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The Impact of The Adoption of Agricultural Revolution 4.0 (AR4.0) on Business Performance and Sustainability in Agro-Food Supply Chain (AFSC) in Malaysia

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Abstract - **Today, the business world is moving towards the "Digitalization 4.0" and most organizations focus on increasing performance in their operations thus will sustain the industry. In agriculture sector, adopting Agricultural Revolution 4.0 (AR4.0) in to the industry and managing supply chains is getting an increasing attention due to higher possibility of economic, environmental and social impact during supply chain activities. The purpose of this study is to this study is to generate the conceptual framework of the relationship of adoption of Agricultural Revolution 4.0 (AR4.0) and AFSC business performance (flexibility, delivery, quality and cost) and AFSC sustainable agricultural performance encompassing all three dimensions sustainability (economic, environmental and social).This research has several important implications for practitioners who have adopted and are willing to implement Agricultural Revolution 4.0 (AR4.0) technology in their firms. In addition, the study significantly contributes to the literature by providing empirical evidence for the impact of agricultural revolution 4.0 on business performance and agricultural sustainability.**

Keywords - **Agricultural Revolution 4.0 (AR4.0); AFSC Business Performance; AFSC Agricultural Sustainability; Malaysia**

I. INTRODUCTION

It is acknowledged that population in Malaysia is expected to grow by 45 percent by 2050, from 30.7 million to 44.4 million people, putting additional strain on the existing food system to meet demand [1]. As a consequence, Malaysia's industry of food has been upgrading and developing not only to fulfil local demand, but also to meet global demand for standards of food and quality, as well as stringent requirements from end users, international customers, and governments in various countries. Despite contributing only 8.2% of GDP, agriculture plays an important role in the development agenda of national socio-economic, especially in reducing poverty, ensuring economic equity, ensuring safety of food and food security, and ensuring sustainability, as outlined in the Sustainable Development Goals (SDGs) [2]. With an ever-increasing population, ensuring quality food and access to it becomes a major economic obstacle. With the passing of time and an unmatched rate of population growth, food security becomes the core and immediate focus of economies [2].

In light of escalating environmental degradation and human rights violations, sustainability has become a burning issue for most of today's corporate organizations [3] and has become a topic of increasing interest in operations management. Recent developments in the business environment suggest that pursuing economic goals alone may not be a sound decision alternative for an organization in terms of long-term sustainability and profitability, if the organization's actions result in irreversible damage to the environment and fail to ensure safety, security, minimum wage, and healthcare, better working conditions for employees, improved living condition for the surrounding community, and the society at large. Expectations for adopting and enhancing sustainability practices are emerging, and it is expected that public and private institutions and organizations will impose such practices across a wide range of industries sooner or later [4]. The agro-food industry is one of the industries where substantial problems concerning sustainable practices have been raised. The organizations in the agro-food industry will, without doubt, have to incorporate social and environmental objectives in addition to commercial ones in the years ahead in order to fulfill higher sustainability expectations. Many initiatives for strengthening food network sustainability exist as a result of their increasing importance. In today's scenario, some of the organizations attempt to minimize the negative environmental impact by adopting the advanced technology.

According to Arshad et al. [5], agricultural marketing or agro-food supply chains (AFSCs) in Malaysia is undergoing a rapid transformation which include all stages of food processing, manufacturing, and distribution up until end consumption. in response to changes in economic well-being of the consumers, industrialization, globalization and informa ionization. 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

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and sellers open to intermediary cooperation, with a large number of collectors, primary and secondary wholesalers, and retailers between producers and consumers [5].Other recurring issues include: inadequate infrastructure and logistics; sharp price fluctuations; producers' lack of knowledge of consumer preferences in terms of volume, variety, grade, and standards; and outstanding payments to producers. Because of the limited shelf life of food and the variability in quality and availability of raw materials as organic products, AFSCs face not only these general threats, but also their own unique vulnerabilities [6]. As a result, these traditional channels must work in conjunction with the integrated supply and value chain that characterizes Malaysia's industrial product exports, as well as the expanding urban consumer markets facilitated by the supermarket revolution [5].

The agro-food industry in Malaysia facing the challenges in sustainability and business performance as well. Due to a lack of land, labor, inputs and capital, the agro-food sector, in particular is suffering structural and supply-side issues. Small-scale production, limited technical application, scarcity of water resources, environmental degradation due to climate change, rapid urbanization and labor shortages are all limiting factors for agricultural sector growth at the regional level [6] Prior to examining the sources of sustainability pressure, it is necessary to determine the factors that are contributing to the sector's increasing "unsustainability." There are four major causes which are the agro-food industry's globalization, changes in consumer consumption and product preferences, the sector's concentration at the retailer level and patterns of food delivery have changed. In order to overcome all of these challenges, the adoption of Agricultural Revolution 4.0 (AR4.0) is needed. However, there are obstacles facing the adoption of these technologies. Ransbotham et al. [7] 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. Secondly, the firm is unsure how to improve their sustainability performance and business performance and what is meant by being "innovative" and the firm is under pressure to boost quality, reduce costs, and increase flexibility to meet consumer demands in the face of stiff competition (even if this means less environmentally practices and technologies are adopted). Agriculture offers food and raw resources to people. The agriculture 4.0, is a viable strategy to increase the sustainability by boost farm profitability while also reducing manual labor and lowering environmental impact. Hence, this study is to generate the conceptual framework of the relationship of adoption of Agricultural Revolution 4.0 (AR4.0) and AFSC business performance and AFSC sustainable agricultural performance.

II. LITERATURE REVIEW

2.1 The Agricultural Revolution 4.0 (AR4.0)

The concept of Agriculture 4.0 has gained large popularity and importance since it was first introduced by the German. According to [8], 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. The concept of Agriculture 4.0 is an implementation of Industry 4.0 methods in the agricultural sector [9, 10, 8, 11]. Emerging technology Industry 4.0 brings a technological revolution in 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 the performances

Despite the fact that the revolution was intended for the manufacturing sector, it can also be implemented to the agricultural industry. In truth, the agricultural industry has gone through various stages of revolution [12]. According to Dung and Hiep [6], 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 [6].

Agriculture 4.0 involves the integration 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. Agriculture 4.0 evolves in conjunction with similar developments in the industrial sector, namely Industry 4.0, which is based on a concept for future production [9]. Farmer fields which are used in conjunction with technology and innovation result in increased agricultural productivity and sustainability. Agriculture 4.0 and high-tech agriculture deployment, according to the study, result in increased agricultural production, improved environmental quality, and other

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sustainable aspects. The impacts on labor-intensive agriculture fields causes due to Fourth Industrial Revolution. Farming is evolving in terms of technology and production processes, as well as the size of the business, resource control and operation, and the business model with customers and suppliers [13].

Due to the extreme combination and integration of production technology and devices, information and communication systems, data and services in network infrastructure, factories become smarter, more effective, healthier, and more environmentally friendly [14]. A constant communication between market and production and within the company itself is one of the key needs that to be met [15]. Today, the farm's technical equipment has reached a level comparable to industry. Developing data use declares a digital agricultural revolution driven by several developments in agriculture [16]. Subsequently, the agricultural data provide a major driver is not only for output and food chain revolutions, but also of environmental management [17]. Current industry's transformation into a smart chain is the keystone of the new millennium industry. Agriculture 4.0 technologies such as mobility, cloud computing, IoT, Artificial Intelligence (AI) and big data analytics are enabling a future of "smart everything" and "Internet of Everything".

Kher et al. [18] stated that the AFSC is getting larger and sophistication as a result of economic globalization and the growth of international food trade. In order to ensure the accuracy and consistency of the food traceability, every part of the AFSC need to be monitored [19]. Digitalisation 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 Internet of Things (IoT).

2.2 Agro-Food Supply Chain (AFSC)

The supply chain is typically described as a network of organizations that participate in various processes and activities in the hands of the ultimate customer or consumer through upstream and downstream linkages, resulting in value in the form of products and services [20]. Overall, Agro-Food Supply Chain is consisting of a set of operations such as input supply, output, post-harvest, storage, processing, marketing delivery, food services, and consumption that follow a 'seed-to-the-shelf' or 'farm-to-fork' sequence [21]. Furthermore, they cross through the entire supply chain, including commodity manufacturers, suppliers, intermediaries, processors, exporters, retailers, and customers [21]. Non-agricultural sectors such as manufacturing, transport, and steel production have historically dominated the literature on supply chain performance [22].

The supply chain for agro-food is similar to conventional supply chains, but with agriculture/horticulture as the product. Individuals from various organizations collaborate on various processes and activities to market products or services in order to satisfy customer demand in the agro-food supply chain [23]. An agro-food supply chain can be described as a supply chain involved in the production and distribution of agricultural products, as well as the flow of information [22,23]. The management of the supply chain is derived from three interconnected components which are: 1) management of activities and materials flow from supplier to producer and ultimately to customer through the process of transformation of raw materials into finished products; 2) information management through the supplier-manufacturer and manufacturer-consumer chains; 3) chain relationship management [24]. This includes the integrated manufacturing process where the finished products are manufactured from the raw materials and then shipped via distribution channel, retail or both to consumers [25]. Hence, each and every organization is at least part of any supply chain or network that affects the supply chains, including the consequences towards natural environment through the derivation of operations and marketing decisions [26].

Sustainable AFSCs are increasingly seen as a precondition for assuring food security [27]. They responded by saying that in order to ensure food security, all components of food systems must be sustainable, robust, and efficient; otherwise, food security and nutrition would be jeopardized. While this need is widely recognized, the different strategies to foster sustainability transitions in AFSC continue to be debated [28]. As a result, modernizing the agro-food sector through the adoption of Industry 4.0 innovations is one of the steps to move forward, focusing on production quality as a central to the sustainable AFSC pathway [29]. The agricultural sector requires transformation and modernization in the 11th Malaysian Plan (2016-2020) to ensure food security, increase productivity, improve farmer skillsets, enhance AFSC, and improve relevant support and delivery services for all stakeholders [30].

2.3 AFSC Business Performance

Supply chain business performance is an aggregate performance metric that is based on supply chain stage performance. According to Neely et al. [31] a performance metric is a measure used to calculate the efficiency and effectiveness of an action. These primary business performance indicators can be regarded as a standard collection of measurements and the process of quantifying and action's effectiveness and efficiency for the entire supply chain. 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.

Cost of a resource is an indicator of how effectively it is used [32]. It takes into account a number of factors, including production costs, profit, return on investment, and inventory.

Quality is a very important dimension of any organization's performance. For the organization's long-term sustainability, both the finished product and raw materials must fulfill specific quality standards. The quality is divided into product and process quality [25].

Flexibility refers to the supply chain's ability to respond to changing circumstances and specific customer service requests [33]. It may include customer satisfaction, volume flexibility, delivery flexibility, reduction in the number of backorders and lost sales. Flexibility allows organizations to respond quickly, cost-effectively, and strategically to problems like as globalization, technological development, and economic uncertainty [34]. 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 [35].

Delivery process is linked with all activities in supply chain management. The concept of supply chain management emerged from the realization that the process of changing raw materials into finished goods and distributing those goods to customers is a complex one [25].

2.4 AFSC Sustainable Agricultural Performance

Sustainability, defined as "development that meets current needs without jeopardizing future generations' ability to satisfy their own needs" [36], is a long-term process that poses several challenges to supply chain management. In order to accomplish sustainability, they must tackle integrated social, environmental, and financial objectives throughout the supply chain [37,38]. 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 [39]. As a result, sustainability is essential for ensuring value, information, understanding, society, and company reputation, as well as for enhancing a business and cooperation environment across the supply chain [40,41]. The fulfillment of sustainability goals is demonstrated by sustainability performance. Research on supply chain sustainability, particularly in the agro-food supply chain (AFSC), has primarily focused on the definition of metrics, typically at one stage of the supply chain. According to Validi et al. [42], sustainability is comprising the aspects of economic, environmental and social, the competitive environment in the food supply chain which has a high demand for food safety, food control and environmental legislation which is expected to respond. Sustainable supply chain can be described as the management of material, information and capital flows as well as cooperation between businesses along the supply chain while integrating goals derived from customer and stakeholder requirements from all three dimensions of sustainable development which are economic, environmental and social. In sustainable supply chains, in order to remain within the supply chain, environmental and social requirements must be met by the members, while competitiveness is required to be sustained by fulfilling consumer needs and related economic criteria [43]. Sustainable supply chain is a crucial junction at which merges the triple bottom-line namely environmental, social and economic performance [44].

Economic dimensions are the main drivers in processes of food business that enforce sustainability [41]. These dimensions refer to allocating the resources in a correct manner to achieve productivity and competitiveness in order to maximize contribution to the society [45]. One strand of literature claims that sustainable supply chain contributes to economic benefits as it increases energy efficiency, boosts goodwill and brand value, resulting in cost-cutting and others [46, 47, 44]. The environmental dimension is largely discussed including air emissions, energy consumption, greenhouse gas emissions, energy consumption, recycling, solid waste, carbon footprint, life cycle assessment, water consumption, and the indicators in this context illustrated by [48]. Several metrics and measurement systems such as energy and resource consumption, carbon emissions and waste production have been proposed with regard to environmental sustainability. The environmental impact in all of the reviewed work is assessed in quantities of carbon dioxide only or total greenhouse gases (GHG) expressed as CO2eq emitted throughout the supply chain, with exception of [49] which reflected the environmental aspect in terms of supply chain energy consumption, water consumption and waste disposal. , in terms of social results, the measurement areas outlined in the literature include ethical behavior, involvement of stakeholders, observance of human rights and safety at work . According to Gold et al. [50], the social emphasis in the food industries can be related to the local farmer's procurement of raw materials, adding vitamin to the local food and local income by supplying local safe and affordable goods. These social dimensions foster the growth of the economy, labor opportunities and human welfare [46]. Yakovleva et al. [49] determined the ratio of incomes, jobs and gender to survive in the development of equal market share and maintain the productivity.

III. CONCEPTUAL FRAMEWORK

As we mentioned on the introduction above, the business performance and sustainable agricultural performance are highly related with the adoption of Agricultural Revolution 4.0 (AR4.0).

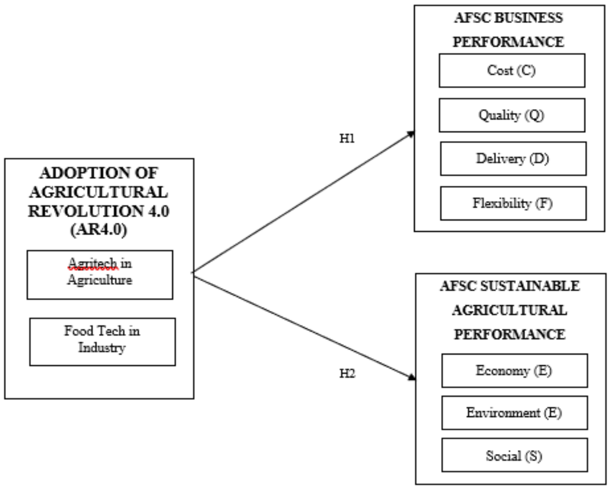

Figure 1. Conceptual Framework

3.1 The Relationship between the Adoption of Agricultural Revolution 4.0 (AR4.0) and AFSC Business Performance

There are several impacts of the adoption of Agricultural Revolution 4.0 (AR4.0) on AFSC business performance outcomes. There is a positive relationship between AR4.0 adoption and multiple business performances in flexibility, delivery, quality and cost. While for the business performance outcome which including the cost, delivery, flexibility and quality, the study by Bhattacharya et al. [51] and Yontar and Ersoz [52] revealed that the positive relationship between the adoption of agricultural revolution 4.0 with the delivery and flexibility while the study conducted by Tripathi and Pandit [53] found insignificant relationship between agricultural revolution 4.0 adoption and flexibility. Mat Lazim et al. [12] have indicated that by adopt IR4.0 in agricultural sector, the firms can reduce the cost of production as it can bring maximum or partial changes to production and operational activities. They pointed that the lower cost of production resulted in reduce price, making the products more competitive in the international market. Ali and Thai [54] 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, previous study by Laaper et al. [55] has pointed 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 [56] stated that by 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 have a positive impact on cost
H1b= AR 4.0 adoption have a positive impact on quality
H1c= AR 4.0 adoption have a positive impact on delivery
H1d= AR 4.0 adoption have a positive impact on flexibility

3.2 The Relationship between the Adoption of Agricultural Revolution 4.0 (AR4.0) and AFSC Sustainable Agricultural Performance

In literature, it was found that the adoption of Agricultural Revolution 4.0 (AR4.0) are related to sustainability dimensions. Cole et al. [57] found that production cost appears to have significant impact on sustainable agricultural performance. Previous study conducted by Santiteerakul et al. [58] has mentioned that the firms may obtain the agricultural sustainable performance through the following positive impacts due to the adoption of smart technology in agriculture which are increase resource efficiency and reduction in unit cost due to lower resource consumption and higher productivity. The study by Wong et al. [59] proved significant positive relationship between AR4.0 adoption and environmental sustainability. By adopting the agricultural revolution 4.0 technology, firm can gain the sustainability by reducing the environmental logistic footprint and strengthen the ecological dimension of sustainability [59]. Hence, it would be possible to incorporate several environment 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. [60], the technology allows the carbon footprint of products to be traced and offers organization the ability to collaborate and trade their carbon assets effectively in the green asset markets. The sustainability performance from environmental dimension can be ensure 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. [58] which is to focuses on the role of smart technology implementation in sustainable agriculture found that adoption of AR4.0 positively associated with social sustainability. She mentioned that the food safety can be achieved by implementation of AR4.0. The result of the study showed that the adoption of intelligence technology in plant factory enhances sustainability performance by improving product traceability (food safety), as well as improving employees' quality of life.

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 have a positive impact on economy sustainability
H2b= AR 4.0 adoption have a positive impact on environment sustainability
H2c= AR 4.0 adoption have a positive impact on social sustainability

V. FUTURE RESEARCH

The conceptual framework explaining the proposed relationship between the adoption of Agricultural Revolution 4.0 (AR4.0) in SMI and performance and sustainability elements later will be continued as further study to be tested using survey questionnaire data collection and quantitative study methodology, particularly Structural Equation Modelling (SEM).

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