$), so that H3, H4, H5 are accepted. Also, *AI* has statistically significant positive effect on the dimensions of *Sustainable Supply Chain;* as for *Economic* ($\beta = 0.483$), for *Environmental* ($\beta = 0.574$), and for *Social* ($\beta = 0.556$), so that H6, H7, H8 are accepted.

Furthermore, *Robotics* has statistically significant positive effect on the dimensions of *Sustainable Supply Chain;* as for *Economic* ($\beta = 0.559$), for *Environmental* ($\beta = 0.574$), and for *Social* ($\beta = 0.578$), so that H9, H10, H11 are accepted. Additionally, *Self-driving trucks* has statistically significant positive effect on the dimensions of *Sustainable Supply Chain;* as for *Economic* ($\beta = 0.682$), for *Environmental* ($\beta = 0.741$), and for *Social* ($\beta = 0.65$), so that H12, H13, H14 are accepted. Finally, *Supply chain Security* has statistically significant positive effect on the dimensions of *Sustainable Supply Chain;* as for *Economic* ($\beta = 0.5$), for *Environmental* ($\beta = 0.73$), and for *Social* ($\beta = 0.59$), so that H15, H16, H17 are accepted. The effect size values were reported in table 3, and it is noticed that all values were ranged between moderate and large effect. A comparison of effect sized between the dimensions of constructs was given in figure 4. It can be noticed that both *Self-driving trucks* and *Supply chain Security* have the largest effect especially on environmental construct. We evaluated predictive relevance by assessing Stone-Geisser's Q^2 Blindfolding . We executed the blindfolding procedure and calculated the Q^2 values for all variables, which are greater than zero, thus indicate predictive relevance for endogenous latent variables in our PLS path model (Hair et al. 2017). Tenenhaus et al. (2005), proposed the Goodness of Fit (GoF) as a global fit indicator. The criteria of GoF for deciding whether GoF values are not acceptable ($Q^2 < 0.1$), small ($0.1 < Q^2 < 0.25$), moderate ($0.25 < Q^2 < 0.36$), or high ($Q^2 > 0.36$) to be regarded as a globally appropriate PLS model. The value of the GOF

(0.622) is greater than 0.36 indicating high fit, so, it can be safely concluded that the GoF model is large enough to considered sufficient valid global PLS model.

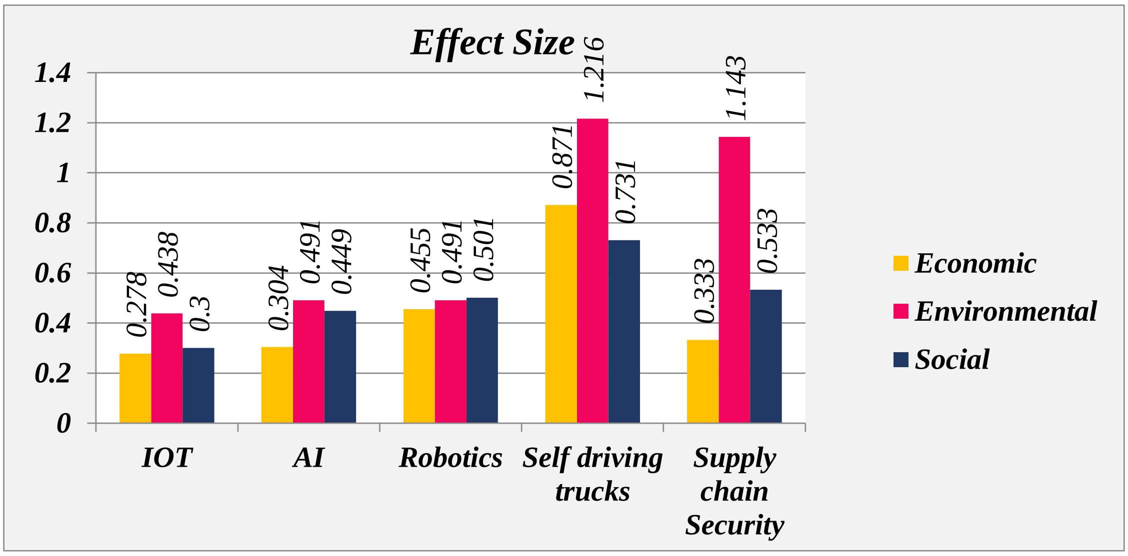

Figure 5: Comparisons of effect size for some selected constructs

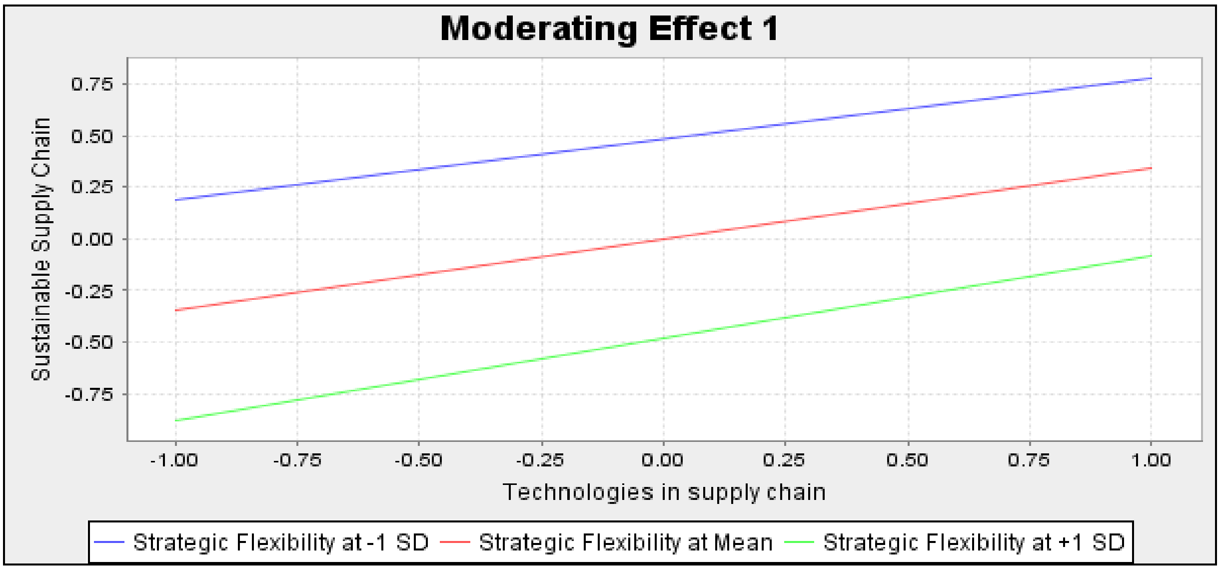

Figure 6: Interaction Plot

5.3 Moderating Effect

The variable " *Strategic Flexibility* " was included to the original structural model as a recommended aid for strengthening the association between the independent variable (*Technologies in supply chain*) and the dependent variable (*Sustainable Supply Chain*) to analyse the moderating effects (in Fig. 3). To investigate such moderating relationships, PLS-SEM bootstrapping was used. Table 4 shows that the moderator variable " *Strategic Flexibility* " has a statistical significant influence on the relationship between "*Technologies in supply chain*" and " *Sustainable Supply Chain* " since ($\beta = 0.051, \mathrm{t} = 2.85, \mathrm{P} < 0.01$, 95% CI for $\beta = [0.017, 0.086]$), hence hypothesis H2 is accepted. Furthermore, figure 5 shows the interaction plot of the mediating role of *Strategic Flexibility* on the path from *Technologies in supply chain* to *Sustainable Supply Chain*, it can be concluded from the graph that the moderator variable strengths the positive relationship between *Technologies in supply chain* to *Sustainable Supply Chain*. In conclusion, we can easily say that *Strategic Flexibility* moderates the relationship from *Technologies in supply chain* to *Sustainable Supply Chain*.

5.4 Respondents' Profiles

Table 5 shows firms of the Egyptian Holding Company for Food Industries

shows different classifications firms including	United Mills and Complementary Industries.
Sugar and integrative industries.	Valley of the Kings Milling.
Delta Sugar.	rice marketing.
Dakahlia Sugar.	Dakahlia rackets.
Fayoum Sugar.	Damietta and Belqas rackets.
Nubaria Sugar Refining Industry.	Kafr El Sheikh rackets.
Nile Oils & Detergents.	lake bats
Tanta for oils and soap.	oriental rackets
Egyptian Starch, Yeast and Detergents.	Rasheed rackets.
Extracted oils and their products.	Qaha for preserved food
Misr for oils and soap	United Packaging Production.
North Cairo Mills	Misr Edfu for pulp and writing and printing paper.
Mills and bakeries south of Cairo and Giza.	Nag Hammadi for Fiberboard.
Middle Egypt Mills.	Qena Paper Industry.
Alexandria Flour Mills and Bakeries	General for wholesale.
General Bakeries of Greater Cairo.	Alexandria for consumer complexes
East Delta Mills.	Al-Ahram Consumer Complex.
Upper Egypt Mills.	Egyptian for meat, poultry and fish

The results showed that participants are distributed among the industries, however the maximum participants were from the food and supply sector (39.8%) followed by oils and soap sector (26.2%).

5.5 Demographic information of the respondents

Demographic information of the respondents including gender, years of experience, Level of education, position, and number of employees is presented in table 6

Table 6: demographic information of the respondents

Category	Subcategory	Frequency	Percent %
Gender	Male	246	75.3
	Female	81	24.7
Work experience	Less than 5 years	177	54.2
	5-10 years	105	32.1
	More than 10 years	45	13.8
Education level	PHD degree	35	10.7
	Master degree	77	23.6
	Bachelor's degree	215	65.8
Position	Top Manger	56	17.2
	Middle Manger	271	82.8
Number of employees	Less than 20	185	56.6
	20-100	92	28.2
	More than 100	50	15.3

The previous results show that the majority of the sample members are male, with a percentage of 75.3, as well as 54.2 of the sample members have less than 5 years of experience, and that most of the respondents hold a bachelor's degree and work as managers in the middle management of the company being studied.

6- Discussion and Recommendation

The growing threat of climate change, combined with the global COVID-19 pandemic, has accelerated trends in sustainability, with more and more international trends and conferences devoted to finding long-term solutions to shape our future. The need for systemic change and radical rethinking of how organizations and industries operate is being addressed, and bold ideas are being implemented. Food supply chains have a significant environmental impact.

Therefore, there is a strong tendency to emphasize sustainability issues associated with food logistics. Sustainability in the food industry means reducing food waste and lowering the environmental impact of food production as produce moves from field to processor to table.

Sustainability benefits more than just the environment. Food companies can increase profitability in the long run by reducing food waste, limiting energy and water consumption, and developing more sustainable business models. For both environmental and commercial reasons, the Holding Company for Food Industries and an increasing number of food companies must seek ways to increase sustainability throughout the food chain. Finding areas for change and investing in updated equipment and operational strategies is the first step in improving sustainability. The researchers have concluded that the following recommendations should be made in light of their analysis and interpretation of the results

A. Sustainable supply chain management performance:

Sustainability concepts should be incorporated into environmental rules in such a way that top management is convinced of their importance and necessity. Consequently, they must recognize that if they resist sustainability thinking in the supply chain, they will soon fail.

- Companies are recommended to report all sustainable practices they are engaged in and their impact on their performance; however, annual sustainability reports should cover all aspects of the triple bottom line.
- In order to make the food chain more sustainable, companies need to embrace technologies such as artificial intelligence and machine learning. Furthermore, they will need to incorporate systems to monitor and control such things as water usage as well as advanced processing equipment to reduce waste and resource use.
- Utilising high-quality equipment in order to reduce energy consumption, production costs, and overall waste.
- A priority for sustainability should be to limit water consumption. Washing equipment and ingredients and turning off the tap when not in use are ways that businesses can conserve water.
- By composting and reducing food waste, less industrial fertilizers are required, resulting in chemical-free crops and lower production costs for farmers.

- Businesses can be encouraged to adopt sustainable practices through the efforts of the government. Initially, the government should develop a long-term public procurement strategy. According to World Bank data, Egyptian government spending constitutes 12% of GDP. Implementing a sustainability plan such as this would spread sustainability practices across numerous companies, including Egyptian Food Industries Holding Company, in their supply chain.
- The government can motivate companies through corporate responsibility indexes or financial incentives such as tax breaks and easier loan access. It is possible that the government has contracts with these companies. As a result, environmental audits conducted by government representatives may be conducted with less red tape.
- The government's support for companies and small projects in the field of sustainability plays an important role in enabling companies to establish sustainable supply chains. For example, the Good Water Company, which offers the first Egyptian mineral water bottle made of plant materials. This bottle uses covers made of a biopolymer derived from sugar cane, enabling them to be replanted as carbon dioxide-absorbing plants.
- Egypt plans to produce green hydrogen from waste in a huge plant in eastern Port Said, which will cost $3bn to establish and is expected to produce 300,000 tonnes of green hydrogen annually using approximately 4 million tonnes of organic waste and plastic non-recyclable materials, so subsidiaries companies of the Holding Company for Food Industries can use this renewable energy to make their supply chain activities more sustainable.

B. supply chain technology tools:

- It is critical to address resistance to change and advanced technology. Your digital transformation programs will be ineffective unless employees and outside partners fully embrace them. Therefore, you must explain the anticipated benefits of digitization to all stakeholders in order to gain their support and adoption.
- Your digital transformation will never end. As new technologies emerge, there will always be more opportunities for process improvement. Review performance on a

regular basis to ensure continuous progress, and make use of automation and advanced analytics.

- Businesses must understand their current supply chain and assess all potential complications and risks associated with digital supply chain implementation.
- Egyptian Food Industries Holding Company's supply chain technologies require numerous improvements and constant innovations in order to meet users' demands at the right time and in the right place. The company makes use of various information systems and logistics modules to make business easier. SAP and its MM module, which covers the entire logistics process, is the best example of such a system. In practice, we also come across logistics management and a Warehouse Management System (WMS).
- Egyptian Food Industries Holding Company supply chain managers have improved visibility, auto-capture/sensory capabilities, business intelligence via in-depth Internet of Things (IOT) data, and communication capabilities over the traditional Information and Communication Technology (ICT)-enabled Supply Chain Management (SCM) context.

C. Strategic flexibility:

1- As a result of the field study's relative decline in strategic flexibility, the researchers advise Egyptian Food Industries Holding Company's senior management to pay attention to the following:

- ✓ Ensure that supply chain development systems are utilized effectively.
- ✓ Creating the partnership's organisational structure to achieve clarity and flexibility in work and formal and informal communications.
- ✓ Creating a precise system for controlling supply chain activities in order to operate in a sustainable manner.
- ✓ Attracting technical skills in the field of supply chain activities.
- ✓ Paying attention to all management levels' support and training, as well as improving their flexibility in terms of sustainability.
- ✓ Rapid responses to fluctuations and sudden changes, particularly in supply chain issues.

2- Effective supply chain management necessitates a long-term, forward-thinking, proactive approach. This contributes to long-term system stability and prepares the supply chain for various future risks and disruptions.

3- Managers who develop strategic flexibility should prefer a horizontal and more streamlined structure because they encourage innovation and provide the ability to act quickly.

4- The manager should eliminate barriers to strategic flexibility, such as organizational stalemates, large and aging organizations, poor governance, and a harsh culture of mistakes within the organization. Flatter and more horizontal structures are preferable for managers who wish to build strategic flexibility since they facilitate innovation and allow them to react more quickly.

7- Managerial implications:

Aside from theoretical implications, this study provides valuable guidelines for practitioners and managers of supply chains at the Egyptian Holding Company for Food Industries. These guidelines will enable them to achieve a high level of sustainable performance across the supply chain by investing in supply chain digitalization.

Those involved in digitalized supply chain initiatives, such as supply chain managers, digitalization managers, technology officers, and other practitioners, will find our research useful. Using the proposed framework, these managers may be able to gain a more comprehensive understanding of the potential benefits, challenges, and success factors associated with technological advancements in supply chain activities. In particular, the five core technologies offer managers an array of options for meeting their specific supply chain needs.

The technology landscape is rapidly evolving, and the Holding Company for Food Industries cannot continue to ignore the importance of implementing the latest digital technologies into their operations as soon as possible. This will enable them to optimize their performance and reap the greatest benefits. Due to cost and resource constraints, the Egyptian Holding Company for Food Industries must consider how to adopt the latest technologies. A notable finding of our research is that many supply chains leveraging digital transformation to improve sustainability are reorienting their business models towards sustainability through circularity. A statistical analysis of the data reveals that self-driving trucks and supply chain security have the greatest impact, particularly on the environment. A further benefit of this paper is that it will help organizations identify technologies that are likely to have the greatest impact. Thus, practitioners are able to invest in the right technologies at the right time to achieve some strategic successes and use strategic flexibility to achieve these goals efficiently and effectively.

8- Theoretical implications:

In this study, insights and results were added to the existing literature regarding how technological advances influence supply chain sustainability; a comprehensive understanding of this relationship was also provided in the context of Egyptian food production.

As a result, the current study contributes to a better understanding of how supply chain technologies affect environmental, social, and economic aspects of performance. It provides a solid foundation for scientists to build upon by looking at several core technologies. In light of the constant changing of existing technologies, and the constant emergence of newly developed ones, this exceptionally broad perspective has a significant impact on supply chain management.

The variable "Strategic Flexibility" has been included as a recommendation for strengthening the relationship between the independent variable (Technologies in Supply Chain) and the dependent variable (Sustainable Supply Chain) in the original structural model. We analyzed the moderating effects of the relationship between Technologies in Supply Chain and Sustainable Supply Chain based on data which indicated that it moderates this relationship.

In conclusion, the research model demonstrates how digitalization of supply chain capabilities can result in higher sustainable performance across the entire supply chain. These findings have increased the research's novelty and contribution by conceptualizing all of the relationships examined and highlighted by the model. These findings may be applicable to other countries with similar cultures and levels of development to Egypt. The findings of this study may also be relevant to other industries, such as fast-moving consumer goods, which are purchased by consumers on a daily basis.

9- Limitations and future research:

Despite the numerous contributions, we must acknowledge that this study has some limitations. The most significant limitation was that data collection was restricted to top and middle management at the Egyptian Food Industries Holding Company. A second limitation of this study is that, even though each firm had a large number of single key respondents, the data used in this study was based on subjective (judgmental) assessments, which added to the subjectivity of the results. As a result, we encourage future researchers to assess the validity of our findings based on more objective criteria and historical data. Third, while the research was focused on a set of five core supply chain technologies, there are other models that involve digital technologies in supply chain activities that increase and enhance the ability to optimise planning, sourcing, and procurement strategies, such as block chain, big data analytics, cloud computing, 3D printing, and so on, which may be of interest to future researchers to expand the scope of the study and incorporate additional variables. Additionally, since the study focused on the food industry, it would be useful to conduct a similar study in other industrial sectors and compare cross-industry findings.

Researchers suggest that in future studies, other variables such as the nature of the production system (agile/lean) in the companies being studied, as well as the moderating effect of efficient customer response (ECR) on the effectiveness of supply chain sustainability, could be added to the study model as mediating variables. Further, future studies should also analyse the impact of digital technology adoption on the human workforce; they can examine the new skills that will require to develop in order to implement digital technologies in supply chain management. In addition, future research could investigate our proposed relationships with a different research model in order to examine this topic from a different perspective (e.g., consumer satisfaction or perception of control), which could have a positive effect on consumers' adoption of self-sufficient technologies.

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أثر استخدام تكنولوجيا سلاسل الامداد في بناء سلاسل الامداد المستدامة في الشركات التابعة للشركة القابضة للصناعات الغذائية: اختبار الدور المعَّدل للمرونة الاستراتيجية للإدارة العليا

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الملخص:

تهدف هذه الدراسة إلى سد الفجوة البحثية في المجال الاكاديمي من خلال دراسة تأثير استخدام أدوات تكنولوجيا سلسلة التوريد على بناء سلاسل التوريد المستدامة ، مع دراسة تأثير المرونة الاستراتيجية للإدارة العليا في تعزيز العلاقة بين المتغير المستقل (تكنولوجيا سلسلة الامداد) و المتغير التابع (سلاسل الامداد المستدامة) بالتطبيق على عينة من 36 شركة تابعة للشركة القابضة للصناعات الغذائية . والجدير بالذكر أن الشركة القابضة للصناعات الغذائية هي شركة حكومية مصرية قابضة مملوكة لوزارة التموين والتجارة الداخلية.

توصل الباحثان الي النتائج الاحصائية للدراسة من خلال اجراء مقابلات متعمقة مع المديرين العاملين في الإدارة العليا ومستويات الإدارة الوسطى في الهيكل التنظيمي للشركات قيد الدراسة وهي 36 شركة تابعة للشركة القابضة للصناعات الغذائية ، حيث تم توزيع أستبيان على عدد مكون من 385 مفردة . والحصول على 327 استمارة صالحه للتحليل الإحصائي من مجتمع الدراسة ، يتكون الاستبيان من مجموعة من الأسئلة معدة وفقًا لمقياس ليكرت المكون من خمس نقاط لكل متغير من متغيرات الدراسة ، بالإضافة إلى مجموعة من الأسئلة الوصفية. وقد تم تحليل البيانات والاستقصاءات الميدانية باستخدام اسلوب نمذجة المعادلة الهيكلية.

وقد توصلت الدراسة إلى وجود تأثير إيجابي كبير لجميع أبعاد تكنولوجيا سلسلة التوريد ، والمتمثل في (انترنت الاشياء ، الذكاء الاصطناعي ، نهج استخدام الانسان الالي ، الشاحنات ذاتية القيادة وأمن سلسلة التوريد) على استدامة سلاسل التوريد ، وكما أن لها نفس التأثير على كل من أبعاد التنمية المستدامة والمتمثلة في (البعد الاقتصادي والبعد البيئي والبعد الاجتماعي). بالإضافة إلى ذلك ، أكدت نتائج التحليل الإحصائي أن المرونة الإستراتيجية للإدارة العليا لها تأثير معدل إيجابي على تعزيز العلاقة بين متغيرات الدراسة المستقلة والتابعة.

الكلمات المفتاحية :

تكنولوجيا سلسلة الامداد ، سلاسل الامداد المستدامة، المرونة الاستراتيجية ، الشركة القابضة للصناعات الغذائية