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THE IMPACT OF DIGITALIZATION ON SUSTAINABLE FOOD SUPPLY CHAIN MANAGEMENT[1]

Abstract: The food supply chain includes all activities from the transformation of inputs to the creation of the final product and its consumption, that is, all activities from the farm to the retail shelf. With the increase in complexity, actors in food supply chains face greater risks in the market so they must follow the latest trends and changes in the food market, and react quickly to challenges. In addition to economic, food supply chain management faces sustainability challenges as well. Instead of focusing only on their own growth and expansion, actors in food supply chains must consider how their business affect the environment and the interests of their communities. On the other side, consumers demand realtime updated information on food they consume and they want to know if the food they are consuming is environmentally and socially sustainable or not. For this reason food product traceability, safety and sustainability issues have become a crucial concern to food retailers and everyone else in the food supply chain. The aim of this paper is to point out digitalization as a solution to those issues. Particularly blockchain as an emerging transformative technology for supply chain management. Secondary data and methods of induction, deduction, synthesis ana analysis were used for the purpose of writing this paper.

Keywords: Digitalization, blockchain, sustainability, food, supply chain, management

1. INTRODUCTION

Globalization and internationalization of business in synergy with other processes, such as: the development of information and telecommunication technology, the improvement of logistics capacities, the increase in consumers` awareness and information, the importance of ethical issues, etc., have led to strong competition on the world market. Achieving a significant competitive advantage, and especially its preservation and improvement, represent one of the biggest challenges for every company. The relentless struggle to win and retain customers has led to a number of competitive strategies, from those focused at the lowest possible costs to those focused at achieving differentiation and premium pricing (Porter, 2007). Basically, company need to create more value for its customers, and to manage its operations more efficiently than its competitors.

The search for the most successful competitive strategy has led to an increase in awareness of the companies` dependence on its stakeholders. The company is not an isolated market player whose business results are outcome of solely its individual efforts. On the contrary, its business results are largely determined by the effectiveness of the

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activities of its suppliers, intermediaries, retailers, etc. It is actually part of the wider supply chain as a network of organizations with which it establishes appropriate relationships. The ways of establishing cooperation and coordination with its business partners, often are a dominant factor in company`s business success. In accordance to that, in modern business, competition between different supply chains in relation to competition between different companies is becoming more important for achieving and maintaining market share. These ideas represent one of the foundations of the development of supply chain management.
The world is well into its Fourth Industrial Revolution (Industry 4.0) where many things, including food, are affected by emerging technologies (Amentae & Gebresenbet, 2021). Digitalization has been emphasized as a key factor to bring supply chains into the new era. Food supply chains can overcome key challenges such as traceability, safety and sustainability by applying one or more modern technologies. In this paper, the emphasis is on blockchain technology by which every important product information can be collected, stored and shared with the actors involved in the supply chain from the first phase to the final consumer (Kurucz et al., 2021).
The paper is organized as follows: section 1 contains introduction; section 2 explains development of supply chain management; section 3 provides insight into key issues of sustainable food supply chain management; section 4 describes the impact of digitalization on the transformation of food supply chains and it also provides an overview of blockchain; section 5 represents the conclusion of this desk research.

2. DEVELOPMENT OF SUPPLY CHAIN MANAGEMENT

Supply chain management, as a recent phenomenon arised in the 1980s, is in the focus of the economic theory and practice today. It indicates the need to integrate and manage movements of materials from numerous suppliers, through intermediaries, all the way to numerous end customers. Supply chain management strategy today must be indispensable part of every successful businsess strategy, and that requires long-term internal and external integration among the actors of the supply chain, which implies sharing of interests, processes, information, risks, rewards, etc (Arredondo & Alfaro Tanco, 2021, p. 13). The basic characteristics of supply chain management include (Mentzer et al., 2001, p. 7):

- "A systems approach to viewing the supply chain as a whole, and to managing the total flow of goods inventory from the supplier to the ultimate customer;
- A strategic orientation toward cooperative efforts to synchronize and converge intrafirm and interfirm operational and strategic capabilities into a unified whole; and
- A customer focus to create unique and individualized sources of customer value, leading to customer satisfaction."

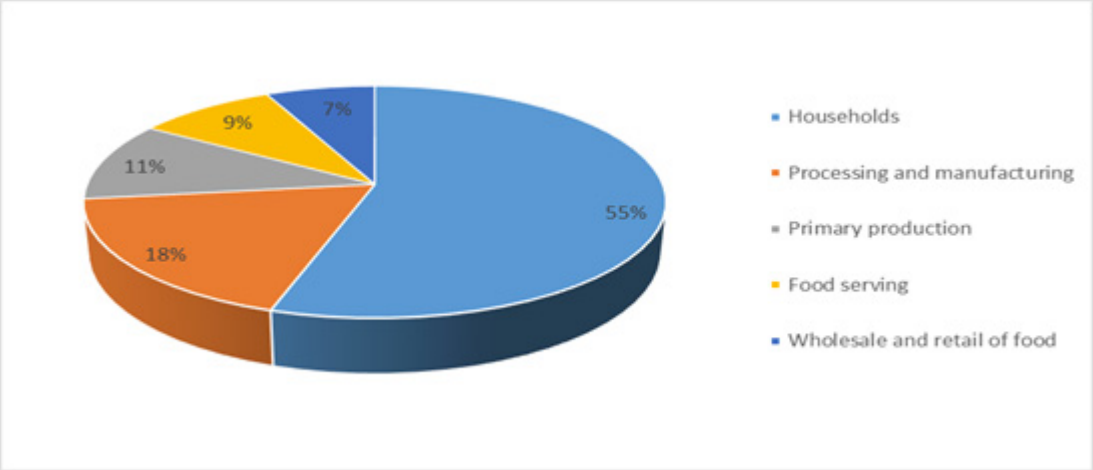
The emergence and evolution of supply chain management was influenced by the development of other phenomena. One of them is the need for a "holistic approach" or internal alignment that implies recognition of the importance of coordinating various functions within the organization. In addition, the increase of worldwide business activities has forced companies to turn to global sourcing, so they had to find more effective ways of developing and maintaining long-term relationships with their remote suppliers and customers. Other factors, such as the development of information and telecommunication technology, social networks, corporate social responsibility, geopolitical turbulence, etc. resulted in increasing consumer demands regarding the time and quality of deliveries. Fast delivery, exactly on time, became a necessary condition for market survival.
It is of an immense importance to understand the relationship between supply chain management and logistics management, because supply chain management originated from the concept of logistics and is deeply connected to it. Supply chain management includes logistics management, so it represents a broader concept (Council of Supply Chain Management Professionals, 2023). Unlike logistics, that is focused at the the movement of materials at the level of one business entity, in the focus of supply chain management are all the movements within one supply chain of a certain distribution channel (Božić & Aćimović, 2021, p. 17). It includes all aspects of the product life cycle, so it implies coordination between the business functions of logistics, marketing, production, finance, product design, etc. Given that product life cycles are getting shorter and shorter, the company's ability to respond quickly and flexibly to customer demand is an important source of competitive advantage in modern business conditions. The availability of the product on the market thus becomes a factor that is of a great influence for the customer when making a decision to purchase a certain brand, or when making a decision about its potential substitution with another brand in situations when the product is not available. Therefore, all activities within the supply chain must be viewed as a whole, and the main goal of supply chain management must be to achieve a sustainable competitive advantage. Logistics management must be oriented towards the complete satisfaction of consumer needs.
It is also necessary to point out the difference between the terms supply chain and supply chain management. A supply chain involves a series of processes (decision making and execution) and flows (materials, information and money) that aim to fulfill the requirements of end customers and that take place within and between different stages of the supply chain (Worst, 2004, p. 3). It includes all actors, regardless of whether they contribute to the satisfaction of consumer needs directly or indirectly. The number of actors in a given supply chain can vary, and accordingly it can be more or less complex. It is most often made up of the manufacturer, its suppliers, transporters, warehousers, wholesalers, retailers and other intermediaries, as well as the consumers themselves. Therefore, every company belongs to a specific

supply chain because it can not operate in the market without appropriate partner relationships. Even more, each company is simultaneously part of several supply chains within which it realizes multiple business connections.
Interconnections between individual actors within a supply chain can be of different strength and intensity depending on the importance that certain partners have for each actor. Therefore, it is very important to manage mutual connections, i.e. supply chain. This is precisely what makes the fundamental difference between supply chain and supply chain management, because a supply chain can exist without being managed. Effective supply chain management involves achieving appropriate speed, reliability, flexibility and cost in meeting customer requirements (Janvier-James, 2012). To be effective, all links between the actors within the chain must function well. Therefore, all connections must be controlled in order to have a higher level of integration.

3. KEY ISSUES OF SUSTAINABLE FOOD SUPPLY CHAIN MANAGEMENT

It is important to emphasize that food supply chain management is of an immense importance because food is necessary for human lives, and therefore food production and distribution represent significant part of every national economy. In 2023, the high-income and upper-middle-income countries comprised the major share of the global food import bill estimated around 2 tn US$, with 62 % and 25 % respectively (Food and Agriculture Organization of the United Nations, 2023, p. 83). The global food market in 2024 was valued 10.07 tn US$, its expected annually growth 6.53% (CAGR 2024-2028), and the value added 1.14 tn US$ (Statista, 2024).
The food supply chain includes all activities from the transformation of inputs to the creation of the final product and its consumption, that is, all activities from the farm to the retail shelf, such as: agricultural production, processing, packaging, marketing, storage, transport, retail, consumption, etc., but also waste disposal. Therefore, it is comprised of a large number of actors, operations and processes, which aim is food availability at the right time, right place, right price, right quality and right quantity. Food supply chains are complex because of the very nature of food as a commodity, that is its perishable to a greater or lesser extent, and it implies appropriate terms of use, ways of storage and/or consumption. In addition, the increase in the complexity of food supply chains is influenced by the growing number of actors, operations and processes; increasing physical distance between actors; implementation of strict quality, health and safety standards; etc.
With the increase in complexity, actors in food supply chains face greater risks in the market, so they must follow the latest trends and changes in the food market, and react quickly to challenges. To achieve this, successful management of food supply chains is crucial. According to Zhong, Xu & Wang (2017, p. 2086) food supply chain management "has been coined to depict the activities or operations from production, distribution, and consumption so as to keep the safety and quality of various food under efficient and effective modes".
In an efficiant and effective manged food supply chain is extremely important that each individual actor contributes by implementing their business operations and processes in the most optimal way. This means creating added value at the lowest possible costs. The Global Supply Chain Forum has precisely emphasized this aspect in its definition of supply chain management as "the integration of key business processes from the end user through original suppliers that provides products, services and information that add value to customers and other stakeholders" (Lambert & Cooper, 2000, p. 66). Added value is created at each stage of the value chain (Porter, 2007). Therefore, food supply chain management implies permanent efforts to increase the efficiency of the operations of all individual actors, while at the same time improving the coordination and optimization of their mutual connections, in order to generate the maximum total value at the level of the entire chain. This total value of the supply chain is defined as the difference between the value that the final product has for the consumer and the costs of the entire supply chain incurred to satisfy the consumer's demands (Chopra & Meindl, 2016, p. 15). The total value generated by a given supply chain must be greater than the simple sum of the individual values generated by its actors, i.e. there must be a synergistic effect.
In addition to economic, food supply chain management faces sustainability challenges as well. Instead of focusing only on their own growth and expansion, actors in food supply chains must consider how their business affects the environment and the interests of their communities. They have to be responsible and behave in a way to satisfy "the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Their approach in identifying, adopting and responding to sustainability issues must be proactive. But not only that they have to be responsible for their own beahviour, actors should also use their power to influence other business entities operating within and outside their food supply chain to adhere to sustainablity principles.
Sustainable development incorporates three dimensions: economic, environmental and social. The economic dimension refers to profitability, innovations, productivity, return on investments, etc. The environmental dimension includes use of energy sources, carbon footprint, loss and waste, plastics pollution, etc. The social dimension considers pay scales, labour conditions, ethical issues, community welfare, etc. When establishing a sustainable food supply chain, it is necessary to take into account all the three dimensions and their interaction with each other. Therefore, a sustainable food supply chain must be profitable and competitive on the market while incorporating social and environmentally responsible business practices of its actors.

For example, one of the major challenges to sustainable food supply management is food loss and waste. It is estimated that losses between harvest and retail represent 13%, and that households, food service and retail waste amount around 17% of the globally produced food (United Nations, 2024). But the value of food loss and waste is only part of a wider problem. Food loss and waste include in themselves all the invested resources as well as all the negative consequences of the environmental pollution during all the stages and movements in the food supply chain, from raw materials to final product. As the graph 1 shows in the structure of European Union`s waste in 2020, households dominated, generating around 70 kilograms per inhabitants.



Graph 1: Food waste in the European Union, 2020
Source: Eurostat, 2022, p. 101

In order to achieve sustainability, and to eliminate incidents, frauds and scandals, the implementation of a traceability system in food supply chains is of invaluable importance. Traceability is defined as "ability to follow the movement of a feed or food through specified stage(s) of production, processing and distribution" (International Organization for Standardization, 2007). It is believed that the scandal known as "mad cow disease" that occurred in the United Kingdom in 1986 raised the issue of traceability and prompted the adoption of the EU food Regulation No 178/2002 or the General Food Law Regulation. The Regulation establishes the general principles and requirements of safe food and feed, and it covers all stages of food and feed production and distribution (Pettoello-Mantovani & Olivieri, 2022, p. 1).
The food traceability system has been mandatory in the European Union since January 1, 2005, so all actors in food supply chains must implement it. They must be able to identify the origin of the food and feed ingridients, and provide that information to the authorities as quickly as possible. As sustainable food supply chains are becoming longer and more complex, with an increasing number of actors, and the distance between them becoming less relevant, the issue of trust and transparency among the actors in the supply chain is of particular importance. So, the role of each actor in sustainable food supply chains must be precisely defined. Besides that, each actor must ensure access and exchange of key and useful information to its partners.
"One step back-one step forward" or "one step up-one step down" principle is in the core of traceability. It implies that the traceability system should be set up in such a way that each actor in the sustainable food supply chain must be able to track back the traceable unit to the initial source (the first supplier), i.e. to follow the flow backwards (GS1, 2012). Aslo, each actor in the sustainable food supply chain must be able to follow the flow forward, to the ultimate recipient of the traceable unit (the final consumer). Although, total traceability is not required for the entire supply chain, the supplier of the traceable unit and the recipient of that same traceable unit must have the necessary documentation of at least one common level of the traceable unit. This implies that each actor in the food supply chain must keep records that represent the link between its individual activities and its traceability system. In this way, each actor is responsible only for that phase in the chain that is under its control. By connecting all stages in the supply chain, complete traceability of the entire chain is achieved.

4. FOOD SUPPLY CHAIN TRANSFORMATION THROUGH DIGITALIZATION

During the last few decades consumers have become more educated. Today, consumers demand realtime updated information on food they consume and they want to know if the food they are consuming is environmentally and socially sustainable or not. They, also put too much emphasis on food ingredients and nutritional composition (Abideen et al., 2021). On the other side, with the globalization, food supply chains became longer and more complex what made them difficult to manage (Kurucz et al., 2021). For this reason, food product traceability, safety and sustainability issues have become a crucial concern to food retailers and everyone else in the food supply chain (Gharehgozli et al., 2017).

Best solution to this problem is digitalization. Why? Because it allows food supply chain to be highly connected, efficient and responsive to consumer needs and regulation requirements. Advances in digital technologies offer a way to optimize the food supply chain (Azzi et al., 2019). Likewise, the digitalization of the food supply chain has been considered a necessity to achieve sustainable competitive advantage and decrease value chain risks (Rejeb et al., 2022).
Nevertheless digitalization itself is not new. Over the years several digital technologies have already been used in the food industry (Gharehgozli et al., 2017). According to Khajavi & Holmstrom (2015) the advancement of digital technologies through years and the availability of big data have enabled food supply chains to be more efficient. That's how they became more cost effective with less labour needs and mistakes along the chain. Today, digital and smart chains are reforming the food chain to help eliminate waste and improve food safety (Abideen et al., 2021).
A few years ago eight emerging technologies were proposed with the aim to transform the traditional food supply chain into a digitalized one (Kittipanya-ngam & Tan, 2019): 1) Artificial Intelligence (AI); 2) Internet of Things (IoT); 3) Augmented Reality (AR); 4) Virtual Reality (VR); 5) Robots; 6) Blockchain; 7) 3D printing; 8) Drones. In this paper, the emphasis is on blockchain technology by which every important product information can be collected, stored and shared with the actors involved in the supply chain from the first phase to the final consumer (Kurucz et al., 2021).
Why blockchain? As an emerging transformative technology for Supply Chain Management, blockchain can offer a solution to many problems such as accessibility, security, accountability and accuracy. According to Saberi et al. (2019) this technology can bring significant improvements in terms of transparency, efficiency and sustainability. It can also offer digital trust among supply chain members (Rejeb et al., 2022). Data is usually stored in time-stamped, tamper-proof, immutable and chronologically connected blocks secured with cryptography (Feng et al., 2020). After being distributed in several nodes data is completely transparent and secure providing the opportunity to the chain memebers to trace the product from the very beginning (Awan et al., 2021). It generates trust without the need for a trusted third party (Patel et al., 2022).
What is blockchain? Blockchain can be defined as a digitalized, decentralized and distributed ledger system for storing and sharing information (Nofer et al., 2017; Saberi et al., 2019). A distributed ledger is a database that is updated independently by each participant (node) on a large network (Presthus & O'Malley, 2017). Each transaction in the public ledger is verified by consensus of a majority of the participants in the system (Kurucz et al., 2021). According to Patel et al. (2022) blockchain is a distributed database that stores information electronically in digital format. Blockchain records and validates user transactions that can not be altered or deleted. These actions are known as „blocks". Each block is having its own digital signature and a connection to the previous one. That is how it creates a growing list of chronologically arranged encrypted records (Abideen et al., 2021).
Blockchain is trustworthy, decentralized, reliable and consists of blocks with sequential transactions. It consists of two parts as it is shown in Figure 1. First part – Block Head er links the forward block. In this way it enables users query, monitor and examine data. Second part – Hash function that forwards blocks. This chained data structure allows each block in a blockchain to keep the previous block's contents. At the same time it injects new data at the head of the next block. Each block corresponds to a timestamped record that is verified through a defined consensus protocol of the blockchain network and secured via public-key cryptography (Seebacher & Schuritz, 2017).

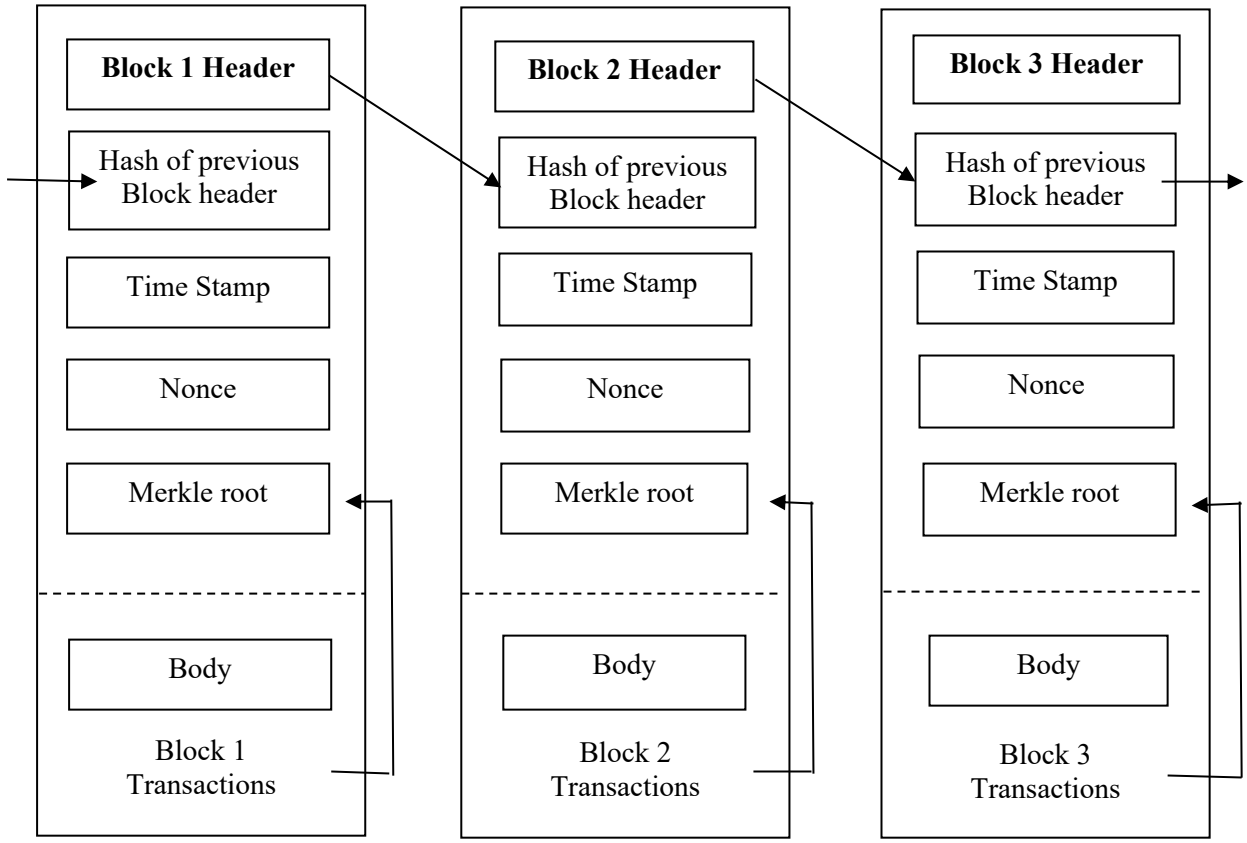


Figure 1: Data structure of Blockchain
Source: Patel et al., 2022, p. 324

What are the main characteristics of blockchain technology? According to Christidis & Devetsikiotis (2016) those are:
1) Trustable exchange of information through blockchain in real time;
2) Accessible information to all members of supply chain;
3) Possibility of automatic execution of agreed transactions when certain requirements are met through smart-contract applications. Smart contracts are computer programs that can automatically execute the terms of a contract (Kurucz et al, 2021).
Blockchain in food supply chain? Figure 2 shows how does it look like when the blockchain technology is applied in the food supply chain.

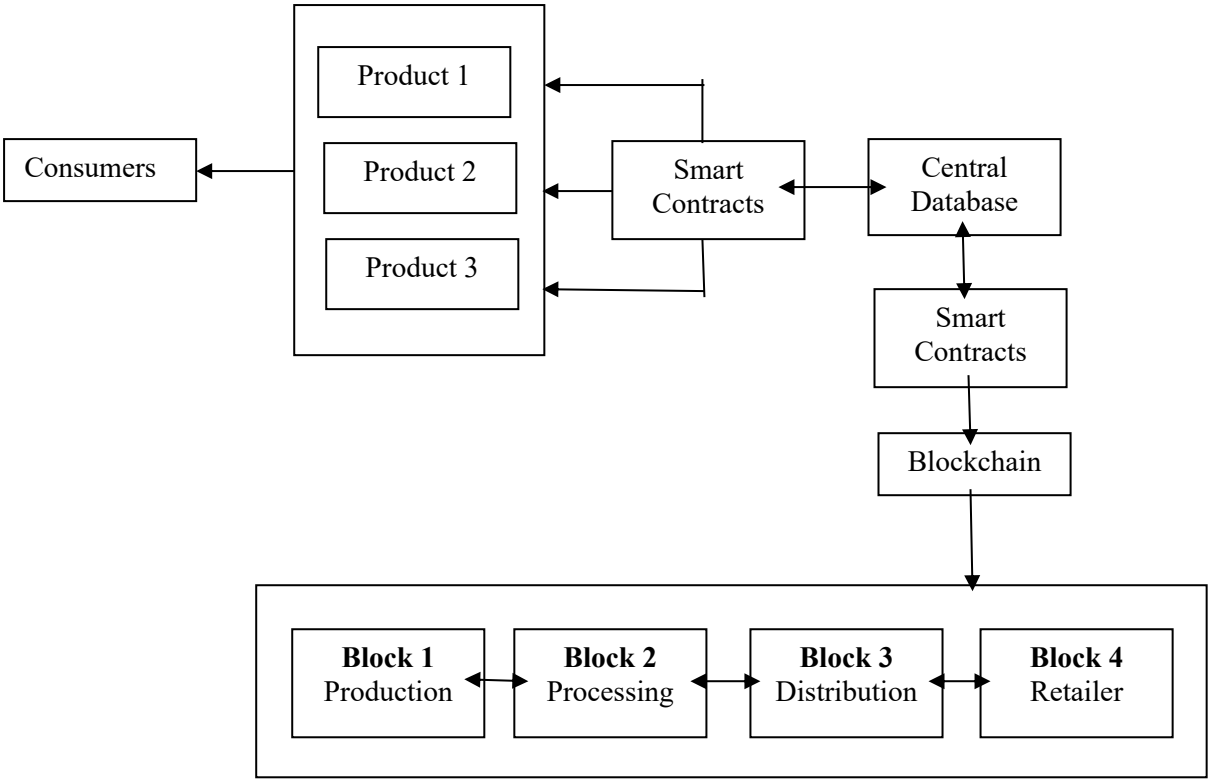


Figure 2: Data structure of Blockchain
Source: Patel et al., 2022, p. 325

Why use blockchain? Compared to traditional supply chains, where any type of data can be changed, blockchains enhance privacy. Blockchain offers data consistency and integrity. It also reduces supply chain costs.

5. CONCLUSION

There are always rwo sides to a coin, teo sides to a story. It is the same now. On the one hand, we have demanding, educated consumers who are looking for realtime updated information about the food they consume. On the other side, there are food producers and retailers who face problems like food product traceability, safety and sustainability. Best solution for both sides is digitalization. Digitalization is much more than an investment in technology. It can be defined as a long-term strategic issue that requires commitment, adequate skills and resources. Application of blockchain technology in food supply chains can help both sides. It can help reduce time, operations become more traceable, food product information can be monitored and shared and, last but not least, quality of food products can be ensured.
The basic limitation of this paper is reflected in the fact that it is theoretical. Of course, as such, in future it can serve as a basis for empirical research on the application of blockchain technology in Serbia.

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