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CONCEPT PAPER

The relationship between the adoption of agricultural revolution 4.0 technology and business performance and sustainability in agro-food supply chain in Malaysia: a conceptual paper

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Abstract

The present study is based on the review of literature related to the adoption of Agricultural Revolution 4.0 (AR4.0) technology, business performance and sustainability dimensions. The new National Agro-food Policy 2.0 (DAN 2.0) was formulated to transform agriculture into a more dynamic, sustainable, and competitive industry in which the agro-food supply chain is one of the most important parts of the agricultural sector in Malaysia. In order to boost the agriculture sector's competitiveness and sustainability, the sector is encouraged to fully utilize digital technology in agriculture. From this perspective, the adoption of the Agricultural Revolution (AR4.0) could provide numerous benefits, particularly in terms of enhancing the business performance for a sustainable agro-food supply chain. Thus, the business world today is moving towards "Digitalization 4.0" to focus on increasing the performance that will sustain the industry. Due to greater possibilities of economic, environmental, and social impacts along supply chain activities, the adoption of Agricultural Revolution 4.0 (AR4.0) into the industry supply chain is gaining more attention in the agricultural sector. The main objective of this study is hence to generate the conceptual framework between the relationship of adoption of Agricultural Revolution 4.0 (AR4.0) towards Agro-food supply chain (AFSC) business performances (flexibility, delivery, quality and cost) and AFSC sustainable agricultural performance encompassing economic, environmental and social dimensions in sustainability. The conceptual paper signifies providing academia with additional literature to use as a reference for future research. The findings of this research could help the agricultural industry to leverage Agricultural Revolution 4.0 (AR4.0) technology in order to boost their business performance. It will also be useful to policymakers in creating support mechanisms and plans to improve the overall performance of the firm.

1. Introduction

Malaysia's population is forecast to increase by 45% by 2050, from 30.7 million to 44.4 million people, putting further strain on the country's current food system (FAO, 2018). As a result, Malaysia's food sector has been upgrading and improving not only to fulfil local demands, but also to meet global food and quality standards, as well as severe requirements from end users, international clients, and governments in various nations. Despite accounting for only 8.2% of GDP, agriculture plays an essential role in national socioeconomic development, particularly in terms of poverty reduction, economic equity, food safety and security, and sustainability, as described in the Sustainable Development Goals (SDGs) (FAO, 2018). As the world's population grows, securing quality food and access to it becomes a big economic challenge. Food security becomes the main and direct priority of economies as time passes and population growth accelerates (FAO, 2018).

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Sustainability has become a burning issue for most of today's corporate entities in light of rising environmental degradation and human rights breaches (Gladwin *et al*., 1995) and has become a topic of increasing interest in operations management. Recent business developments suggest that pursuing economic goals alone may not be a sound decision alternative for an organization's long-term sustainability and profitability if the organization's actions result in irreversible environmental damage and fail to ensure safety, security, minimum wage, and healthcare, better working conditions for employees, improved living conditions for the surrounding community, and the society at large. Expectations for adopting and improving sustainability practices are growing, and public and private institutions and organisations are anticipated to impose such standards across a wide range of industries sooner or later (Svensson, 2007).

The agro-food business is one of the industries that has raised serious concerns about sustainable practices. In order to meet increased sustainability standards, firms in the agro-food industry will undoubtedly have to incorporate social and environmental objectives in addition to commercial ones in the years ahead. As a result of their growing importance, many initiatives to promote food network sustainability have emerged. In today's world, several businesses are attempting to reduce their negative environmental impact by implementing modern technology. According to Arshad *et al*. (2006), agro-food supply chains (AFSCs) in Malaysia are undergoing a rapid transformation which includes all stages of food processing, manufacturing, and distribution up until end consumption. in response to changes in the economic well-being of the consumers, industrialization, globalization and informatization. Nevertheless, traditional wet and dry markets still exist in the agri-food sector, which is dominated by smallholders, SMEs, and small retailers, and these markets leave small producers and sellers open to intermediary cooperation, with a large number of collectors, primary and secondary wholesalers, and retailers between producers and consumers (Arshad *et al*., 2006).

Malaysia's agro-food industry is confronting problems in terms of sustainability and business performance. The agro-food sector, in particular, is experiencing structural and supply-side challenges due to a lack of land, manpower, inputs, and capital. At the regional level, small-scale production, limited technical application, lack of water resources, environmental degradation owing to climate change, fast urbanisation, and manpower shortages are all limiting issues for agricultural sector expansion (Dung and Hiep, 2017). Prior to examining the sources of sustainability pressure, it is necessary to determine the factors that are contributing to the sector's increasing "unsustainability." Globalization of the agro-food business, changes in consumer consumption and product preferences, sector concentration at the management level, and changes in food delivery patterns are the four key drivers. The adoption of Agricultural Revolution 4.0 (AR4.0) is forced to confront all of these challenges.

However, there are obstacles facing the adoption of these technologies. Ransbotham *et al*. (2018) summarized the obstacles facing the adoption of technological innovation in three main points which are the firm believes that a minimum level of sustainability, including environmental problems and business efficiency, is necessary since the environment has little direct effect on strategic objectives which is seen as a costly productivity deterrent. Second, the company is unsure how to enhance its sustainability and commercial performance, as well as what it means to be "creative," and it is under pressure to improve quality, cut costs, and increase flexibility in order to meet consumer demands in the face of fierce competition (even if this means less environmentally practices and technologies are adopted Agriculture provides humans with food and raw materials. Agriculture 4.0 is a potential technique for boosting farm profitability while minimising physical work and lowering environmental impact. Hence, the main purpose of this research is to develop the conceptual framework for the relationship between the adoption of Agricultural Revolution 4.0 (AR4.0) and AFSC business performance and AFSC sustainable agricultural performance.

2. Literature review

2.1 Agricultural revolution 4.0

The concept of Agriculture 4.0 has gained large popularity and importance since it was first introduced by the Germans. According to CEMA (2017), there are different terms frequently used to refer to Agriculture 4.0, such as “Smart Agriculture”, “Intelligent Agriculture” and “Digital Farming”, or “Digital Agriculture”, as well as multiple perspectives from which the concept of Agriculture 4.0 is examined and explained. Emerging technology Industry 4.0 brings a technological revolution in the agriculture sector. More intensive farming practices must be employed as a result of rising population demands. Agriculture techniques that incorporate technological innovations can yield sustainable growth and enhance performance.

Despite the fact that the revolution was designed for the manufacturing business, it may also be used for agriculture. The agricultural industry has, in fact, gone through several eras of revolution (Mat Lazim *et al*., 2020). According to Dung and Hiep (2017), the first stage, which began in the early 20th century, is characterized by low productivity and a labour-intensive farming system. The Green Revolution, the second stage, is characterized by efficient agronomic management approaches with higher yield potential and increasing returns to scale at all levels. The third stage is characterized by farming industries that are more efficient and profitable, resulting in higher product quality. The fourth stage pronounced as IR4.0 occurred in parallel with a similar evolution in the industrial world. Agricultural revolution 4.0 (AR4.0) is a term that refers to a farming operation's integrated internal (within the farm) and external (outside the farm, which includes suppliers, customers, service providers, and so on) networking. The digital information from all farm sectors will be electronically collected, processed, communicated, evaluated, and shared with all people involved in the supply chain as part of this revolution (Dung and Hiep, 2017). The revolution of agriculture is shown in Table 1.

Agriculture 4.0 involves the integration of internal and external networking of farming processes, analogous to Industry 4.0. This suggests that digital form data is present in agricultural activities such as suppliers' electronic connections with end customers. Data transmission, processing, and analysis are all automated as part of the agriculture 4.0 revolution. Agricultural production and sustainability are improved when farmer fields are combined with technology and innovation. According to the research, agriculture 4.0 and high-tech agriculture deployment result in higher agricultural production, enhanced environmental quality, and other long-term benefits. The impact of the Fourth Industrial Revolution is more on labour-intensive agriculture sectors. Farming is changing in terms of technology and production techniques, as well as business scale, resource control and operation, and customer and supplier relationships (Patil *et al*., 2017).

The factories become smarter, more effective, healthier, and more environmentally friendly as a result of the radical combination and integration of production equipment and devices, information and communication systems, data, and services in network infrastructure (Adnan *et al*., 2018). As a result, agricultural data serve as a primary driving force behind not only output and food chain revolutions but also environmental management (Caron *et al*., 2014). The transformation of the current industry into a smart chain is the foundation of the next century industry.

2.2 Classification of agricultural revolution 4.0 technologies and systems

Agriculture 4.0 technologies such as mobility, cloud computing, Internet of Things (IoT), Artificial Intelligence (AI) and big data analytics are enabling a future of “smart everything” and “Internet of Everything”. Agriculture is one of the most significant industries in smart farming or precision agriculture, and the four types of classification under 4.0 technologies are biotechnology, digital and data technology, and physical technology. Smart farming in agriculture is the use of IoT and cloud computing technology to collect real-time data and connect sensors to smart machines, resulting in a data-driven and data-enabled farm management system. Biotechnology enables businesses to transition away from fossil fuels. Businesses can use digital and data technology to track capital, monitor use, and reduce waste capacity. Cloud computing, blockchain, big data analytics, and simulation are examples of modern information and communication technology (Liao *et al*., 2017). The classification of agricultural revolution 4.0 technologies and systems are shown in Table 2.

2.3 Agro-food supply chain

The supply chain is a network of companies that participate in numerous processes and activities in the hands of the end customer or consumer via upstream and downstream linkages, resulting in value in the form of products and services (Au Yong, 2008). Overall, the Agro-Food Supply Chain consists of a series of operations that follow a ‘seed-to-the-shelf' or 'farm-to-fork' sequence, including input supply, output, post-harvest, storage, processing, marketing delivery, food services, and consumption (Jaffee *et al*., 2010). They also affect commodities manufacturers, suppliers,

Table 1. Revolution of AR4.0

Revolution	Period	Technologies
Agriculture 1.0	10000 BC	Manpower and animal forces Usage of simple tools
Agriculture 2.0	19th century	Agricultural machinery Usage of chemicals
Agriculture 3.0	20th and 21th century	Computer programs Deployment of robots
Agriculture 4.0	Today	Smart systems and smart devices such as Internet of Things (IoT), Big Data.

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Table 2. The classification of AR4.0 technologies and systems.

Technology/System	Definition
Blockchain	A non-tampering distributed database that uses advanced encryption and authentication technology as well as network-wide consensus mechanisms to handle an ever-growing list of records. This is a method of creating a list of digital records (blocks) that are connected using cryptography.
Big Data Analytics	When the insights and significance of the underlying data cannot be found using traditional data mining and handling methods, this method of processing large amounts of data is used. This is a hardware and software framework for storing, analyzing, and extracting information and intelligence from harvested datasets in order to make value-based decisions. Data obtained by sensors is analyzed, and the pattern of the data is observed to make real-time decisions. BDA may be used to increase product quality, energy consumption, and predictive maintenance.
Internet of Things	The Internet of Things (IoT) is a network that links several sensors at the same time. AI and big data can be combined with IoT to create self-driving systems that will revolutionize crop production. The IoT refers to a set of hardware components that work together to enhance agricultural and manufacturing processes.
Radio-frequency identification (RFID)	Refers to technologies that monitor and identify objects using wireless communication between an item (or tag) and an interrogating device (or reader).
Barcode	A visual representation of information in the form of bars and spaces on a surface. Bars and spaces of different widths are generated using numbers, characters, and symbols such as dots, colon, and others.
GPS tracking system	GPS receivers can calculate and show precise location, speed, and time data to the consumer due to a group of satellites transmitting precise signals in Earth's orbit.
Cloud Computing	Cloud computing services are any IT services that are provisioned and accessed by a cloud computing provider. These are digital computing systems with on-demand, high-availability hardware and software that can be handled automatically without the intervention of end users.
Drone	A drone is an aircraft that does not have a human pilot on board.
Smart sensors	are used in precision agriculture to provide data that assists farmers in monitoring and optimizing crops as well as keeping up with evolving environmental factors. They are an essential component of the Internet of Things.
Remote sensing	Helps determine the amount of water that can be used for agriculture on a given farmland.
Artificial intelligence	A branch of computer science that focuses on the development of intelligent machines that operate, react, and have cognitive functions similar to those of humans. Reasoning, planning, information representation, learning, perception, and the ability to move and control objects are all examples of cognitive functions.
Digital twin	A digital representation that enables the development of a continuous cycle of supply chain improvement and adjustment in near-real time.
Nano-technology	A specific technology for controlling individual atoms and molecules
Robotics	Drones and unmanned tractors are examples of robotics (autonomous robots) that can carry out tasks according to a predetermined order. Autonomous robots can think, act, and respond independently, similar to how people do. Programmable Cyber-Physical Systems that can execute routines and activities previously performed by humans on their own. They're connected, agile, and constructive, and they can be optimized.
Autonomous robots	Autonomous robots are used in agro-food production (planting, picking and harvesting), processing and transportation.
Augmented reality	A type of interactive, reality-based display environment that enhances the real-world experience with computer-generated display, sound, and other effects. Computer-generated experiences, such as immersive and interactive experiences of real-world environments, are referred to as augmented reality (AR). These are becoming more popular in consumer products so that customers can get a feel for the product before purchasing it.
Energy harvesting	Based on the premise that machines can harvest energy from their surroundings in real time and use it right away, requiring energy to be stored only temporarily.
Conversational systems	Intelligent machines that can comprehend language and engage in a written or verbal conversation with a customer. Their application aims to improve the customer experience by managing interaction.
Machine vision	Imaging-based automated inspection and analysis technology and methods for industrial applications such as automatic inspection, process control, and robot guidance.

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Table 2 (Cont.). The classification of AR4.0 technologies and systems.

Technology/System	Definition
Machine learning	A form of artificial intelligence (AI) that enables systems to learn and improve without having to be programmed explicitly. Machine learning is a technique for developing computer programs that train an actuator/robot to perform a task specified by the programmer. It's a type of artificial intelligence in which machines are taught to perform cognitive tasks. AI can be used to create a smart factory that utilizes supply chain data. Design teams, production lines, and quality control are all connected to create a smart, integrated system.
Aeroponics	A method of growing plants in an air or mist environment without the use of soil or aggregate medium. Aeroponic systems use water, liquid nutrients, and a soilless growing medium to produce more colourful, tastier, better-smelling, and highly nutritious produce quickly and efficiently.
Bio-based material	A substance derived from living organisms that has been purposefully developed.
Bio-energy	A type of renewable energy derived from biologically derived materials
Hydroponics	A practice of growing plants without the use of soil. This method encourages fast growth, higher yields, and higher quality.

intermediates, processors, exporters, retailers, and customers across the supply chain. Non-agricultural industries including manufacturing and transportation have traditionally dominated supply chain literature (Aramyan *et al*., 2006).

Sustainable AFSCs are increasingly seen as a precondition for assuring food security (Buttriss, 2013). They reacted by noting that all components of food systems must be sustainable, resilient, and efficient in order to provide food security and nutrition; otherwise, food security and nutrition would be jeopardised. While this is widely acknowledged, the various tactics for fostering sustainable transitions in AFSC are still being contested (El Bilali *et al*., 2019). As a result, modernising the agro-food industry through the adoption of Industry 4.0 innovations is one of the next phases, with production quality as a key component of the AFSC's long-term sustainability. In the 11th Malaysian Plan (2016-2020), the agricultural sector requires transformation and modernization to maintain food security, raise productivity, improve farmer skillsets, improve AFSC, and improve applicable support and delivery services for all stakeholders (Bujang and Bakar, 2020).

Kher *et al*. (2010) stated that the AFSC is getting larger and more sophisticated as a result of economic globalization and the growth of international food trade. In order to ensure the accuracy and consistency of food traceability, every part of the AFSC needs to be monitored (Houghton *et al*., 2008). Digitalization enables quality food traceability in supply chain management to gain competitive advantage through improved productivity, flexibility, and performance, due to the advancements in tracking technologies such as RFID, Big Data, Cloud Computing, Machine Learning, Digital Twins, and the IoT.

2.4 Agro-food supply chain business performance

The aggregate performance statistic for supply chain business performance is based on supply chain stage performance. A performance metric, according to Neely *et al*. (2005), is a measure used to calculate the efficiency and effectiveness of an action. These major business performance indicators can be thought of as a standard set of measurements and a method of assessing and evaluating the efficacy and efficiency of a supply chain's actions. For this reason, the agro-food supply chain (AFSC) performance metrics are divided into four categories which are (i) cost (ii) quality (iii) flexibility and (iv) delivery.

The cost of a resource is an indicator of how effectively it is used (Lai *et al*., 2002). It takes into account a number of factors, including production costs, profit, return on investment, and inventory. Quality is a critical component of every organization's success. Both the completed product and the raw materials must meet particular quality criteria to ensure the organization's long-term viability. Product and process quality are the two types of quality (Beamon, 1999). The capacity of the supply chain to adjust to changing circumstances and individual customer service needs is referred to as flexibility (Beamon, 1998). Customer satisfaction, volume flexibility, delivery flexibility, backorder reduction, and lost sales are all possible outcomes. Globalization, technological growth, and economic volatility all need firms to adapt rapidly, cost-effectively, and strategically (Zhang *et al*., 2006). Due to the supply chain flexibility is dependent on resource reservations and the effectiveness of reallocating redundant resources, supply chain redundancy can improve supply chain flexibility (Dolgui *et al*., 2018) The delivery process is intertwined with all supply chain management activities. The notion of supply chain management arose from the recognition that the transformation of raw materials into completed goods and their distribution to customers is a complicated process (Beamon, 1999).

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2.5 Agro-food supply chain sustainable agricultural performance

Sustainability is a long-term process that provides various problems to supply chain management. It is described as "progress that meets current demands without harming future generations' ability to satisfy their own needs" (World Commission on Environment and Development, 1987). They must address integrated social, environmental, and financial objectives along the supply chain to achieve sustainability (Mitchell and Walinga, 2017; Raut *et al*., 2019). Sustainability is a notion that is continually evolving in the agro-food business. Consumer health, economic growth, and environmental effect mitigation are all dependent on the food industry (Turi *et al*., 2014). As a result, ensuring value, information, knowledge, society, and company reputation, as well as improving a business and collaboration environment across the supply chain, requires sustainability (Lin and Tseng, 2014; Shokri *et al*., 2016). Sustainability performance demonstrates the achievement of sustainability goals. The majority of supply chain sustainability research, particularly in the agro-food supply chain (AFSC), has concentrated on defining indicators at one level of the supply chain.

According to Validi *et al*. (2014), the competitive environment in the food supply chain, which has a high demand for food safety, food control, and environmental legislation, which is required to respond, encompasses economic, environmental, and social dimensions of sustainability. The management of material, information, and capital flows, as well as cooperation between businesses along the supply chain, can be defined as integrating goals derived from customer and stakeholder requirements from all three dimensions of sustainable development: economic, environmental, and social development. Environmental and social requirements must be met by members of sustainable supply chains in order to stay within the supply chain, while competitiveness must be maintained by meeting customer needs and corresponding economic criteria (Seuring and Muller, 2008). The triple bottom line, namely environmental, social, and economic performance, is merged into the sustainable supply chain (Golici and Smith, 2013).

The key motivations in food industry processes that impose sustainability are economic dimensions (Shokri *et al*., 2016). These dimensions allude to properly managing resources to achieve productivity and competitiveness in order to optimise societal contribution (Leat *et al*., 2011). One school of thought contends that a sustainable supply chain improves the economy by increasing energy efficiency, boosting goodwill and brand value, and reducing costs, among other things (Ageron *et al*., 2012; Golicic and Smith, 2013; Ahi and Searcy, 2013). Air emissions, energy consumption, greenhouse gas emissions, energy consumption, recycling, solid waste, carbon footprint, life cycle assessment, water consumption, and indicators in this context are all heavily debated (Beske-Janssen *et al*., 2015). Several metrics and measurement systems such as energy and resource consumption, carbon emissions and waste production have been proposed with regard to environmental sustainability. In terms of social consequences, the measurement categories identified in the literature include ethical behaviour, stakeholder involvement, human rights compliance, and workplace safety. The social emphasis in the food industry, according to Gold *et al*. (2013), can be linked to local farmers' acquisition of raw materials, adding vitamins to local food, and local revenue by delivering local favourable safety items. These social dimensions foster the growth of the economy, labour opportunities and human welfare (Ageron *et al*., 2012). Yakovleva *et al*. (2012) determined the ratio of incomes, jobs and gender to survive in the development of equal market share and maintain productivity.

The Agricultural Revolution 4.0 (AR4.0) has been mentioned in several publications as a new trend in digitalization, notably in the agro-food industry, however, it is still limited and insufficient. Because it was not established, the adoption of digitalization technology, referred to as AR4.0 in the most recent research, did not reflect the entire concept of sustainability. The current study adds to improved agricultural and industrial performance as well as long-term sustainability. The research will add to the existing literature by developing a set of indicators and metrics to evaluate the outcomes of AR4.0 adoption, including economic, social, and environmental indicators to measure sustainable agricultural performance, as well as a number of indicators to evaluate business performance.

3. Conceptual framework

As we mentioned in the introduction above, business performance and sustainable agricultural performance are highly related with the adoption of AR4.0.

3.1 The relationship between the adoption of agricultural revolution 4.0 and agro-food supply chain business performance

The adoption of AR4.0 has a number of implications for AFSC business performance. AR4.0 adoption coincides with improved business performance in terms of flexibility, delivery, quality, and cost. While for the business performance outcome which includes the cost,

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delivery, flexibility and quality, the study by Bhattacharya *et al*. (2015) and Yontar and Ersoz (2020) revealed that the positive relationship between the adoption of AR4.0 with the delivery and flexibility while the study conducted by Tripathi and Pandit (2019) found an insignificant relationship between agricultural revolution 4.0 adoption and flexibility. Mat Lazim *et al*. (2020) have indicated that by adopting AR4.0 in the agricultural sector, firms can reduce the cost of production as it can bring maximum or partial changes to production and operational activities. They pointed out that the lower cost of production resulted in reduced prices, making the products more competitive in the international market. Ali *et al.* (2020) have maintained that by actively adopting their Agricultural Revolution 4.0 technology, firms can optimize their operational costs which is identified through the analysis of textual data. Moreover, a previous study by Laaper *et al*. (2017) has pointed out that the adoption of digital technology could boost the cost-effectiveness of the supply chain in many ways, such as reducing the need for third-party intermediaries, reducing transaction costs and minimizing human error. For instance, the application of blockchain application allows transparency in real-time, thereby eliminating the need for trusted intermediaries to mediate a supply chain transaction along the supply chain. Similarly, Hua and Notland (2016) stated that eliminating this intermediary will reduce the risk of fraud and human error in the supply chain and reduce costs as well. Therefore, the following hypotheses are postulated:

H1a = AR 4.0 adoption has a positive impact on cost.

H1b = AR 4.0 adoption has a positive impact on quality.

H1c = AR 4.0 adoption has a positive impact on delivery.

H1d = AR 4.0 adoption has a positive impact on flexibility.

3.2 The relationship between the adoption of agricultural revolution 4.0 and agro-food supply chain sustainable agricultural performance

In the literature, it was found that the adoption of AR4.0 is related to sustainability dimensions. Cole *et al*. (2019) found that production cost appears to have a significant impact on sustainable agricultural performance. A previous study conducted by Santiteerakul *et al*. (2020) has mentioned that the firms may obtain agricultural sustainable performance through the following positive impacts due to the adoption of smart technology in agriculture which are increased resource efficiency and reduction in unit cost due to lower resource consumption and higher productivity. The study by Wong *et al*. (2020) proved a significant positive relationship between AR4.0 adoption and environmental sustainability. By adopting the agricultural revolution 4.0 technology, firms can gain sustainability by reducing the environmental logistic footprint and strengthening the ecological dimension of sustainability (Wong *et al*., 2020). Hence, it would be possible to incorporate several environmental protection and control measures by leveraging smart technology by careful monitoring of production parameters such as energy consumption, processing of raw materials and emissions. According to Saberi *et al*. (2019), the technology allows the carbon footprint of products to be traced and offers organizations the ability to collaborate and trade their carbon assets effectively in the green asset markets. The sustainability performance from the environmental dimension can be ensured by mapping the product's trajectory through the supply chain. As a result, through effective and easily traceable greenhouse footprint measurement, AR4.0 technology can significantly contribute to reducing carbon emissions and air pollution. The study by Santiteerakul *et al*. (2020) which is to focus on the role of smart technology implementation in sustainable agriculture found that the adoption of AR4.0 positively associated with social sustainability. Santiteerakul *et al*. (2020) mentioned that food safety can be achieved by the implementation of AR4.0. The result of the study showed that the adoption of intelligence technology in plant factories enhances sustainability performance by improving product traceability (food safety), as well as improving employees' quality of life. The framework presented in this paper is illustrated in Figure 1.

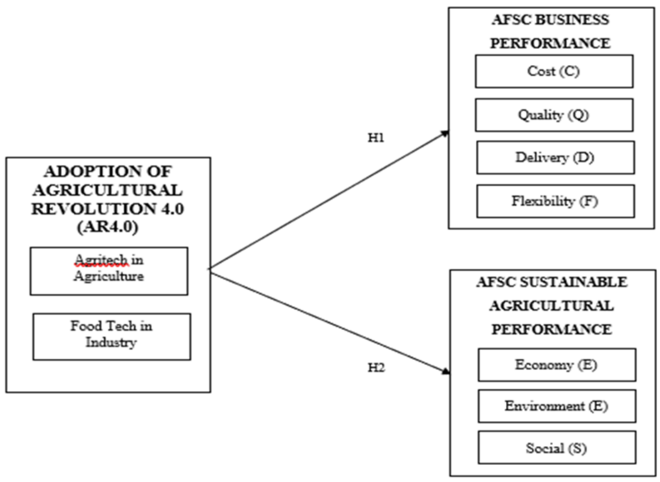

Figure 1. Conceptual framework.

Accordingly, the following hypotheses are posited to identify the relationship between the adoption of Agricultural Revolution 4.0 (AR4.0) and sustainability performance:

H2a = AR 4.0 adoption has a positive impact on economic sustainability.

H2b = AR 4.0 adoption has a positive impact on environmental sustainability.

H2c = AR 4.0 adoption has a positive impact on social sustainability.

Conflict of interest

The authors declare no conflict of interest.

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