Food Supply Chain Management

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FOOD SUPPLY CHAIN

Food supply chain or food system refers to the processes that describe how food from a farm ends up on our tables. The processes include production, processing, distribution, consumption and disposal. In the food supply chain, food moves from producer to consumer via the processes of production, processing, distribution, retailing and consumption; thus, food moves from farmer to consumer in adomino- like fashion. At the same time, money that consumers pay for food moves from consumers to producers in the reverse process, again in a domino- like fashion from consumer to retailer to distributor to processor to farmer. Thus, the two- sided causality that connects farmers and consumers is mediated by these two sets of domino causalities (see Figure 1).

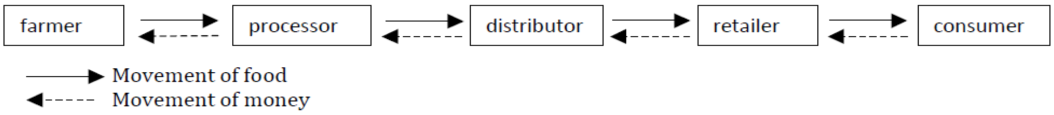

Figure 1. Movements of food and money in a simple food supply chain

In addition, both movements of food and money are facilitated by “pulls” and “pushes.” In a food supply chain, producers and processors push or supply food and consumers pull or demand food thereby facilitating the dominoes (food) to fall (move) towards the consumers. Similarly, producers farmer→ processor→ distributor→ retailer→ consumer and processors pull money and consumers push money to facilitate the movement of money from consumers to producers. Thus, if consumers’ pull for food or push for money is weak or absent, the producers’ push for food or pull for money would have to be strong in order to keep the food supply chain moving.

DEFINITION

There are many ways to define supply chain; however, in terms of the fundamental nature it comprises of assets, information, processes that provide supply. Links of the chain are various interconnected organizations, right from the raw material and component suppliers, sub-assembly suppliers, service providers, distribution channels, and finally the consumer or customer as may be the case. In order to optimize right quality, reasonable inventory costs and to get rid of herds of suppliers to an organization, sophisticated supply chain strategies are essential more than ever before. Those strategies are often termed as **supply chain management (SCM).** Worthen (2006) put SCM as the combination of art and science that goes into improving the way companies find the raw materials needed to make a product or service and deliver it to customers. Basic components of SCM are plan, source, make, deliver and return.

DIFFERENTIATION OF FOOD SCM WITH TRADITIONAL SCM

Food SCM is differentiated from traditional SCM (e.g., autoparts) due to an additional dimension of safety concerns in addition to quality. The Food Safety failures have led to the development of standards like **HACCP** (Hazard Analysis and Critical Control Point), **GAP** (Good Agricultural Practice), **GMP** (Good Manufacturing Practice) and various protocols have been introduced by **Codex Alimentarius** and International Standard Organization (**ISO**). The latest on the list is **ISO22000** that directly associated with the SCM. This paper covers International perspectives in supply chain management in context with food and agri-business. Food supply chain has experienced a great deal of technological advances over the last decade. Since 2005, law for the traceability of agricultural commodities have been in place in Korea that include beef, rice, apple, lettuce and other over 100 products. The evolution of RFID technology has eased the record keeping and traceability job to manifolds which used to be a hurdle in recordkeeping due to low literacy and old aged farmers or less interest in doing so. On the other hand, food safety data management is also in place which provides GAP, traceability, policies of food safety etc.

RELATIONSHIP BETWEEN ERP AND SCM

Many SCM applications are reliant upon the kind of information that is stored in ERP software. ERP is the system that integrates all that information together in a single application, and SCM applications benefit from having a single major source to go to for up-to-date information instead of Excel spread sheets. For example, if a company wants to build a private website for communicating with the customers and suppliers, they will want to pull information from ERP and supply chain applications together to present updated information about orders, payments, manufacturing status and delivery.

SUPPLY CHAIN MANAGEMENT FOR FOOD INDUSTRY

1. Frameworks:

A framework for **Food Supply Chain Management (**FSCM) is a basis for manufacturing, processing, and transforming raw materials and semi-finished products coming from major activities such as forestry, agriculture, zoo techniques, finishing, and so on (Dubey et al., 2017). In order to identify the relationships among different items, **interpretive structural modeling** (ISM) was used to establish a hierarchical framework (Faisal and Talib, 2016). This framework helps users to understand the interactions among logistics operators in a food supply chain. ISM-enabled framework was also used to support risk management in identifying and interpreting interdependences among food supply chain risks at different levels such as first-tier supplier, **third-party logistics** (3PL), etc. (Colin et al., 2011). It is observed that this framework was proven as a useful method to structure risks in FSCM through a step-by-step process on several manufacturing stages. Information plays an important role in making FSCM more efficient. In order to assess the information risks management, an ISM based framework was proposed by twining graph theory to quantify information risks and ISM to understand the interrelationships in FSCM (Nishat Faisal et al., 2007). As the global FSCM is emerging with international collaborations, ISM-enabled framework confines to explain causal relationships or transitive links among various involved parties. A total interpretive structural modeling was then introduced to analyze some enablers and barriers of FSCM (Shibin et al., 2016). In this paper, ten enablers and eight barriers are examined by separate frameworks to further understand the interactions within a dynamic era of globalization FSCM.

Currently, coordination in the food supply chain from production to consumption is significant to ensure the safety and quality of various collaboration in FSCM using of contracting approaches. This work has critical impacts on transaction cost economics by developing a closer vertical coordination. In an international food supply chain, Folkerts and Koehorst (1997) talked about a framework which integrates the chain reversal and chain management model to make vertical coordination. In their framework, an analytical service designed particularly for bench marking food supply chain projects is used so that an interconnected system of high performance and effectiveness are achieved as an integrated supply chain. Facing a global FSCM, strategic decision-making is important since the profitability of an entire chain could be increased by the holistic efforts from an efficient framework. To this end, Georgiadis *et al.* (2005) presented a system dynamics modeling framework for the FSCM. In this framework, end-users are able to determine the optimal network configuration, inventory management policy, supply chain integration, as well as outsourcing and procurement strategies. Collaboration is becoming more of a necessity than an option despite some barriers which deteriorate coordination among enterprises in food industry all over the world. Doukidis *et al.* (2007) provided a framework to analyze supply chain collaboration in order to explore a conceptual landmark in agro-food industry for further empirical research. It is observed that, from this framework, supply chain collaboration is of critical importance and some constraints such as time and uncertainties arise due to the nature of agro -food industry foods, for example agro-food supply chain. Hobbs and Young (2000) depicted a conceptual framework to achieve closer vertical

2. Models

Globalization of food production, logistics and consumption have resulted in an interconnected system for FSCM whose models play crucial role in ensuring food products of high and consistent safety and quality (Choi et al., 2016). In this section, we present related work using various models for considering five major aspects like food quality, supply chain efficiency, food waste, food safety, and value chain analysis.

IT SYSTEMS FOR FSCM

It is no debate that IT systems are essential for FSCM where so many things can go wrong such as trucks, food suppliers, data entry, etc. This section takes the traceability and decision-making systems for FSCM as examples to review the state-of-the-art situations that are useful for practitioners when they are implementing IT-based solutions.

TRACEABILITY SYSTEMS

Traceability of a food refers to a data trail which follows the food physical trial through various statuses (Smith *et al.*, 2005). As earlier as two decades ago, US food industry has developed, implemented, and maintained traceability systems to improve FSCM, differentiate foods with subtle quality attributes, and facilitate tracking for food safety (Golan *et al.*, 2004a). Some systems deeply track food from retailer back to the sources like farm and some only focus on key points in a supply chain. Some traceability systems only collect data for tracking foods to the minute of production or logistics trajectory, while others track only cursory information like in a large geographical area.

IMPLEMENTATION OF FSCM

(A) Reported cases:

Case studies from implementing various IT systems in FSCM are significant to get some lessons and insights, which are meaningful for industry practitioners and research academia. This section reports several cases using different systems for facilitating their operations or decision-makings in food supply chain from 2007 to 2017. They are categorized, which includes key information like company name, district, system, and improvement.

From the reported cases, it could be observed that, European countries have much more successful cases on using various IT support systems in FSCM. Another interesting finding is that before 2010, IT systems are used for optimization or supply chain coordination decision-makings. However, currently, companies are more concentrating on the sustainability and environmental performance in the food supply chain. For example, environmental influences like Co_2 emissions and waste reduction are widely considered.

(B) Data-driven implementations:

Data, usually used for decision-makings, have been considered in FSCM for various purposes. Data-driven implementation in FSCM is categorized into two dimensions in this paper. First is the simulation-based modeling which focuses on adopting different data for FSCM optimization or decision-making. The other is data collection from practical implementations for supporting IT systems for various purposes such as traceability, risk assessment, and so on.

For simulation-based modeling, studies mainly focus on establishing various simulation models which adopt different types of data such as product quality, customer demand for different decision-makings and predictions. In order to meet increasing demand on food attributes such as integrity and diversity, Vorst *et al.* (2009) proposed a simulation model which is based on an integrated approach to foresee food quality and sustainability issues. This model enables effective and efficient decision support on food supply chain design. FSCM is becoming more complex and dynamic due to the food proliferation to meet diversifying and globalizing markets.

IMPLEMENTATIONS

FSCM implementations from real-life industries are based on cutting-edge technologies which are used for addressing some issues faced by food supply chain. Reported cases from literature mainly concentrated on verifying some hypothesis and presenting the improvements after using an IT system (Canavari *et al.*, 2010; Soto-Silva *et al.*, 2016). Few studies highlighted the natural characteristics of food supply chain or generic issues summarized from a set of companies so that the essence of FSCM could be figured out. After that, suitable technologies can be picked up to work out the solutions for the company or involved parties in food supply chain. Regarding the complexity of food supply chain, some important issues involving waste, re-use of resources, facility sharing, greenhouse gas emissions, and holistic lifecycle management are still unaddressed (Genovese *et al.*, 2017). Take food waste for example, about 40 percent of total food produced in the USA goes as waste yearly which is equivalent of $165 billion (Pandey *et al.*, 2016). Such vast wasted food not only physically influences our environment by polluting the water, but also significantly increases the Co_2 emission since large number of pollution will be generated when they are deteriorating. Thus, reduction of food waste requires the actions at different echelons within food supply chain like food production, delivery, storage, retailing, and recycling. Regarding different echelons, associated solutions such as food production management system, WMS, logistics management system, etc. should be highly integrated in terms of data sharing and seamless synchronization.

Emerging cutting-edge techniques may contribute to system integration in the near future. First, Cloud technology has been used to integrate segregated sector using minimum resources. It allows involved stakeholders to access various services via software as a service, platform as a service, and infrastructure as a service (Singh *et al.*, 2015). Through Cloud-enabled solution, the information sharing and collaborative working principle could be achieved by using basic computing and internet equipment. Second, IoT technologies like Auto-ID and smart sensors have been widely implemented in manufacturing and aerospace industry (Zhong, Li, Pang, Pan, Qu and Huang, 2013; Whitmore *et al.*, 2015). IoT-based solutions for FSCM are able to provide an entire product lifecycle management via real-time data capturing, logistics visibility, and quality traceability. Additionally, within an IoT-based environment, every object with sensing, networking and calculating ability can detect and interact with each other to facilitate logistics operations and decision-making in a fashion that is ubiquitous, real-time, and intelligent. Third, Big Data Analytics for FSCM has received increasing attention since it is able to deal with immense data generated from food supply chain. Big Data Analytics can help food companies to make graphical decisions with more accurate data input by excavating hidden and invaluable information or knowledge which could be used for their daily operations. With such information, ultimate sustainable food supply chain could be realized by optimal decisions.

In the future implementation, giant companies play important roles in leading the food supply chain toward a green and sustainable direction. To this end, collaborations with green relationships could lead to a win-win situation that large companies will get the economic benefits, and in turn the food supply chain members like SMEs could also be benefited. That green relationship is based on the joint value creation by using new business models in terms of internal and external green integration which will be enabled by advanced technologies (Chiou *et al.*, 2011; Gunasekaran *et al.*, 2015). So these companies may take initial actions to be equipped by advanced IT systems, while up-stream and down-stream parties within food supply chain can follow up for a green future.

Finally, the implementations need the involvement of government bodies which are going to work out strategic plans for guiding and supporting various enterprises toward a better future. Thus, Big Data Analytics is extremely important for these bodies to figure out up-to-data statistics report, current status of a food supply chain, and industrial feedbacks. Further to identify the strategies, they can use advanced prediction models or data-driven decision-making systems for assisting deeper analysis. As a result, each individual end-user could be beneficial from future implementation.

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