Journal of Agricultural Science and Practice
Volume 7(3), pages 36-42, October 2022
Article Number: 2E9EB1021
ISSN: 2536-7072
https://doi.org/10.31248/JASP2021.323
https://integrityresjournals.org/journal/JASP
Full Length Research

Nigeria Agriculture supply chain for digital intervention: Some mitigation strategies

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Received 2nd November, 2021; Accepted 14th January, 2022

ABSTRACT: Supply chain management has played a very important role in improving organizational effectiveness at every possible level. The supplies of products from farm gate to retail level constitute the supply chain management. The consumer demand for variety, quality, and year round availability that has provided the stimulus for the formation of these chains. For Nigeria to move closer to unlocking its full agriculture potential, the value chain have to be identified, mapped, prioritized and digitized. The findings reveal that Information technology (IT) play an overwhelming role to put together and streamline the supply chains and supply chain management in full. This supply chain also requires a continuous cold chain during various steps along its network. Currently, technologies like RFID, GPS, Data recorder, Blockchain are used with Information technology (IT) mainly in tracking and tracing the products right from the field to the consumer. The purpose of this paper is to discuss various technologies and their applications in the agricultural sector and to show how those technologies can impact supply-chain management.

Keyword: Agricultural products, COVID-19, information technology, supply chain management.

INTRODUCTION

With the ever-changing advancements in Information Technology (IT) and Internet-of- Things (IoT) technologies, processing and managing data has never been more important in companies that are dependent on utilizing them. This is especially the case in the food sector, where the supply chain can be considered quite massive, spanning multiple countries at once, and where the biggest focus lies on a quick time-to-market, in a reliable and safe manner while still being able to maintaining a high standard product quality.

As most of the developing and third world countries are heavily dependent on agriculture and agricultural imports, the agricultural supply chains (ASCs) in all these countries are exposed to unprecedented risks following COVID-19. Food and Agriculture Organization (2020) reports that COVID-19 is affecting ASCs on two critical aspects viz. the demand and supply for food. Food supply and demand are directly related to the food security aspect; therefore, global food security is at risk (Siche2020). In the absence of vaccine or effective medicine to contain the spread of the disease, the governments worldwide are turning to non-pharmaceutical measures such as social distancing policies and civic lockdowns to stop the spread of the virus. The impact of keeping people from being able to work, meet, and socialise has severely damaged economic activities, especially in the services and the agricultural sector (Barichello, 2020). Countries have imposed travel bans, border controls, and export restrictions on food commodities. At this point, there is no definite end date of these lockdowns and the ensuing economic damage, and no region of the globe is being spared as COVID-19 tests the resilience of global health systems.

As ASCs are labour-intensive for fisheries, meat products, and high-value crops, the effects of lockdown are taking a toll on the labour markets. The labour market shocks that arise from the movement restrictions on migrant labourers are affecting their ability to harvest, process, and market the agricultural produces. COVID-19 has had a significant impact on global food imports and exports. Along with the labour market issues, horticultural

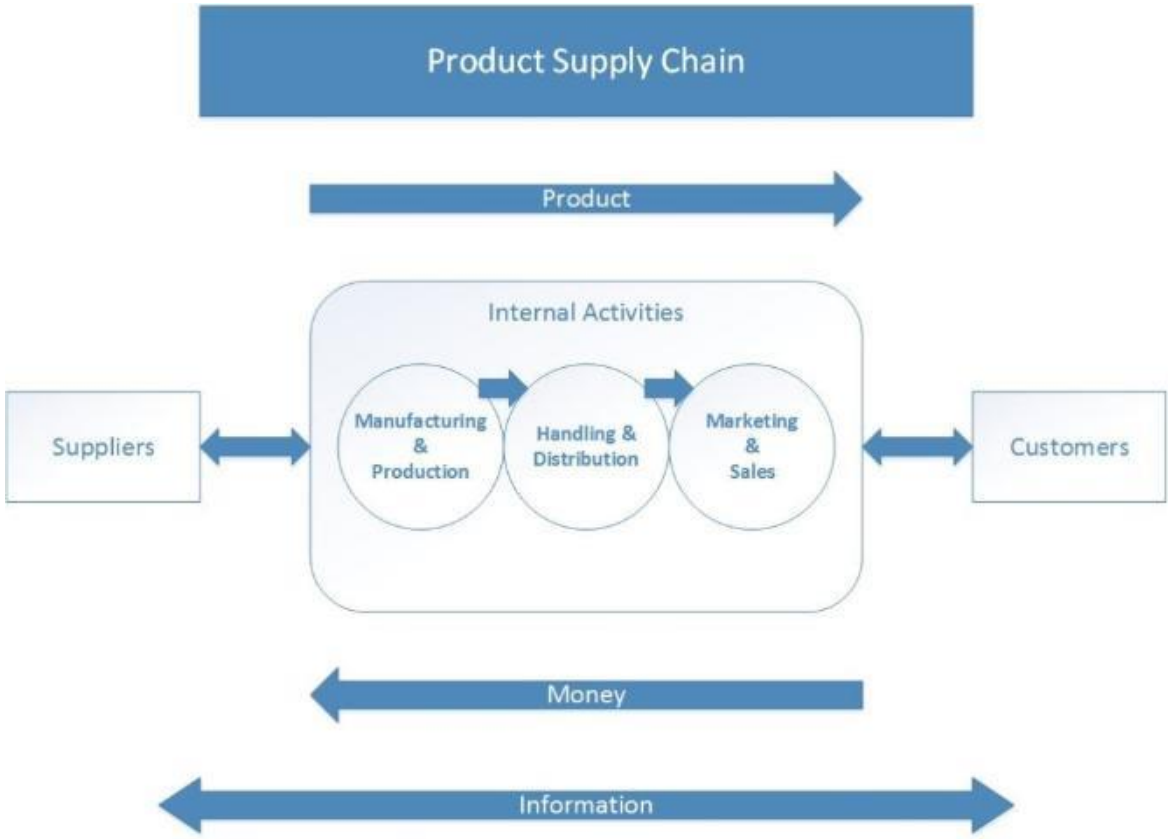

Figure 1. General supply chain schematic (Credit: Jonathan A. Watson, UF/IFAS).

produce, which makes up a substantial part of the fresh food supply chains have suffered heavily. Major ports worldwide are congested with reefer containers that cannot be shipped due to trade restrictions. Therefore, the shipments are being diverted to minor ports resulting in substantial revenue losses for the logistics providers (Hey, 2020). Despite having the latest technological tools at their expense, supply chain organisations worldwide are facing a crisis in tackling COVID-19 as they have never experienced such an event in the near past. In this uncertain situation, there is a need to discuss various technologies and their applications on the ASCs for the supply-chain researchers and practitioners.

A typical agricultural supply chain includes farmers, suppliers, processors, distributors, consumers and other stakeholders. Due to a number of actors involved in the agricultural supply chain, they become more complex and riskier. Without a doubt, technology has had the effect of increasing profitability and efficiency for most parties in ASCs. The supply chain (Figure 1) is defined as a sequence or network of different companies or individuals that produce, handle, or distribute commodities or specific products.

Modernization has led to advances in the agricultural sector with the purpose of benefiting producers, wholesalers, retailers, and consumers. Within 1809, Nicolas Appert introduces a procedure which provide for the tinning and canning of food for troops in the French army. The foremost patents for food irradiation were granted in the United States and the United Kingdom, within 1905. Also, in the 20th century, iced boxcars were replaced by mechanical refrigerated trucks, and this reduces interstate travel to a great extent, reduced delivery times, transportation costs, and losses due to spoilage. At the same time, a fresher product reached the shelves of retailers and ultimately consumers. It is in large part because of modernization that the global food system has enhanced its ability to deliver products with a higher degree of variety, quality, and consistency.

Modernization still plays an important role in the 21st century. Newer tools such as electronic devices, information technology, Internet of Things, Block chain and Artificial Intelligence are an integral part of supply-chain management within the food industry. Often, it is supply chains that compete with one another, as opposed to individual firms. Various technologies have the potential to provide a competitive advantage to those supply chains and, in extremely competitive markets, these technologies can determine which firms succeed and which firms fail.

The purpose of this paper is to discuss various technologies and their applications in the food industry and to show how those technologies can impact supply-chain

management. The information in this article is intended to provide insight to managers and stakeholders regarding the potential benefits of these technologies. With this insight, firms in the food industry can make more informed decisions on which technologies should be incorporated into their own systems and to what degree.

WHAT IS AGRICULTURAL SUPPLY CHAINS?

Agricultural supply chains ASCs has been defined as 'the set of activities included in a "farm to fork" progression, including activities such as farming (i.e. Land cultivation for crop production), processing/ production, testing, packaging, warehousing, transportation, distribution and marketing' (Tsolakis et al.,2014). ASCs encompass the activities of supply management, production and process management, and demand management through a competitive distribution channel for satisfying the end consumers (Chandrasekaran and Raghuram, 2014). ASCs comprise of stakeholders such as food procurement, processing, and manufacturing organisations, distribution and commercial organisations, agents, food-service firms and hotels and restaurants, and grocers, and retail organisations (Sgarbossa and Russo,2017). Different studies have utilised the term ASC according to the study context, such as food supply chain (Zirham and Palomba, 2016), agriculture value chain (Brewin2016), post-harvest supply chain (Mvumi et al., 2016), fruit supply chain (Glowacz and Rees, 2016), agri-business supply chain (Bhagat and Dhar 2011), perishable produce supply chain (Yared et al., 2014), fresh produce supply chain (Glowacz and Rees, 2016) and horticulture supply chain (Mahajan et al. 2014). The ASC comprises of three main aspects viz. farming and agriculture inputs, processing and storage, and transportation and distribution. Further, these are segregated into six phases based on the nature of operations, i.e. commodity types, and stakeholders involved. The stages in ASCs are exposed to severe disruptions that arise due to complex operations due to produce seasonality, varied production lead times, low standardisation of product quantity and product quality, trade and inventory storage restrictions, and lack of traceability. These shortcomings expose the ASCs to severe disruptions (van der Vorst et al.,2000; Dong, 2006). Consequently, investigating the complex nature of agri-food supply chain will aid agri-food firms/managers managing risks effectively to improve the performance of the chain.

Use of electronic device in the context of supply chain management in the agricultural sector

Radio-frequency identification (RFID) has become an essential component of supply chain management. The use of electronic devices such as radio-frequency identification (RFID), global position systems (GPS), and data recorders has drastically improved efficiency and reduced waste for food processors and distributors. For example, the use of RFID technology has enabled the food industry to track inventory and to ensure that products arrive at their intended destination. Tags (Figure 2) communicate with electromagnetic waves via a terminal that interprets the data associated with that product, such as temperature and expiration date. The data is used for tracking inventory, monitoring for foreign pathogens or bacteria, and identifying the product's contents. Wal-Mart has recently begun using RFID technology to track its pallets and cases for a variety of different types of goods ranging from fresh fruits and vegetables to household consumer products. This has reduced stock-outs and increased on-time deliveries. RFID tags have potential for "smart packaging", automatic checkout, "smart appliances", "smart recycling", and marketing/promotional opportunities. It is also believed that this type of technology could improve security, productivity, inventory control, and traceability as well as result in capital and other operational savings (Chandler, 2003).

Advances in RFID technology have also included monitoring the temperatures of various products. This has proved to be extremely valuable for perishable products, particularly in the food industry. For example, a perishable food product moving through the distribution channel can be monitored for quality. If temperatures exceed a threshold, a decision can be made regarding the product's quality and the product can be returned to the producer or rerouted to a closer distribution center or store in order to minimize financial losses and maximize consumer satisfaction.

Recently, RFID tags have been equipped with sensors and data recorders to monitor product as it moves through the supply chain. Data recorders (Figure 3), also known as data loggers, are electronic devices that record data over time or in relation to location with an internal or external sensor. In general, they are small, portable, battery powered, and equipped with a microprocessor and memory for data storage. The range of applications varies from general purpose types (which can be programmable) to very specific (where few parameters are changeable). In the food industry, data recorders are extremely useful for monitoring fresh fruits and vegetables in transit. The data recorder can be affixed to the inside of a shipping container and scanned without opening the container until it reaches its final destination. Key variables such as temperature, humidity, and change in elevation are extremely important when monitoring perishable product. Data can be downloaded from the data recorder and analyzed later, while newer data recorders use wireless technology to allow communication via smartphone or computer.

There are other electronic technologies that companies in the food industry use specifically to track and manage product. For example, GPS has enabled the food industry

Figure 2. Assortment of RFID tags (Credit: Lauren Douma, UF).

Figure 3. Data recorder with temperature sensor (Credit: Lauren Douma, UF).

to have a greater degree of control and flexibility in handling products that they manufacture or purchase. Firms in the food industry can monitor and track expected shipments of product within their distribution channel starting with their input suppliers and ending with their customers. This eliminates uncertainty or lack of knowledge for delayed or lost shipments since the product location is easily identifiable. GPS can track products with pinpoint precision and provide real-time, in-transit data about the product's condition and location. With this information, firms can more easily adjust to or even avoid a scenario where a necessary input does not arrive as promised or planned. In order to make the movement of products flow more smoothly, the delivery of these

products must be choreographed and planned out accordingly. Delivery vehicles are given a "window" (usually about 30 minutes) during which raw materials can be delivered and finished products dispatched to ensure smooth operations and to avoid congestion (Burch and Lawrence, 2005).

Information Technology in the context of supply chain management in the agricultural sector

In the food industry, information technology plays a critical role in reducing costs and meeting customer demand. Information technology coordination is the method of organizing, planning, and strategizing when synchronizing the needs of two or more distinct groups. The specific role of information technology depends on the type of product that is being sold. Salin (1998) states that choosing the appropriate type of information technology coordination depends on whether your product is "functional" or "innovative", and that choosing the correct coordination can ultimately lead to a supply chain with a competitive advantage.

In agriculture, "functional" products are defined as those that are homogenous in nature; often they are commodities such as sugar or flour. A cost-reducing, supply-chain style is the most appropriate in this scenario, because consumer demand for these products is relatively predictable. Transportation, production, and inventory management are areas where information technology can reduce costs within the supply chain, particularly for functional products. Some examples of information technologies suitable for functional products include automated ordering processes, quality-assurance control systems, and delivery scheduling. All of these technologies can reduce costs for players within the supply chain and can increase efficiency.

New, differentiated products require different methods of coordination using information technology, because it is often difficult to predict consumer demand for innovative products. Because of this, firms in the food industry should adopt an approach that monitors the sales and purchasing habits of consumers and uses this information to forecast demand. This may not be the most effective technique to reduce costs, but it is the most appropriate model to deliver the attributes that consumers most desire. Examples of information technology coordination for innovative products would be the use of scanner data collection at point-of-sale terminals. Additionally, portable scanners (Figure 4) in conjunction with software are also used to monitor and track product in an inventory control system. Most traditional food retailers such as Shoprites and Dangote use this type of information technology to manage inventory levels for these innovative products and re-order products when necessary. Customer loyalty cards are another example, because they can help retailers gather information to predict consumer behavior. Retailers such as Shoprites and Dangote use loyalty or shopper cards as an incentive to attract consumers with the benefit of collecting demographic, socioeconomic, and consumer spending information. Ultimately, the approach for innovative products must be responsive and flexible because innovative products in the food industry can have very short product life cycles.

Internet of Things (IoT) in the context of supply chain management in the agricultural sector

Currently, there exists almost nothing that cannot be tracked, and this is in large part thanks to the concept of IoT. Due to the fact that connectivity is crucial for data gathering and data management, the more devices that are able to communicate with each other, the better due to the information sharing capabilities. Not only will IoT help you achieve data, which in turn can be transformed and used as information, but the information it provides would also be capable of optimizing the supply chain, resulting in new insights as well as optimized work processes. A better utilization of IoT in supply chain, will be capable to speed up decision times, an increase in flexibility and eliminates the usage of older technologies such as fax machines or the need for phone calls (O'Byrne, 2018).

Implementing this technology in the food sector, could yield some highly beneficial results. Not only because of the need of food to sustain life, but also due to how accessible data is in regards to transportation and preservation of food over longer distances. First of all, IoT allows people to order whatever they would like right on to their doorstep. Farmers are constantly looking to minimize risk and mitigate weather, while still being able to maximize their yield. Furthermore, logistic companies are focusing on how to transport products to consumers without incurring extra costs while still maintaining record times. First of all, IoT is widely used in regards to food safety, being able to remotely control the climate that the food is currently being transported in has a significant positive impact on the quality when it arrives to its next destination. If a product is exposed to a climate that it is not suitable for, the companies can take the product out of circulation in order to prevent any food-borne illnesses to manifest. Furthermore, restocking warehouses will allow companies to minimize food shortages, and will allow them to restock with the help of pressure sensitive sensors. These are included, but not limited to what IoT can help achieve for food producers (Madden, 2019).

Blockchain in the context of supply chain management in the agricultural sector

It is hard to envision an efficient supply chain with extensive involvement of ICT, without taking into the consideration Blockchain technology. Blockchain technology is

Figure 4. Portable barcode scanner (Credit: Tyler Jones, UF/IFAS).

attractive due to the high degree of financial transparency that it provides throughout the entire value chain, where data that has once been entered, cannot be altered by any parties. Blockchain works as a public ledger, where each transaction is approved by a consensus of the majority of the individuals involved within the system, which creates the transparency throughout the entire supply chain. However, because of the fact that the blockchain technology is a technology that has just recently emerged, it has some defects which would need to be addressed, such as issues that have to deal with scale, due to the massive amounts of data that it would have to process (Tian, 2017).

A reason that blockchain would then be of such a high interest, would be exactly due to how little it is currently known about it in academia. If the possibilities are explored and understood, it could have a significant impact on how we currently conduct business, one hypothesis is that it could potentially eliminate the need for third party banking companies to facilitate business (Behnke and Janssen, 2019). The blockchain will actually have those capabilities, are yet to be discovered, where hopefully this paper will also provide some insight on the matter.

Artificial intelligence in the context of supply chain management in the agricultural sector

Perhaps one of the most popular domains or widely known decision making tools is Artificial Intelligence (AI). Artificial Intelligence not only allows faster data processing power, but it also enables rapid decision making and data analysis when concepts like Big Data starts entering the picture (Benton, 2018). Perhaps one of the bigger applications of AI in SCM, is to manage productivity and supply chain performance. AI can be implemented to calculate, accurately forecasts and produce demand and is thus also used to reduce supply chain latency. However, with AI, it is also important to highlight that we are mostly talking about robotics and how robots move around a plant, or are used to help improve movement in a plant/factory.

Conclusion/Recommendation

The ASCs play an essential role in achieving the United Nation's Sustainable Development Goals, i.e. SDG 2 (to end hunger through achieving food security and improved nutrition) and SDG 12 (to ensure sustainable consumption and production). Therefore, it is necessary to investigate the impact of risks and to create resilient ASC organisations during and after the COVID-19 pandemic. As stated before, technology has the potential in designing and developing and programs and digital platforms that improve the livelihoods of smallholder farmers by linking them to modern supply chains, and creating opportunities to increase agriculture productivity through improved farming practices, access to financing, technology, and high-quality inputs. Firms in the food industry must weigh the benefits and the costs before deciding if a certain technology is appropriate for their given business model. This study shows the impact of COVID-19 in Nigeria

context, further studies can be carried out in other sectors as well to emphasize the similarities and differences of risks across different sectors. Future studies can focus on comparing the impact of risks in developing and developed countries during the COVID-19 pandemic.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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