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CHALLENGES IN THE FOOD SUPPLY CHAIN MANAGEMENT

From

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Abstract

In current years the intricacy of the food industries has augmented, resulting in the appearance of various potential risks. The operating systems implemented by food companies to deal with these possible threats are of great importance both for the economy of a country, but also for humans and the environment. The distraction of the food supply chains' operation has significant consequences on the health of the wider society as well as the global economy. At the same time, there is a shift in human demand and needs, therefore it is increasingly necessary to study and know the technologies that help identify and encounter these risks. The purpose of this dissertation is the identification and analysis of the risks involved in the food supply chain and some technologies which are implemented in order to detect and finally protect the supply chain. First, the international literature on food supply chains' management and risk definitions are presented, followed by the main risks that threaten the food supply chains' operation. Also, two innovative technologies on the detection and protection of the supply chains' efficient operation are introduced. Subsequently, an empirical survey was conducted with the distribution of 50 questionnaires to food industries, which were answered by employees working in different departments within these industries. Descriptive statistical analysis of the responses was applied. Results of the research reclaim the weight of the existing models/operating technologies and the benefits and drawbacks that these have in the risk management of a food supply chain and suggestions for future work are outlined.

Keywords: *Food supply chain, Risk, Risk Management, Blockchain technology, Pre-warning system*

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1. INTRODUCTION

1.1. Introductory Remarks

Risk management is a very important science, which is becoming more and more important for businesses. It is essentially a tool of modern administration and public relations with the main goal of analyzing and managing the risks faced by a company, organization, person, or country (Pearson and Clair, 1998).

A risk can be due to either natural disasters, accidents, natural disasters, health problems, technical failures as well as market forces and the economy are the main manifestations of possible crises that a company or a state may face (Pearson and Clair, 1998).

This dissertation will analyze the risks that threaten the food supply chain of a company as well as some technologies that aim at their timely detection and treatment.

1.2. Necessity of Dissertation

Food is a good with a very important role and incalculable value for life, people, and the economy of each country. For this reason, food supply chains must be treated with great delicacy and protect them from any potential risks. However, in recent years there has been an increase in the emergence of risks, with catastrophic consequences for both the economy and man himself.

The need to find appropriate measures to protect food chains is constantly growing. With the development of technology, the construction of hazard detection systems, as well as various models using artificial intelligence, have shown that if they work efficiently, they can significantly reduce their destructive effects.

In this light, it is necessary to further investigate the operating systems and the risk management models of food companies, in order to analyze and determine their efficiency and the ways in which companies and organizations can implement them.

1.3. Purpose of Dissertation

The purpose of this dissertation is the importance and necessity of maintaining a food chain, the analysis of the efficiency of existing risk detection systems, as well as all the measures that can be taken to address a potential threat.

The main objectives of this dissertation are summarized in the constructive and in-depth analysis of the above issues as well as in the study of the way in which they are applied, in order to present a comprehensive overview on the topic.

1.4. Structure of Dissertation

The dissertation is developed in 6 chapters, first introducing the reader to the meaning and value of the food supply chain, and then analyzing the risks that threaten it.

In the first chapter, a reference is made to some introductory concepts on the subject of the dissertation. Then, the necessity and the contribution of the specific thesis, as well as its purpose are emphasized. At the end of the first chapter is presented the structure of the chapters of the dissertation.

The second chapter constitutes the theoretical framework of the dissertation. More specifically, a reference is made to the concept of the food supply chain and the risks involved. These risks are then analyzed, and the various categories are presented depending on the area in which they operate. Furthermore, the effects of the coronavirus on the food supply chain are listed.

In the third chapter, the overview of research on the topic of the dissertation begins. More specifically, the analysis of 2 systems that are used as means of prevention and management of imminent risks is performed. The way of application of each of them and their advantages and disadvantages are presented.

The fourth chapter presents the empirical part of the dissertation. In more detail, the research methodology used to conduct the present investigation is listed. First, the population and the sample (50 respondents) of the research are presented, while then the content of the empirical research is presented in detail. Finally, the fourth chapter concludes with the citation of the

methodology of statistical analysis of primary data collected through the electronic questionnaires that were shared.

In the fifth chapter, the results obtained from the processing of the questionnaires are presented. In more detail, the results from the descriptive statistics performed using the Microsoft Excel computer program and the SPSS program are presented, where for each question there are some tables and diagrams concerning frequencies and percentages.

Finally, in the sixth and last chapter, the conclusions resulting from the statistical processing of the results obtained in the dissertation are recorded, as well as the comparison of the results of the present research with other research from the literature.

2. THEORETICAL APPROACH

2.1. Supply Chain

According to (Ganesham and Harrison, 2002) a supply chain is a system that includes all the facilities and the disposal alternatives that a company must adopt, in order to operate all the stages from the production of a product, until its final destination, the consumer. This process consists of the acquisition of the raw materials, their convention into transitional and then final products and ultimately their distribution to the public. Supply chains are fundamental for each company or business, and, in turn, they rely on the supply chain's operations - comprising of the design, manufacture, delivery and then use of each product or service (Mishra and Singh, 2019). Although all companies deal with a specific target group and possess distinctive requirements and risks, there are still many commonalities. The decisions made in every company have to be taken, both individually and as a whole, with regard to their functions in the following five areas:

1. Production
2. Inventory
3. Location
4. Transportation
5. Information

2.1.1. Food supply chain management

As claimed by Folkerts and Koehorse (Folkerts and Koehorst, 1997), food supply chain is "a set of interdependent companies that work closely together to manage the flow of goods and services along the value-added chain of agricultural and food products, in order to realize superior customer value at the lowest possible costs". Food production, in contrast to other sectors, occurs in more sensitive value chains, necessitating greater attention to managing activities such as manufacturing and warehousing (Yu and Nagurney, 2013a; Aung and Chang, 2014a; Ting *et al.*, 2014a). Furthermore, food has an inherent ability to shift in quality over time, which necessitates

more effort in order to maintain food safety standards (Aung and Chang, 2014a). The condition and "freshness" of food products may be influenced by external factors like climate and transportation. Processed and prepackaged products with an extended expiry date, may have more complicated manufacturing processes including several components. Adequate awareness to the quality of raw materials and the manufacturing process is also needed, as composite food manufacturing entails a greater possibility of product setback (Ting *et al.*, 2014a; WHO (World Health Organization), 2016; Lin *et al.*, 2018a). Contaminated products, food poisoning, inferior foods, imitation goods, mislabeling, and undisclosed substances after manufacture, are all examples of food malfunctions. Each element and process of the food supply chain, plays a significant role in the effectiveness and utility of the manufactured product. To sustain the value chain and reduce product collapse, the food supply chain demands increased productiveness and tighter partnership engagement.

The current food supply system is centralized, relying primarily on central authorities to manage sharing of data. Centralization may jeopardize supply chain accountability, resulting in information injustice and concerns of trustworthiness (Tian, 2016a, 2017a). Companies might opt to offer public certain information that avails their company's reputation (Mao *et al.*, 2018). Corporations, on the contrary, can conceal details just so clients solely discover whatever both corporations and governments would like them to discover. Corruption is more likely to occur in a centralized supply chain (Tian, 2017a). As a result, a minor mistake might cause the entire supply chain network to be damaged (Tian, 2017a). It becomes even more difficult for customers to determine the legitimacy of some items, for example organic, kosher, vegan, or green products, if there is lack of proof of customers falling ill as a possible consequence of ingesting them. As a result, people are more concerned about food crises and seek more information about items prior making a purchase.

2.2. Risk definitions

The word risk is vague, and it diversifies according to the way and to by whom it is used. It is said that it either originates from the Arabic word *risq* or from the Greek word *risicum*. Among these concepts are the following:

- A threat or danger
- A probability
- The total appraisal of probability and size of the consequence
- A measure of dispersion

The most accurate description of risk comes from the Royal Society in Britain which outlines it as the possibility of a risk to arise throughout a specified period or accrue as a consequence of a threat. According to the statistical theory, a risk follows the rules of blending these possibilities, in order to receive all the feasible combinations. Another outstanding definition was conducted by (Deloach, 2000) who characterized a risk as a potential consequence on a company's performance, due to variations in the subjacent variables. He underlines that as the spread of potential results is increasing, it is becoming more possible for the company to be exposed to precarious outcomes, which can have either positive or negative results in the company's performance. The significance of the company's exposure to change, the probability of these changes to take place and the company's competence to control them are a combination of variables to the company's vulnerability.

2.2.1. Risks distinctions

"Strategic decision making" (Mach and Shapira, 1992), "tactic" (Sitkin and Pablo, 1992; Wiseman and Bromiley, 1996), "operational processes" (Newman, Hanna and Maffei, 1993a; Pagell and Krause, 1999), "auditing" (M. C. Ashton, 1998; Baucus *et al.*, 2008), and "economics" (Ho and Pike, 1992; Chow and Denning, 1994; Celly and Frazier, 1996; Lassar and Kerr, 1996) have all been explored in multiple corporate compositions.

Supply systems are becoming more intricate and difficult as a consequence of rapid business advancements. As a corollary, risk is increasing and spreading throughout supply chains. Managers must be able to handle risks from a broader range of sources and situations. When corporations produced in-house and regional, and delivered directly to the public, risk was less diffused and easier to handle. As a result of increased product complexity and outsourcing of supply networks across country boundaries, risk is expanding, and the location of risk has shifted towards sophisticated moving supply networks.

2.2.2. Static and dynamic risks

In the available literature there are two identifications of risks – static and dynamic risks. Static risks refer to all the risks that can solely have a negative result and will therefore lead to economic loss (Singh, Jain and Mishra, 2009). Dynamic risks on the other hand can have both negative and positive effects on a business (Singh, Jain and Mishra, 2009).

Relativity is another perspective which can also affect the outcome of it. For example, relativity denotes that when a natural disaster occurs and the results of it are not as harmful as to another company (Singh, Jain and Mishra, 2009).

2.2.3. The circle of risks

Insurable risks have traditionally been the focal point of risk management, but in a broader sense, commercial and non-commercial risks have been divided. Noncommercial risks, on one hand, can only result in wastages, whereas commercial risks, on the other hand, can avail a business, but also economically harm it. Another way to categorize risks is to divide them into dynamic and static risks, with dynamic risks roughly correlating with commercial risks and static risks corresponding to non-commercial risks (Singh, Jain and Mishra, 2009). The "circle of risks," as defined by (Hamilton, 1996), is a complete assessment of all dangers that potentially affect a business.

The circle of risks is naturally separated into two halves. The right side of the diagram depicts operational, static hazards in production, with the most significant risk being a disorganization in the production circulation. The majority of the risk manager's work is reflected on this side. The dynamic hazards outside of production, such as inflation, latest regulations, and terrorism, are added in the left half. This half is inserted in the circle of risks to provide a complete picture of the organization's risk status.

2.2.4. Risks within the production

There are four different categories included in the production risks. To start with, employee risks consist of accidents within the production process, drug addiction issues and harassment in the workplace. Problematic working conditions can cause intolerable levels of hardship and working accidents, that may be followed by a higher absence rate or even a continuous staff turnover. Major upheavals can in this way be raised in the production, which can reduce the product's standards. A second type of a production risk refers to property risks. This category includes all the property impairments, generated by natural disasters, as for example fires, floods etc. The development of technology has benefited a company regarding handling fires, which used to be the most dangerous threat in the production procedure and harm the business's performance. One additional category which seems to be more significant nowadays, refers to the environmental risks, which involve pollution and contaminations. One big threat companies must encounter in recent years, is criminal acts among the employees. This classification contains sabotage, industrial espionage, theft, and fraud. Employees are becoming more and more accountable for these threats, as there is a current trend for criminal operations in the inner environment (Singh, Jain and Mishra, 2009).

2.2.5. Risks that occur outside the manufacturing process

Inflation, trade agreements, new terms of competition, currency hazards, and other market risks are all factors to consider. In recent years, financial transactions have become a significant danger. Because of the hazards connected with speculating in stocks, foreign currencies, and other financial instruments, most large corporations today have some type of finance policy in place. Liability risks include, for example, environmental and product liability, as well as contract-related hazards. When a company's product causes injury to a person or property, it is called product liability. Damage lawsuits provide the greatest danger in the United States, because compensation demands are typically very large. To reduce product liability issues, it's critical to have a quality assurance system in place that ensures products and services meet customer expectations. New legislation, terrorism, nationalization, and social revolution are all examples of political hazards.

Politically unstable countries are more vulnerable to changes that might drastically alter economic situations. As a result, holding businesses in such nations carries significant political risks (Singh, Jain and Mishra, 2009).

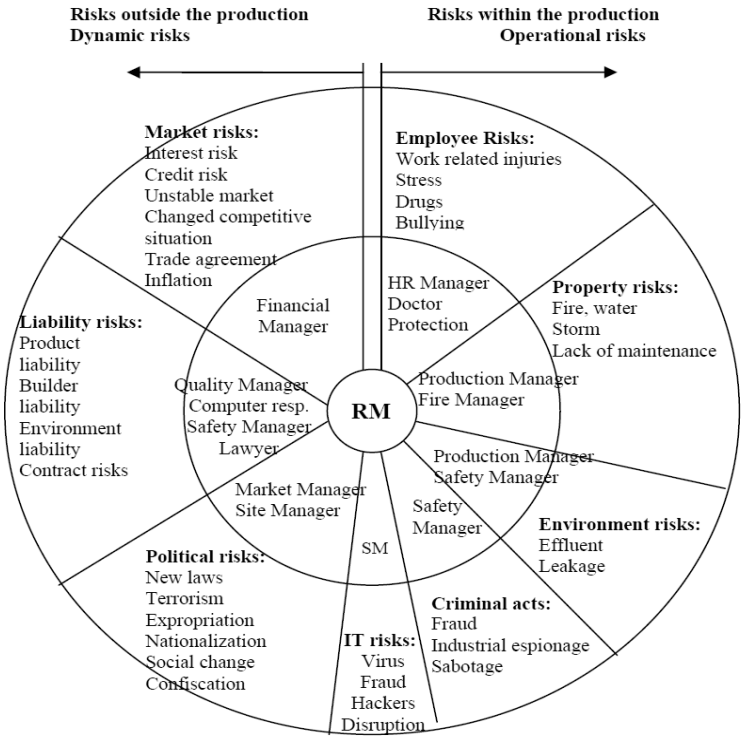

Image 1: The circle of risk (Hamilton, 1996, p.16)

2.3. Food supply chain risk factors

The complexity of the food supply chain depends on the change of the food industry in recent years. The food industry focuses not only on the local market, but it also started cooperating with businesses internationally. This new trend influences the food industry creating a more diversified and refined form of industry. Having that in mind, risk factors are differentiated and their possibility of existing has grown. Taking into consideration the four principles of objectivity, significance, system and continuity, five primary risks can be identified in the food supply chain: quality risk, market risk, logistics risk, cooperation risk and environment risk (Haishui and Jun, 2018).

Quality Risk

The food supply chain's quality risk, which stems from the food's substances and the intricacy of the supply chain system, can arise at any point along the chain. Natural circumstances have an impact on the food production and storage environment. Food is produced in a seasonal and regional manner. Each consumer has his unique taste when it comes to food (Haishui and Jun, 2018).

The food's appearance and inherent quality can be threatened by the food supply chain's quality risk, which can disrupt and jeopardize the supply chain's usual operation. Based on the system theory, it is assumed that quality risks exist throughout the food supply chain, from the delivery of raw materials to completed products. The quality of the completed products depends on the quality of the raw material, which in the majority consist of agricultural products. For example, if the quality of raw material is poor, then the goods generated from them will be poor as well. If these products reach customers, the entire food supply chain's reputation is jeopardized. These variables, such as the misuse of chemicals and artificial ingredients, the usage uncertificated packaging materials, and obsolete and non-compliant manufacturing and distribution machinery, can all result in enhanced issues in the food processing industry. The product has a large market region; thus, the circulation lasts longer and there are numerous links in the process. Heat and humidity are elements that cause some foods to decay owing to their own or packaging factors. This relationship poses little risk to upstream raw material suppliers and product manufacturing firms, but it is catastrophic to downstream wholesalers and retailers. In terms of sales linkages, monetization strategies are various, and many merchants lack sticking and hygienic conditions, resulting in concealed threats in sales quality (Haishui and Jun, 2018).

As presumed, the food supply chain's quality risk might arise at any time throughout the chain. Even though the effects of individual links vary, from the viewpoint of the complete supply chain, issues in any of them will result in the decrease of the overall supply chain's objectives (Haishui and Jun, 2018).

Market Risk

Market risk is linked to unknowns, including modifications to the existing market, market pricing, and financial policies that cause producers' or businesses' production goals and market

trends to divert, leading to economic damages and material inefficiency. The supply chain represents the central chain and the market the fountain of funds. Therefore, the production system can only function properly if it obtains benefits. However, fluctuations in the market requirements are associated with food prices, consumer economic status, consumer geographical location, consumer tastes and the amount of competitors. Volatility in customer preferences is a factor that raises the supply chain's operational risk, due to the fact that it becomes harder to determine whether a product follows the market's standard guidelines and build a manufacturing plan that respects them. The knowledge about food market need is reinforced from downstream consumers to upstream providers, which inevitably results in a supply and demand mismatch in the food supply chain, diminishing total functional expenditures and efficacy (Haishui and Jun, 2018).

Logistics Risk

The logistics risk pertains to the transfer of crude material to the actual products that can be used by the customers. These risks can emerge from loading, transportation, packaging and shipping, warehousing, and storage of food. Food ingredients have degraded or have been exposed to environmental contamination during the supply chain's procedure of transportation, resulting in enterprises' failure to release on schedule and in the correct volume, disrupting the supply chain's agility. Simultaneously it can impact the product's features and constitute a danger to people as well (Haishui and Jun, 2018).

Risk of Cooperation

The risk of cooperation is related to the hazards posed by the collaboration among different firms, such as limited assistance, and the incapacity of a particular part to satisfy the associate's expectations. Inadequate collaboration can result in restricted organizational performance, scarcity of antagonism and finally negatively influence the company's objectives. Since each part in the supply chain has distinct liturgical classifications, the overall food supply chain system converts into a solid and integrated system, that may considerably improve the viability of the whole supply network and create prosperity for each individual part of the procedure (Haishui and Jun, 2018).

Environmental Risks

Environmental risk takes into account various elements causing explicit or implicit harm to the food supply chain, culminating in supply chain disruption or delay, as well as a degradation of the supply chain's initial strength and flexibility. Natural and social environmental risks are the most common types of environmental risks (Haishui and Jun, 2018).

Natural environmental impacts can cause supply chain commotions and even destroy the whole supply chain. Agricultural items, for instance, provide the majority of food's raw components. Crops are diminished as a result of the weather change, resulting in lower quality agricultural goods. The cost, amount and integrity of food natural resources are all influenced which has an impact on the cost, volume, and integrity of the entire food supply chain's products. Product will have a limited life span if the weather conditions are unusual or extreme, particularly if the food has a high freshness need. Food distribution will be severely hampered by torrential downpours, cold temperatures, and strong winds and rainfall. Product shipping complications and hence cancellations, disrupt the current food supply's stability, affecting product cost (Haishui and Jun, 2018).

2.4. Supply Chain Risk Management

Various companies have adopted systems which could help them deal with risk and uncertainty, in order to make operational decisions. These functions include managerial decision making (March and Shapira, 1987), strategy (Ruefli, Collins and Lacugna, 1999; Sitkin and Pablo, 1992; Wiseman and Bromiley, 1991), operations (Newman, Hanna and Maffei, 1993; Pagell and Krause, 1999), accounting (Ashton, 1998; Baucus, Golec and Cooper, 1993), finance (Chow and Denning, 1994); Ho and Pike, 1992) and distribution (Celly and Frazier, 1996; Lassar and Kerr, 1996).

Due to the adaptations of businesses to developing practices, risks have escalated, leading to more difficult management. The current complexity of supply networks has resulted in demanding adjustments from managers. Traditionally, companies used to produce their products themselves, source them from a local market and distribute them directly to the consumers. Within

this process the whole procedure was more manageable and secure, and potential risks could be handled more easily. In recent years, the developing trends are towards more complicated products and local sources have been replaced by international ones, necessitating more effort to recognize and control a possible risk (Singh, Jain and Mishra, 2009).

As already mentioned, supply chain networks have nowadays taken more complex forms, a fact which has been influenced mainly from the following four factors: augmentation of product complexity, e-business, outsourcing and globalization.

Product complexity

Requirements for greater capabilities and varieties of products and services, alongside the need for more sophisticated supporting processes, has resulted in products and services progressively growing more complex. Multiple factors leading to increased complexity that affect supply chains have been noted, such as the volume of production, the number of involved parts and parties, the degree of innovation or customisation, the range of specialised knowledge required for the design and production process, the requirements of the end consumer (in addition to any adjustments resulting from end user feedback), as well as the overarching financial, regulatory, and political environment under which both companies and suppliers operate. One result of this increasing complexity is an acknowledgement that it is ever more difficult for companies to specialise in all elements of their product design and manufacture, which has led to a growing move towards outsourcing at least some of these aspects (Singh, Jain and Mishra, 2009).

Outsourcing

Risks in the supply chain have increased due to outsourcing. That means that different people or companies, which all specialize in their own field, must deal with the different procedures for the products' assembly (Gomes-Casseres, 1994; Lonsdale, 1999). Outsourcing's consequences can influence both the organisation and the composition of the supply chain. Taking into consideration these variations, supply markets' equilibrium has altered, often approaching global markets, and forcing the organisations to discover international sources so as to reach the best outcome (Singh, Jain and Mishra, 2009).

Globalization

Globalization can have diverse elements besides outsourcing, such as international flow of capital, products, people, information, and services. All the above can influence businesses and

provoke difficulties on the supply chain management as well as on the identification of potential risks.

E-business

E-business is the last factor that can influence the supply chain. Although through e-business companies can approach new clients and amplify the speed within they can adjust in the changing markets, they can at the same time face intricacy recognising a risk (Erridge, Fee and McIlroy, 1998; Croom, Romano and Giannakis, 2000).

2.5. Risks that the food supply management is facing

As mentioned above, there are many risks that can be traced in a food supply chain. These risks can be distinguished according to which specific sector in the food supply chain they affect or which particular group of people, for example employees or customers.

2.5.1. Impact of COVID-19 in the food supply chain management

The COVID viral outbreak has ushered a new age on the globe, as we figure out the consequences in all aspects of our daily lives. Natural disasters and emergencies cause supply chain upheaval. COVID-19 has caused not only a worldwide disaster in terms of human mortality, but it has also impacted aspects of the economy and operations, such as production, supply chain logistics, and so on (WHO (World Health Organization), 2020). Given the lack of interest, the closure of food manufacturing facilities, and financial constraints, commercial operations and the delivery of various food items have been halted throughout the food supply chain (Abhijit, Rubi and Pijus, 2021). COVID-19 is a new, unknown disease which was introduced as a health disease, but has also caused damage to the food sector (Mollenkopf and Ozanne, 2020). It is a fact that the food sector is one of the most vital areas of the economy, affected by COVID-19, to a great extent. There is presently substantial worry regarding food production, processing, dispersion, and consumer need, given the current issues in the food supply chain. COVID-19 has negatively influenced all the procedures included in the food supply chain such as workers' mobility limitations, shifts in consumer needs, the suspension of food production lines, limited food trade

laws, and financial constraints (Aday and Aday, 2020). Different goods have faced interruptions at different points of the supply chain, and not all industries and products have been equally affected (Deconinck, Avery and Jackson, 2021).

There has been a lot of discussion on whether the food supply chain can satisfy the consumers' demands due to COVID-19 (Mollenkopf and Ozanne, 2020). Both consumers and supply chain businesses have taken measures in order to face this crisis. On one hand consumers, being afraid of the predicted food shortages, have reacted by stockpiling merchandise (Hall *et al.*, 2020; Venuto, 2020). They've moved their purchasing habits drastically to online purchase/delivery choices, considerably beyond the supply chain's immediate capacity (Dunkley, 2020; Smith, 2020). Provided the unexpected high levels of unemployment and changing to food stores, many customers are unable to purchase food (Charles, 2020). Unexpected changes in the market and wellbeing restrictions have wreaked havoc on the supply chain, with farmworkers unable to farm the land, the hospitality industry failing and altered workplace practices in food processing facilities impeding productivity (Cagle, 2020; Corkery and Yaffe-Bellany, 2020a, 2020b; Hall *et al.*, 2020).

According to the Food and Agriculture Organization (FAO (Food and Agriculture Organization of the United Nations), 2020a), COVID-19 has an impact on the food and agri supply chain in two major ways, food supply and food demand. As stated by the food inventory network, COVID-19 has influenced the whole food production, from the field to the client (Barman, Das and Kanti De, 2021). The COVID-19 epidemic has revealed four key challenges in the food business and food supply chain. For starters, individuals are likely to have a balanced diet in order to preserve their bodies and immune systems (Rodríguez-Pérez *et al.*, 2020). As a result, interest for practical meals containing bioactive substances has surged. Secondly, food safety has received wider acceptance in order to avoid coronavirus spread among producers, merchants, and consumers. Furthermore, due to lockdown constraints, food security problems have developed. Finally, in the era of pandemics, food sustainability issues have arisen (Galanakis, 2020).

2.5.1.1. Effects of pandemic on food supply chain

According to (FAO (Food and Agriculture Organization of the United Nations), 2020a) COVID-19 is a disease totally different from the ones in the previous years, such as Escherichia coli (E. coli), Listeria or foot and mouth disease. The reason for the above statement is because COVID-19 has no immediate impact on the production since it does not expand through animals or agricultural goods. Nevertheless, as a result of the epidemic, governments throughout the world have imposed strict limitations on commodities transit (by land, sea, and air), along with migration flows. Based on the most recent estimates, the use of lorries for food distribution has decreased to 60% in France since the limitations, down from 30% before the outbreak (Bakalis, Valdramidis and Argyropoulos, 2020; FAO (Food and Agriculture Organization of the United Nations), 2020e).

Temporary or seasonal work is popular in emerging and undeveloped nations, notably for growing, selecting, collecting, preparing, or delivering products to markets. As a consequence of the lack of domestic or international labor owing to illness or movement barriers faced by lockdown, the supply chain is greatly impacted. In circumstances where the sickness immediately influences their well-being or mobility, it also decreases not just others' production capacity, but also their own food standards (FAO (Food and Agriculture Organization of the United Nations), 2020g). The COVID-19 issue, in particular, caused major disturbances in various labor-intensive industries, such as cattle production, gardening, planting, picking, and agricultural processing (Stephens *et al.*, 2020). Yet, a labor shortage was a severe concern even before the COVID-19 pandemic (Richards and Rickard, 2020).

Attributed to the reason that several experienced crop employees were unable to reach other nations thanks to immigration restrictions, an appeal has been issued to the jobless to assist in France's crops. The 'Pick for Britain' campaign in the United Kingdom intended to recruit 70 000 British workers to work in the fields as well as through harvest (Nature Plants, 2020). The problem, though, weakens the capacity of farms and agricultural enterprises to function owing to a labor shortage caused by disease and the personal space that must be preserved throughout production. These circumstances slowed the transportation of food and agricultural supplies, posing challenges in ensuring a steady source of food to marketplaces (ILO (International Labour Organization), 2020). Despite the fact that many firms depend on their fundamental supplies, the majority of them are more vulnerable to interruptions since they must get their supplies from local marketplaces.

Owing to a low life span, high-value items are further weakened by logistical impediments that disturb food supply networks (FAO (Food and Agriculture Organization of the United Nations), 2020g, 2020f; Shahidi, 2020b).

Because most agricultural operations are dependent on the period and climate, they must adhere to a finely adjusted timetable with adaptability so that rapid measures may be taken when necessary. Because all operations and phases in a supply chain are interconnected, even a minor hiccup or malfunction can cause a "butterfly effect", leading to substantial drop in production (FAO (Food and Agriculture Organization of the United Nations), 2020g). Farmers have been compelled to ruin their produce by burning or allowing them to decay as a result of the limitations, according to several accounts. According to the American Co-operative of Dairy Farmers, 14 million liters of milk are discarded every day owing to a broken supply chain. In addition, it was stated that due to logistical difficulties in India, tea plants were being destroyed (BBC (British Broadcasting Corporation), 2020). As a result, sustaining logistical competence is critical for the food business, particularly in times of worldwide crises. Acquiring necessary supplies and maintaining the sustainability of food circulation from producers to end consumers are the two most pressing concerns in the food supply chain (Alonso *et al.*, 2007). The issues are endangering agricultural firms' capacity to extend business, and they might have significant consequences on food standards, purity, and security, as well as restricting access to markets and cost (FAO (Food and Agriculture Organization of the United Nations), 2020g). As governments battle the epidemic, they should seek out opportunities to shift the food supply networks' mechanisms. The effect of pandemic concerns on farming production is primarily determined by the magnitude and mix of agriculture products, which differs by item and nation. Regions with increased revenues often utilize capital-intensive strategies for agricultural production, whilst low-income ones rely heavily on workforce. As a result, the supply chain must maintain functioning, with a special emphasis on the fundamentals of logistical issues (FAO (Food and Agriculture Organization of the United Nations), 2020e).

Meat, fruit, vegetable, dairy, ready-to-eat meals, and other consumable items are all part of the food industry (Hueston and McLeod, 2012). Nevertheless, in terms of financial investment and personnel, the food and agricultural chain may be divided into two types. The first category includes items like wheat, corn, maize, soybeans, and oilseeds, whereas fruit, vegetables, and fish

are among the high-value items. Significant financial funds are expected for basic items. The transportation of basic foodstuffs is hampered by restrictions imposed by towns, provinces, areas, and states (FAO (Food and Agriculture Organization of the United Nations), 2020c). Generating high-value items, opposed to core products, takes a significant amount of labor.

The constraints posed by mobility restrictions (domestic or foreign border policies) as well as shifts in consumer preferences are significant. People are unable to eat out due to the limitations and must prepare home-cooked meals. Furthermore, because of the risk of contracting COVID-19 in shops, customers avoid going to grocery stores (FAO (Food and Agriculture Organisation of the United Nations), 2020).

The supply chain has an impact on not just manufacturers, retailers, and buyers, but also food processing companies with high labour demand. During the epidemic, numerous plants' production was decreased, paused, or significantly delayed as a result of personnel who were determined to be COVID-19 positive and who were afraid of getting infected at work, primarily in meat-processing food industries. As a result of these factors, it was estimated that pork production capacity declined by almost 25% in late April (Devereux, Béné and Hoddinott, 2020; Flynn, 2020).

Due to difficulties in locating a plant to sell their cattle, farmers were compelled to slaughter their animals. Vacant shelves arose from increased customer demand, and a loss in supply originated a rise in the value of meat items. Market constraints were applied in only purchasing a certain quantity of things, for example, beef, and pork. Hamburgers made of beef were reduced from selling, due to the fact that many food services were severely impacted by the pandemic (Hobbs, 2020; Levany, 2020; Murphy, 2020; Rude, 2020; Valinsky, 2020). In order to avoid purchasing frustration, plenty retailers began offering free delivery on purchases, regardless of the government’s guarantees. Furthermore, limitations were placed on the amount of clients permitted in a shop at the same time, so as to avert congestion. Exceptional hours were also set up by stores, for customers who had more possibilities of getting infected or had a burdened health history (Nicola, Alsafi and Sohrabi, 2020).

There seem to be a number of factors at work which constitute food-processing establishments prospective epidemic hotspots. It's hard to maintain social distance within food factories since people work alongside on manufacturing lines for lengthy periods of time.

Furthermore, owing to loud places, speaking loudly, or yelling leads to the emission of additional droplets into the air (Stewart, Kottasova and Khaliq, 2020). Staff typically ride the same vehicles or utilize car-sharing services, thus transmitting the infection on a greater extent. Besides that, the plurality of workers are low-wage earners who lack medical insurance and healthcare benefits. As a result, employees working in food industries, jeopardize their health by attending work, even though they might seem unwell, endangering themselves and others by spreading the virus. A further element that aids the growth of COVID-19 is the cold and damp atmosphere found within food-processing plants. It's probable that chilly, gloomy surroundings devoid of UV radiation might keep coronavirus active, leading to greater spread (Artiga and Rae, 2020; Gulland, 2020).

Another issue that affected food systems during the COVID-19 pandemic was centralized food production. Food manufacturers were able to boost productivity while lowering expenses because of this approach. Nevertheless, there are certain disadvantages to centralization, such as tight and long supply chains. Moreover, relying on a limited amount of high production lines to cope with supply demand might cause issues (Almena, Fryer and Bakalis, 2019), including the shutdown of the whole site in the event of an epidemic, ending up with fewer options for the high-volume manufacture lines. The COVID-19 pandemic necessitated the deployment of processes intended for emergencies. This impacted contracts and agreements throughout the food supply chain. Simultaneously, it caused a disruption to the equilibrium of the supply and demand. For smaller producers this may have led to precarious positions (FAO (Food and Agriculture Organization of the United Nations), 2020d).

2.5.1.2. Effects of pandemic on global food trade

Even though the present status appears to be extraordinary, food systems have generally been susceptible to weather and disease-related issues, even before the COVID-19 catastrophe. Numerous crises and events in the past, including the oil crisis in the 1970s, the SARS and Ebola epidemics, and the 2006–2008 food crisis, have made food systems fragile. Less than a year ago, the African Swine Fever outbreak threw global commodities markets into disarray, and it has now spread to Eastern Europe and Asia. China, the biggest global pig manufacturer (with a third of the worldwide market) and distributer, suffered the loss of 37% of its pigs by the end of 2019 (IPES

(The International Panel of Experts on Sustainable Food System), 2020). Ebola has a significant detrimental influence on certain African countries' agricultural output, marketing, and commerce sectors. Farmers had restricted access to supplies like seeds, fertilizers, and pesticides owing to transportation limits, and most areas experienced staff scarcity. As a result, about 40% of farmland has remained unused. The pandemic, on the other hand, had little impact on productivity since agricultural regions were frequently located at some distance from densely populated places (Agrilinks, 2020; Shahidi, 2020a).

Some nations' food trade strategies have shifted as a result of the present COVID-19 problem, with exports prohibited and imports enabled. The major causation that governments adopt export limitations is to guarantee that the quantity of items available on the national market remains constant. While export controls usually have this impact in the near future, they also have certain obstructive affects. For starters, export limitations lower domestic pricing, which harms farmers economically, leading to lower agricultural production and less motivation in the business. Furthermore, by relinquishing their position in the global markets, nations will forfeit their competitive edge. Finally, export limitations tarnish exporters' fames and lead importers to lose faith in the global market, diminishing trust in global commerce and obliterating exporters' potential investment chances (FAO (Food and Agriculture Organization of the United Nations), 2011; Espitia, Rocha and Ruta, 2020).

Despite the fact that local food prices rose dramatically during the 2008 food crisis, several large nations that were able to seclude themselves from global markets remained unaffected. Rice prices have risen by 224 percent, wheat prices have gone up by 108 percent, and corn prices have augmented by 89 percent since 2004 (FAO (Food and Agriculture Organization of the United Nations), 2011). Prices escalated overall owing to trade limits, dangers, and ambiguities in world trade, resulting in higher-than-expected price inflations in nations that rely on imports. Panic purchasing has been witnessed in importing nations as a result of export limitations imposed by leading export economies, and prices have risen as a result of increased demand for items (dos (United States Department of State), 2011).

Despite recent large global food supplies, an extended pandemic outbreak might generate challenges in the food supply chain, along with laws that limit exports, which could set off a domino effect. As stated by FAO grain production predictions for 2019, there was a total of 2.721

billion tons of grain produced, including 1.44 billion tons of coarse grains, 763 million tons of wheat, and 512 million tons of rice. Wheat and coarse grain output is predicted to be comparable to 2019 in 2020, as claimed by FAO forecasts. As a result, regardless of warnings over COVID-19, international grain markets are projected to remain stable (FAO (Food and Agriculture Organization of the United Nations), 2020b).

In essence, trade allows for the transfer of goods and products from regions with surplus to those with a deficit. This serves to minimize scarcity and food insecurity that can arise from exclusively domestic production (Baldos and Hertel, 2015; Fitton *et al.*, 2019). The emergence of COVID-19, however, resulted in widespread dislocation to the food trade - a situation further exacerbated by accompanying export restrictions introduced in the wake of the pandemic. This introduction of policies restricting exports caused a global increase in the prices of stable food commodities such as wheat, maize, and rice, with the result that both the quality and quantity of food intake decreased (Fyles and Madramootoo, 2016). These restrictions also created shortages of goods which were not grown or produced nationally as food imports either declined or ceased entirely. Furthermore, the impact was not just limited to consumers, as producers were also affected by the loss of export markets. The introduction of export restrictions and loss of potential buyers created a situation of surplus supply, driving up both waste and economic losses for sellers. This disruption also spread to foods needed for processing - food-manufacturing plants were faced with the twin impacts of reduced imports as well as decreased production capacity due to the impact of the pandemic (Reddy, Singh and Anbumozhi, 2016; Ndemezo, Ndikubwimana and Dukunde, 2018; Arianina and Morris, 2020). Alongside these issues created by various import/export policies, transportation difficulties for air and sea freight created additional food waste problems (OECD (The Organisation for Economic Co-operation and Development), 2020).

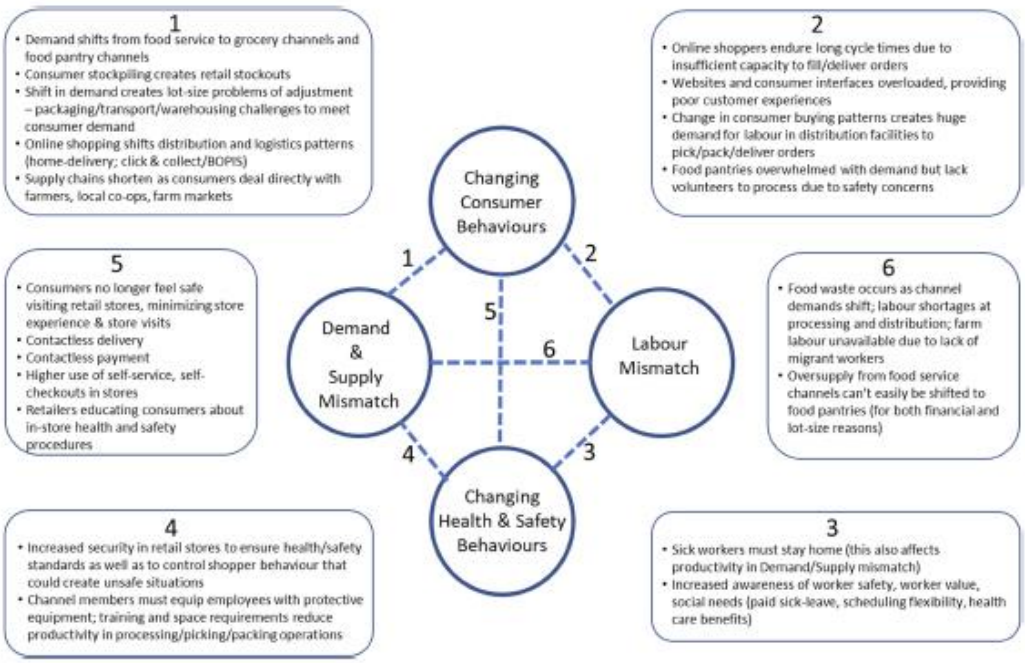

Image 2: Interrelated supply chain themes identified during the coronavirus disease of 2019 pandemic (Mollenkopf, D.A. & Ozanne, L.K., 2021, p.193)

3. RESEARCH OVERVIEW

3.1. Pre-warning system

Food safety events have been increasingly common in China currently, and concerns associated with food quality and safety have drawn increasing public significance. Many organizations have built a reliable data monitoring system to assure product quality in the supply chain network, given the importance of quality conservation in the food supply chain. This system is known as a food safety pre-warning system and uses data mining algorithms and Internet of Things technology to detect and instantly pre-warn all detection data across the entire supply chain. The goal of a pre-warning system is to assist managers in food manufacturing organizations in identifying food safety risks ahead of time and providing information for decision-making in order to preserve food quality and safety (Wang and Yue, 2017).

Due to the general enlarged global supply chain and growing customer expectations for quality and safety, the food supply chain has witnessed higher quality risk (Tse and Tan, 2011). Because all food safety data originates from each stakeholder in the supply chain, there are always unknown dangers in data transfer (Applequist, Pekny and Reklaitis, 2000). A data analysis technology has lately been established for the classification of deficiencies and identification of food safety along the entirety of the food supply chain, thanks to the emergence of the Internet of Things (IOT), which offers increased ability to achieve efficient supply chain data aggregation and dissemination (Verdouw *et al.*, 2016). As a result, a system was created that can evaluate food safety risk and issue warnings depending on some food safety and quality assurance regulations. As a result, every activity in various supply chain phases has the possibility to be improved in order to decrease product inconsistency and resource loss, thus preventing food safety issues (Ting *et al.*, 2014b). Furthermore, pre-warning is an excellent strategy to create food supply chain sustainability, as product conservation is the most critical factor for a long-term food supply chain (Reisch, Eberie and Lorek, 2013).

Pre-warning is a constant concern for supply chain management in the food business. The intensity and intricacy of the product quality have been exacerbated while more companies merge into the food supply chain. This problem exists as the product has to involve numerous

stakeholders until it eventually reaches its final destination (Kuo and Chen, 2010). Firm leaders may struggle to foresee the sequential impact that happens often throughout the supply chain activities in a quite complex and antagonistic market (Lamarre and Pergier, 2009). In severe instances, goods or products with safety concerns may prompt a large-scale recall, with the consequent effects being felt throughout the entire supply chain. Inadequate transparency in the supply chain is another source of risk that affects the efficacy of product quality management (Roth *et al.*, 2008). The sharp rise in product returns demonstrates that multi-tiered supply chains with limited visibility are acutely susceptible to food standards threats (Tse and Tan, 2012). Users, on the other hand, demand improved manufacturing techniques and premium goods, which encourages the food supply chain to become more quality conscious. Supply chain rivalry has steadily shifted to reliability conflict (Foster, 2008). Furthermore, as consumer stipulation for food freshness and operational integrity rises, temperature, microbiological data, and other food quality factors are being closely observed (Abad *et al.*, 2009; Heising *et al.*, 2013) . As a result, it is important to acquire knowledge on how to ameliorate the expanded supply chain's resilience, and the significance of data gathering, and food standards pre-warning is critical to achieving these objectives.

Information exchange may improve planning and collaboration among supply chain components, ensuring the food supply chain's long-term viability (Ahumada and Villalobos, 2009). The Internet of Things (IOT) is used to accomplish data exchange, which has a lot of potential in the food business. It allows supply chain participants to monitor processes instantaneously, gather and send data, and tackle the issue of food traceability (Atzori, Iera and Morabito, 2010). Alongside this, processes enabled by the Internet of Things allow supply chain members to improve operational procedures by actively visualize factors such as perishability, fluctuations in supply or demand, or requirements around safety or viability.

Due to the growing worry about food safety issues in the food supply chain, a variety of solutions are being deployed, including pre-warning, which can detect and notify abnormalities before an incident arises. Various traceability methods which rely on the Hazard Analysis Critical Control Point (HACCP) Standard (McAnelly, 1994), namely the animal production data traceability system in China, use the pre-warning method. Because of the multiple stakeholders engaged in the food supply chain, marketing logistics have gotten more intricate than

previously, increasing the complexity of managing, supervising, and inspecting food product commerce (Watsona and Pauly, 2013). As a result, the majority of food safety accidents are triggered by poor surveillance, necessitating the implementation of a pre-warning system to oversee product transactions automatically and reliably.

The food safety pre-warning system improves three components of the food supply chain's quality and sustainability: food safety risk detection, customer experience, and supply chain transparency.

1. Food safety risk detection: The pre-warning system in food supply management assists in evaluating the food safety risk, minimizing the manufacture and delivery of dangerous or low-quality goods, and lowering the level of harm by eliminating product withdrawal actions. Because the supply chain quality sustainability validation procedure has been greatly improved, pre-warning likewise maximizes food quality. The efficiency of food safety recognition is progressing, which raises the degree of safety and lowers the expenditure on food returns. One of the most critical goals of every healthy food supply chain is to ensure food integrity. By recognizing risks, the pre-warning system may provide notice to supply chain counterparties, facilitating food emergencies and eliminating product recalls. As a result, the impact of a food revocation may be minimized (Wang and Yue, 2017).
2. Customer experience: Customer experience may provide a company with a competitive edge. The use of a food safety pre-warning system improves product safety and quality for both firms and consumers, strengthening the company's competency to expand market dominance and clients' trust in the items it supplies (Wang and Yue, 2017).
3. Supply chain transparency: The concealed supply chain data would be visible with the IOT deployed in the pre-warning system to facilitate improved interaction and information sharing across supply chain participants. The entire data generated in the supply chain, as well as merchandise operations, would be assessed by manufacturers within every corporation, and the outcomes of such evaluations would be saved in the database of the information-sharing memory, bridging the decision-making disparity between supply chain members (Wang and Yue, 2017).

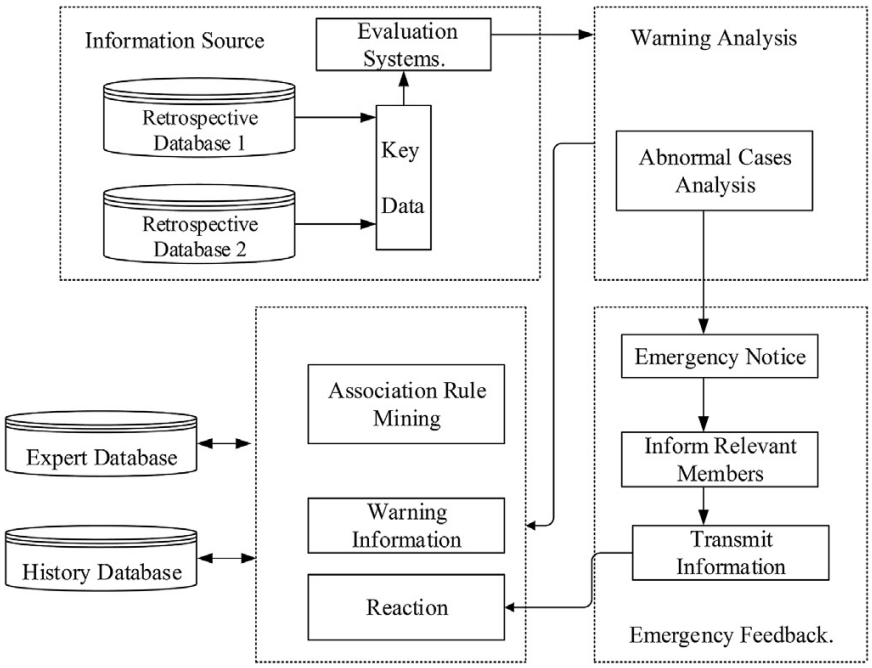

Image 3: The architecture of food security information pre-warning model. (Wang, J. & Yue, H., 2017, p.225)

3.2. Blockchain Technology

Due to unceasing developments in cutting-edge information and communication technologies (ICTs), almost all company structures have been enduring enormous changes in the technological age (Ismagilova *et al.*, 2019). The blockchain is a well-known and extremely revolutionary invention that is already helping to transform established business structures and generate future capabilities throughout the supply chain. Blockchain is usually defined as "A completely distributed system for cryptographically collecting and maintaining a consistent, immutable, linear event log of transactions between networked participants" (Risius and Spohrer, 2017). Blockchain is a technology that was developed to facilitate bitcoin operations (Nakamoto, 2008; Oh and Shong, 2017; Prybila *et al.*, 2017). Blockchain is often assumed as a serious issue as well as a potential model. For example, blockchain may promote transparency, responsibility, and credibility, as well as reliability, effectiveness, and waste reduction (Kshetri, 2018b).

Furthermore, blockchain is considered as a possible answer for supply chain management (SCM) traceability issues (Lu and Xu, 2017) and for fostering more effective partnerships (Aste, Tasca and di Matteo, 2017; Wang, Luo Robert and Lee, 2019) both between organizations and

their distributors, and therefore across the SCM (Aste, Tasca and di Matteo, 2017; Wang, Luo Robert and Lee, 2019). On the one hand, a blockchain-empowered smart contract (a program that may initiate a transaction) has the capacity to boost SCM productiveness while maintaining a decentralized approach. Blockchain, on the other hand, may be integrated with other innovations (such as big data analytics, the internet of things, and cyber-physical systems) to create uncontrollable effects in a variety of industries.

Blockchain technology is considered one of the emerging applications that is expected to transform the contemporary food supply chain (Kouhizadeh and Sarkis, 2018; Queiroz, Telles and Bonilla, 2019a). It represents a decentralized platform that besides enabling immediate interchanges by removing the need for intermediaries, it also verifies data using encryption and preserves a permanent record of transactions. According to some academics, it can increase delivery performance and solve concerns such as data disparity and ineffective food returns, among others (Queiroz, Telles and Bonilla, 2019a; Zhao *et al.*, 2019a).

For tackling food supply chain concerns, blockchain has lately received a lot of study attention. In 2008, Nakamoto proposed the idea of a decentralized peer-to-peer ledger. It has been effectively utilized in economic domains, such as Bitcoin, and it is now generating significant attention in a variety of industries, including the food supply chain, real estate, voting, and so on. Blockchain technology can be described as "a shared, immutable ledger for recording transactions, tracking assets and building trust" (IBM, 2020). Decentralization, immutability, security, and smart contracts are all elements of blockchain's core technology that may provide considerable benefits when implemented appropriately.

1. Decentralization: Unlike conventional transactions that require approval from national regulators, decentralization removes the requirement for centralized approval and tackles data disparity by permitting users to deal directly with one another. It guarantees that each and every legitimate personnel on a system has equivalent power. Users assist one another in ratifying transactions, preserving backups of information, and having equitable rights to information at any point (Yiannas, 2018a; Hastig and Sodhi, 2019; Queiroz, Telles and Bonilla, 2019a). Goods details may be documented around the entire food supply chain, from raw material producers to consumers. The duplicates of documents are saved by several parties and may be accessed easily (Kamble, Gunasekaran and Sharma, 2019).

Customers may access precise information about items, such as legitimacy and provenance. Manufacturers should also keep an eye on their providers to ensure that the content of their raw materials satisfies their standards. As a result, a decentralized supply chain can aid in the obliteration of information inequity and the development of trust.

2. Security: Information privacy is possible with the blockchain protocols method. Proof of Work (PoW) is one of the consensus techniques, which demands that all operations be confirmed by other participants (Reyna *et al.*, 2019a). To accept an operation and enter information into the system, users must establish computer calculations. Decentralization reduces central power on the network, which protects a supply chain from collapsing, since one individual malfunction does not result in the entire network collapsing, lowering the risk of cyberattacks. Hacking can therefore be accomplished practically if the plurality of people is under control, which will require a significant quantity of energy (Reyna *et al.*, 2019a). As a result, if a blockchain network is more intricate and has more participants, then hacking can occur harder. When used in the food supply chain, blockchain can protect documents and information, reducing the danger of data theft and hacking.
3. Immutability: Blockchain secures the documents' integrity and validity by granting authorized users' similar competence to post and examine information. This implies that no changes to past records may be made before notifying additional participants. As a result, the blockchain's characteristic inalterability can serve to reduce human interaction and alteration of records. This characteristic is particularly beneficial in food failures, as it prevents any linked parties from modifying their records and avoiding accountability (Kamble, Gunasekaran and Sharma, 2019; Queiroz, Telles and Bonilla, 2019a). It's 1 food, and so on, providing secure online purchasing. Invariability, on the other hand, does not always ensure the validity of original information, and these must be right from the start. Due to the growth of transaction volume, blockchain might be used as an effective instrument to incentivize food supply chain parties to take accountability as well as obtain quality data (Petersen, Hackuys and See, 2018; Verhoeven, Sinn and Herden, 2018a).
4. Smart Contract: Another key element of blockchain is the smart contract, that is a digitalized agreement that functions autonomously whenever certain terms are satisfied (Reyna *et al.*, 2019a). Smart contact may dramatically help accelerate operations while also

building confidence (Jeppsson and Olsson, 2017; Pournader *et al.*, 2019a). Money to manufacturers, for example, can be issued instantly whenever things reach storage. The utilization of automated smart contracts can reduce both labor and administration demands, thereby also reducing the processing time required in comparison to conventional supply chain processes. For instance, when delivering a package of roses and avocado from Kenya to the Netherlands in 2014, Maersk discovered that over 30 persons and organizations were engaged (Park, 2018). Furthermore, 34 days were needed in order to finish the entire shipping operation, comprising 10 days for data handling (Park, 2018), without taking into account absent paperwork that created delay problems and time extensions. Because smart contracts depend on the consent of all parties, no one may make modifications to them. It can therefore preserve long-term relationships.

3.2.1. Traceability

Traceability has been defined in a variety of ways. The oldest definition was given by the International Organization for Standardization in 1994 (Olsen and Borit, 2013): "the ability to trace the history, application or location of an entity by means of recorded identifications". Traceability is stated by the Codex Alimentarius Commission as "the ability to follow the movement of a food through specified stage(s) of production, processing, and distribution" (FAO (Food and Agriculture Organization of the United Nations), 2014). According to Bosona and Gebresenbet (Bosona and Gebresenbet, 2013). "Food traceability is part of logistics management that capture, store, and transmit adequate information about a food, feed, food-producing is correct animal or substance at all stages in the food supply chain so that the product can be checked for safety and quality control, traced upward, and tracked downward at any time required".

Several food traceability advantages (Golan, Krissoff and Kuchler, 2004; Aung and Chang, 2014b; United Nations Global Compact, 2014) have been suggested, that could be outlined into four categories: increase efficiency (food safety, productivity improvements, company image); fulfill stakeholder desire (reaching stakeholder criteria and maintaining food originality); comply with regulations (satisfying regulatory guidelines) and create global harmony (sustaining global standardization and maintenance of natural pores).

Effective traceability helps firms to have a greater understanding of their supply chain, strategize, and prevent possible quality problems (United Nations Global Compact, 2014). The capacity to track items back and forth across the supply chain helps accelerate the process of distinguishing and locating particular items from different vendors, delivering great inspections, and product returns more productive. Consumers have a deeper understanding and faith in purchasing items when the resources and goods circulation are displayed.

As a result, traceability is regarded as a benefit to food items (Golan, Krissoff and Kuchler, 2004; Dabbene, Gay and Tortia, 2014). Furthermore, the traceability system may be used as a marketing method to promote customer trust and gain customers. Companies can also benefit from employing tracing processes as a means of verifying that producers are supplying products that meet the agreed standards (Aung and Chang, 2014b). As a result, an effective monitoring program may be leveraged as a key asset to increase associate confidence (Golan, Krissoff and Kuchler, 2004). Authorities and non-governmental groups have also developed rules to promote and compel food firms to evolve their traceability systems for monitoring and quality objectives, in response to food dangers and client expectations. Food traceability rules were established by the European Commission (EC) Food Law Regulation 178/2002, which declared that food has to be identifiable in every phase (United Nations Global Compact, 2014).

Multinational supply chains are becoming more complicated, with varied rules to adjust in various locations, putting additional pressure on global enterprises to track their products. Globalized standardized may be customized for all nations and areas using blockchain, and enterprises can avoid duplicative effort (United Nations Global Compact, 2014). Traceability is also a means to evaluate ecological consequences for sustainability objectives, which motivates businesses to be more sustainable.

Whilst traceability is vital and required, it may help food firms distinguish between strengths and weaknesses when product recalls by speeding up the process and avoiding needless expenditures (Golan, Krissoff and Kuchler, 2004). Because of the intricate and ineffective operations used in the past, food recalls required weeks or months, especially for packaged foods. As per the FDA, a recall generally needs 57 days, although it might delay up to 10 months in some cases (Mccallister, 2017; O'Donnell, 2019). Present traceability solutions are primarily paper-based or reliant on proprietary databases (Aung and Chang, 2014b), making

successful recalls even more difficult [34]. The longer it takes for a product to be recalled, not only raises serious food safety issues, and harms a company's brand image but also threatens public health (Reyna *et al.*, 2019b). As a result, an efficient traceability system may benefit either customers or businesses.

3.2.2. Advantages of the Blockchain

1. Improved Food Traceability

The use of traceability processes is not standardized across the food industry, with different companies employing a variety of different mechanisms, both digital and analogue. However, the already complex nature of food supply chains – with multiple producers, suppliers, transporters, and retailers all involved in delivering the final product to consumers – is only exacerbated by this plethora of track and trace systems (Pearson *et al.*, 2019). The problems introduced by current traceability systems range from inefficiency and susceptibility to error with manual methods such as paper record keeping, to lack of interoperability and transparency with, often proprietary, digital tracing approaches.

Currently, therefore, both analogue and digital traceability systems can serve to undermine the central goal of providing an accurate, straightforward history of food products' journey through the supply chain (Hua *et al.*, 2018). This increased complexity also raises both the risks and the costs associated with any issues such as contamination or spoilage, incorrect or inadequate labelling, or insufficient regulatory alignment, that necessitate a product recall. The lack of shared traceability processes means that any issues affecting a product typically involves multiple, non-aligned systems, which can take significant time and effort to navigate, leading to delays of many months before products can be recalled (Lin *et al.*, 2018b; Yiannas, 2018b). Yiannas (Yiannas, 2018b) has estimated that this inefficiency in tracing the root cause of a food safety issue can incur costs up to $93 billion to remove products from shelves. With blockchain technology, however, there is the ability to include each step of the food journey - from ‘farm to fork’ - within the blockchain ledger. This standardization can therefore both increase the ease and accuracy of traceability, as well as increase overall consumer confidence.

A study of the possible advantages of blockchain technology in providing tracing and authentication of foodstuffs by Galvez et al. (Galvez, Mejuto and Gandara, 2018), also highlighted that the blockchain could be employed effectively to reduce food fraud and improve the efficacy of food traceability, both in terms of costs and time spent. These suggestions were also borne out by Caro et al. (Caro *et al.*, 2018) with the development of model traceability processes using blockchain and IoT. Utilizing both Ethereum and other blockchain platforms, this study reinforced the suggestion that blockchain technology could be effectively harnessed to deliver increased transparency and so verifiability. A feasibility study carried out by IBM in conjunction with Walmart in 2016 looked at using blockchain-based traceability tools to track mangoes from farm to shop. Compared to existing traceability systems, which took over six days to verify the transport of the mangoes through each part of the supply chain (Yiannas, 2018b), the use of blockchain technology was able to track the progress of the mangoes through each step of their journey almost instantaneously, while also enabling the process to be monitored in real-time (Yiannas, 2018b). A similar study by AgriDigital and CBH group looking at the grain in Australia also revealed that the blockchain network allowed for improved track and tracing (CBH Group and AgriDigital, 2019).

2. Blockchain Improves Food Supply Chain Transparency

One of the biggest drawbacks of current processes used in the supply chain is a lack of transparency for end consumers. The dissemination of information regarding the origins of products and suppliers involved is at the discretion of large food brands, and so is typically limited to what information is advantageous to the companies (Yu and Nagurney, 2013b). As stated by Reyna et al. (Reyna *et al.*, 2019c), this lack of transparency has an impact beyond consumer choice in that it can also affect food security. Products that require specific manufacturing processes or ingredients, such as kosher food, demand transparent origins in order to maintain consumer confidence (Tieman and Darun, 2017). Despite regulatory bodies and policies aimed at maintaining food standards - including routine testing and tracing - the ability of governments and food agencies to guarantee standards and safety can be impacted by factors ranging from inadequate oversight to instances of bribery and deliberate concealment by food companies. Famous instances of food safety violations, such as the Sanlu milk scandal, were allowed to take

place due to a cover-up by both the company and authorities (Barboza, 2018). Even in instances where companies provide data in-line with regulations, this data can be manipulated or presented in ways that mislead or conceal the reality of the situation (Tian, 2016b, 2017b; Biswas, Muthukkumarasamy and Tan, 2017; Caro *et al.*, 2018). As a result of this lack of transparency, consumer confidence in current supply chain processes is hard to attain and always vulnerable to scandals, whether real or perceived (Hua *et al.*, 2018).

One of the principal advantages of blockchain technology is that it is decentralized. This enables supply chain members to both carry-out transactions and check the original records without needing to rely on centrally held databases. Each authorized supplier or producer has the shared ability to assess goods and products to determine their exact history and journey through the supply chain (Queiroz, Telles and Bonilla, 2019b). This ability to independently verify information serves to undermine large companies' monopolies on key data and empowers smaller stakeholders, thereby increasing accountability and openness throughout the supply chain.

Equally significantly, once information is stored on the blockchain, it becomes inextricably linked to it. The immutability of blockchain data is a central component of the technology and is validated by mining of the blockchain (Tian, 2017b). After transactions are authenticated by miners as legitimate, this data becomes stored within the blockchain itself and cannot be amended without the agreement of all stakeholders (Tian, 2017b). The progress of products through the supply chain can therefore be viewed and analyzed quickly at any point by all stakeholders, without impacting the data itself. This information can also then be updated at all stages through the supply chain to include transport history and regulatory accreditation, while remaining accessible to authorized users at any time (Yiannas, 2018b). This ability to easily verify origins and suppliers is especially important for the food industry, where companies are obliged to demonstrate their authorization to manufacture or sell products. Digitalization of records serves to also reduces the possibility of data manipulation and inaccuracies (CBH Group and AgriDigital, 2019). Walmart and Tsinghua University tracked pork from producer through to end-consumer in China in 2016 (Yiannas, 2018b). The results demonstrated the blockchain's ability to improve information validity, reduce information mistakes, and build confidence.

3. Blockchain Can Be Combined with IoT Devices

The Internet of Things (IoT), which incorporates RFID (Radio-Frequency Identification), GPS (Global Positioning20182018582025 System), GIS (Geographic Information System), WSN (Wireless Sensor Network), and other technologies, is a smart, dependable, and high-speed information network that connects items.

IoT sensors can automatically gather information such as temperature and humidity, eliminating the need for manual recording. This ability to capture real-time data is particularly critical for fresh and frozen food goods, as quality is intimately linked to the environment (Tian, 2016b; Lin *et al.*, 2017). IoT automation can improve the efficacy of obtaining and processing data while decreasing manual errors (Tian, 2016b, 2017b; Lin *et al.*, 2018b; Rejeb, 2018). Nevertheless, data confidentiality and integrity, vulnerability, and privacy are some of the issues that IoT installations face (Tzounis *et al.*, 2017; Caro *et al.*, 2018; Panarello *et al.*, 2018; Rejeb, Keogh and Treiblmaier, 2019; Reyna *et al.*, 2019c). As a result, when employing IoT devices in supply chains, protection and security are critical, which can be achieved through the use of blockchain technologies (Kshetri, 2018a; Panarello *et al.*, 2018; Pournader *et al.*, 2019b; Queiroz, Telles and Bonilla, 2019b; Rejeb, Keogh and Treiblmaier, 2019; Reyna *et al.*, 2019c).

Multiple studies have employed blockchain technology alongside IoT to claim that blockchain can aid in the management of IoT and the improvement of supply chain efficiency (Tian, 2016b, 2017b; Galvez, Mejuto and Gandara, 2018; Leong, Viskin and Stewart, 2018; Lin *et al.*, 2018b; Rejeb, 2018; Rejeb, Keogh and Treiblmaier, 2019). Rejeb (Rejeb, Keogh and Treiblmaier, 2019) proposed six improvements to the scalability, security, auditing, efficiency, interoperability, and quality of IoT solutions by combining blockchain and IoT. Tian (Tian, 2016b, 2017b) created a traceability system for foodstuffs that uses RFID tags and blockchain to provide real-time product data. Lin et al. (Lin *et al.*, 2018b) also presented a blockchain and IoT-based system for use in the food supply chain, which they agreed is trustworthy and self-organizing without the need for human involvement.

The Accenture traceability analysis included several blockchain pilot studies that have been combined with IoT, such as WWF's use of smart tagging in conjunction with blockchain

technology to prevent illegal fishing in Fiji; Belagricola also deployed IoT and smart contracts to track grains and validate quality (Leong, Viskin and Stewart, 2018). When issues arise, such as loss of environmental controls, these processes can be automatically activated to provide users with relevant warnings to avoid additional spoilage (Lin *et al.*, 2017; Tian, 2017b; Caro *et al.*, 2018). The integration of the two technologies enables for data collection and transmission without manual involvement, ensuring greater food quality and safety from manufacture through to consumers.

4. Blockchain Can Improve the Efficiency of Food Recall

The food supply chain can be rendered more sustainable through the use of blockchain technology, which allows for more efficient operations and focused product recalls. The ability to update product information in real-time on the blockchain provides stakeholders with an enhanced understanding of product movements and the capability to respond to events more quickly.

Walmart, for example, learned that the import of fresh products like mangoes could be delayed for up to four days as part of border inspections (Yiannas, 2018b). However, by employing blockchain technology, Walmart was to track product movement, speed up the product inspection process, and so extend the shelf life of products for retailers. Improvements in the openness of information can help to increase supply chain efficiency and reduce product spoilage.

Using current systems, one of the leading causes of food waste is untargeted product recalls. Food goods are often complex, containing a variety of products. Food recalls resulting from single-ingredient contamination are traditionally complex and time-intensive and demand highly efficient traceability mechanisms. The use of blockchain technologies, however, makes it feasible to extract the necessary information, segment products from specific providers and reduce the number of products requiring a recall. Simultaneously, companies develop more accurate client demand predictions based on point-of-sale data (Wang *et al.*, 2019). Zhao et al. (Zhao *et al.*, 2019b) also highlighted that using blockchain technology can provide a means to develop a more sustainable system of water management through the use of blockchain-based recordkeeping for water trading.

3.2.3. Challenges of Blockchain

Blockchain appears to be an auspicious innovation which can transform the food supply chain, increase productivity, and minimize risks. Additional experimental research has been conducted, with favorable results (Yiannas, 2018b; CBH Group and AgriDigital, 2019). Yet, it is apparent that blockchain is still in its early stages, and efforts need to be made until it is generally adopted.

1. Companies' poor understanding and awareness about blockchain technology

One serious problem is to explain the idea to the general public; findings indicate that many individuals involved in supply chain management still don't completely get the possibilities of blockchain (Hackius and Petersen, 2017; Galvez, Mejuto and Gandara, 2018; Kamilaris, Fonts and Prenafeta-Boldv, 2019; Queiroz, Telles and Bonilla, 2019b; Zhao *et al.*, 2019b). The users' opinions can be considerably influenced by their ability to comprehend the technology. Respondents who are more aware of the idea and have more expertise, appear to have a more optimistic view on blockchain implementation, as stated by an analysis by Hackius and Petersen (Hackius and Petersen, 2017). Verhoeven et al. (Verhoeven, Sinn and Herden, 2018b) noted that a scarcity of thorough knowledge of blockchain possibilities still exists since many organizations are inclined to adopt blockchain as a remedy prior to identifying corporate challenges. According to Leong et al. (Leong, Viskin and Stewart, 2018), various phases of the supply chain may have varied technological adoption needs.

2. Technology Scalability Issue

Another issue is blockchain scalability, commonly known as the "scalability trilemma" by Ethereum co-founder Vitalik Buterin (Perboli, Musso and Rosano, 2018). As he mentioned, accomplishing decentralisation, scalability, and safety simultaneously is difficult; just two of the three can be accomplished at once (Ometoruwa, 2018; Perboli, Musso and Rosano, 2018). At the moment, smart contract networks like Ethereum can handle 15 operations per second, whereas systems like Visa can perform 45,000 transactions per second (Coindesk, 2019). Blockchain may demonstrate an elevated level of decentralization and safety by using a difficult mining algorithm to accept payments and retain all transaction records in each site; but it can also lead verifications to be delayed, notably when a significant volume of transactions is taking place. As a result, excessive scalability might exacerbate security vulnerabilities, whereas inadequate

scalability can create transaction congestion and network delays. Because of scalability concerns, Pearson et al. (Pearson *et al.*, 2019) estimated that blockchain would be more likely to occur in niche sections of the food supply chain at which the blockchain possibilities are required, for example, green items. According to Leong et al. (Leong, Viskin and Stewart, 2018), various phases of the food supply chain may have distinct blockchain implementation needs, with the equilibrium of the three attributes varying.

3. Possibilities of Raw Data Manipulation before Uploading to Blockchain

While blockchain can accommodate a secure mechanism to store data, several researchers have focused on raw data tampering, such as with IoT sensors, and it is difficult to verify whether the raw data is primarily accurate (Lin *et al.*, 2017; Galvez, Mejuto and Gandara, 2018). It is indeed feasible to intentionally harm things before informing blockchain consumers (Kshetri, 2018a). Third parties, alongside authorities and certification organizations, can participate in the blockchain system by conducting frequent audits to guarantee raw data validity (Tian, 2017b; Leong, Viskin and Stewart, 2018). In the meantime, the irreversible recording may be utilized as a tactical way to motivate vendors to claim ownership of their goods and supply accurate data.

4. It Is Hard to Require All Stakeholders within a Food Supply Chain to Adopt Blockchain

Instead of relying on paper documents, blockchain needs participation from all parties, including raw material producers to consumers at all levels of the supply chain. Users can enroll as legitimate personnel, enabling them to add information, check activities, and view historical data. Clients will likewise have the ability to request and review goods details. With the involvement of all stakeholders, information integrity and capacity can be improved, but it can also be a challenge owing to varying levels of knowledge and equipment. The cost of blockchain implementation and infrastructure might be an obstacle to embracing innovative ideas for small and medium firms (SMEs) and underdeveloped nations (Leong, Viskin and Stewart, 2018; Perboli, Musso and Rosano, 2018; Kamilaris, Fonts and Prenafeta-Boldv, 2019; Pearson *et al.*, 2019). The majority of blockchain initiatives, according to Kamilaris et al. (Kamilaris, Fonts and Prenafeta-Boldv, 2019), are situated in industrialized countries. As a result, it is critical for blockchain to become accessible to SMEs, that is, simple utilize, implement, and have minimal start-up expenses (Leong, Viskin and Stewart, 2018; Pearson *et al.*, 2019). Perboli et al. (Perboli,

Musso and Rosano, 2018) established a blockchain framework for SMEs depending on Hyperledger Fabric and concluded that the blockchain installation price may be extremely viable and reimbursed through cost savings.

5. Regulations/Laws Need to Be Updated

Because blockchain is a public system, regulations will be required to safeguard members' privacy and trading information. Tse et al. (Tse *et al.*, 2017) used PEST analysis to look at the unpredictable outer conditions for blockchain adoption, which comprises political, economic, social, and technological variables. Some nations and agencies have also expressed interest and support for blockchain innovation (Tse *et al.*, 2017), such as China, which has released a Blockchain White Book and initiated projects associated with blockchain (Tse *et al.*, 2017). International blockchain guidelines were also being established by ISO Blockchain (TC307) (Pearson *et al.*, 2019). Regulations and guidelines, according to Leong et al. (Leong, Viskin and Stewart, 2018) and Pearson et al. (Pearson *et al.*, 2019), should be designed to safeguard users, such as what information should be shared, who possesses the information, how to utilize and keep the data, and so on. According to Kamilaris et al. (Kamilaris, Fonts and Prenafeta-Boldv, 2019), strategy scarcity might be a hurdle to widespread blockchain use. As a result, encouraging all firms or individuals to adopt blockchain before certain finalised regulations and rules are established, is challenging from the standpoint of safeguarding users' rights.

4. RESEARCH METHODS

4.1. Introduction

In this chapter, the empirical part of the dissertation is analysed, and more specifically the following chapter presents the methodology of the research carried out, to examine the capacity of a food company to cope with a risk and the technological support it has to achieve this. At the beginning of the chapter, the population and the sample (50 respondents) of the empirical research are presented. Then, the content of the empirical research questionnaire that was created is thoroughly examined, as well as the methodology of statistical analysis and interpretation of the research answers.

4.2. Sample

Food industries and food processing companies should be aware of the threats that can interrupt the smooth operation of them and be able to handle them, in order to protect both the environment but people as well. In order to examine the factors related to the occurrence of an imminent risk and the ways to prevent and / or deal with them, the research sample (50 respondents) consists of employees of food companies as well as organizations involved in food processing in Greece.

4.3. Questionnaire

The questionnaire is the determining factor in conducting a survey and for this reason, it was designed with a lot of care, so that it is clear and understandable. For the needs of the research, after a careful analysis of the international literature, a structured electronic questionnaire was created, through the Google forms, which was sent electronically to employees of Greek food companies.

The questionnaire, unlike other methods (such as interviews or observation), is one of the most efficient methods of data collection for quantitative surveys, as the sample can be accessed easily and directly, it does not require much time and cost to complete and provides useful information that comes directly from the people involved in the research.

The questions of the questionnaire are 23, closed-ended and multiple-choice based on the Likert type scale (five-point scale), where the respondent is asked to state the degree to which (at least - very much) the respective sentences - questions about the subject of the research. The goal was easy to understand as well as its rapid completion and for this reason, it was divided into three (3) parts - thematic sections, which are analyzed below.

The questionnaire consists of three different sections, which emerged from an analysis of the relevant literature. Each section consists of different questions, semantically connected to each other, with the result that each group of questions creates a factor to be considered. The structure of the questionnaire is as follows:

- Section A deals with general business information
- Section B deals with personal skills and their relationship to implementing Blockchain Technology. It also explores the advantages and disadvantages of the use of Blockchain Technology.
- Section C investigates the employees' knowledge of the Food Safety Pre-warning System which uses data mining algorithms and Internet of Things technology. In addition, it examines the benefits and the challenges of the implementation of Pre-warning Systems.

Initially, the questionnaire starts with 3 questions (1 to 3) in section A where the demographic data are examined and more specifically the size of the company, the position of the respondent and the number of employees of the company. Question 4 and 5 assess the degree to which the respondents are familiar with Blockchain technology (Kayikci *et al.*, 2020) and Pre-warning systems (Wang and Yue, 2017) respectively.

Section B, which examines the "Personal Skills and Blockchain technology", consists of questions 6 to 14. Question 6 assesses the degree to which the respondents have attended a seminar on better knowledge of Blockchain Technology (Chowdhury *et al.*, 2022). Question 7 then assesses the degree to which the respondent has knowledge and skills regarding Blockchain

Technology while question 8 assesses the degree to which he thinks he/she is handling it correctly (Chowdhury *et al.*, 2022). Question 9 examines the extent to which a business is controlled by Blockchain Technology (Chowdhury *et al.*, 2022). Questions 10 examines the extent in which the company the responded works implement Blockchain Technology (Chowdhury *et al.*, 2022). The extent in which the company has established a dedicated group to support Blockchain Technology is studied in Question 11 (Chowdhury *et al.*, 2022). Questions 12 considers the degree in which the company has developed a budget for its Blockchain efforts (Chowdhury *et al.*, 2022). The last two Questions on this section investigate the benefits and the drawbacks that might arise from Blockchain Technology's application. Question 13 focuses on the advantages (Ray *et al.*, 2019) and Question 14 on the disadvantages (Menon and Jain, 2021).

Finally, section C, which examines the "Personal Skills and Pre-warning systems", consists of questions 15 to 23. Question 15 assesses the degree to which the respondents have attended a seminar on better knowledge of Pre-warning systems (Wang and Yue, 2017). Question 16 then assesses the degree to which the respondent has knowledge and skills regarding Pre-warning systems while question 17 assesses the degree to which he thinks he/she is handling it correctly (Wang and Yue, 2017). Question 18 examines the extent to which a business is controlled by Pre-warning systems (Wang and Yue, 2017). Questions 19 examines the extent in which the company the responded works implement Pre-warning systems (Wang and Yue, 2017). The extent in which the company has established a dedicated group to support Pre-warning systems is studied in Question 20 (Wang and Yue, 2017). Questions 21 considers the degree in which the company has developed a budget for its Pre-warning systems efforts (Wang and Yue, 2017). The last two Questions of this questionnaire investigate the benefits and the drawbacks that might arise from Pre-warning systems' application. Question 22 focuses on the advantages and Question 23 on the disadvantages (Wang and Yue, 2017).

4.4. Statistical Analysis Methodology

In order to achieve the complete analysis of the data obtained from the research, both the descriptive statistical analysis of the data and the regression analysis were selected.

After the questionnaires are collected, they are processed. Initially, the Excel program of the Microsoft Office toolkit (Microsoft, Corp., WS) was used for the descriptive statistical analysis of the data. Through this, tables were created with the frequencies and response rates for each question, as well as the corresponding diagrams.

Finally, the Excel program of the Microsoft Office toolkit (Microsoft, Corp., WS) was used to create the statistics table.

5. RESULTS

5.1. Introduction

The following chapter presents the findings of the analysis of the research results, as they emerged from the responses of the audience that participated in the research. After collecting the questionnaires, they were processed and exported using the Excel tool of the Microsoft Office toolkit and the IBM SPSS Statistics 28.0.1 program.

The results of the descriptive statistics for the demographic characteristics of the sample that took part in the present survey are presented first and then the results of the reliability analysis of the questionnaire used are given. The chapter concludes with the presentation of the results of the descriptive statistics for each question included in the questionnaire.

5.2. Demographic Sample Data

The following section presents the findings regarding the demographic characteristics of the 50 participants in the survey. For each question a table has been created that includes the frequency, the percentage, the valid percentage, and the cumulative percentage, as well as the corresponding bar chart based on the frequencies of the answers.

The first five questions (1 to 5) belong to section A of the questionnaire and refer to general information about the company and the respondent, what is his/her position in the company and what is his/her familiarity with the two technologies examined.

The questionnaire starts with the first question regarding the size of the business. The results of the question are shown in the table below.

Business Size

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very Small	9	18.0	18.0	18.0
	Small	15	30.0	30.0	48.0
	Medium	12	24.0	24.0	72.0
	Big	14	28.0	28.0	100.0
	Total	50	100.0	100.0	

Table 1: Frequency Table of question 1

Overall, small, and big-sized enterprises participated in the survey, with small enterprises making up the majority of responses and medium-sized ones following, with 15 responses (30%) and 14 responses (28%) respectively. They are followed by the medium enterprises with 12 answers (24%) and the very small enterprises with 9 answers (18%). The above results are also presented diagrammatically in the following bar graph.

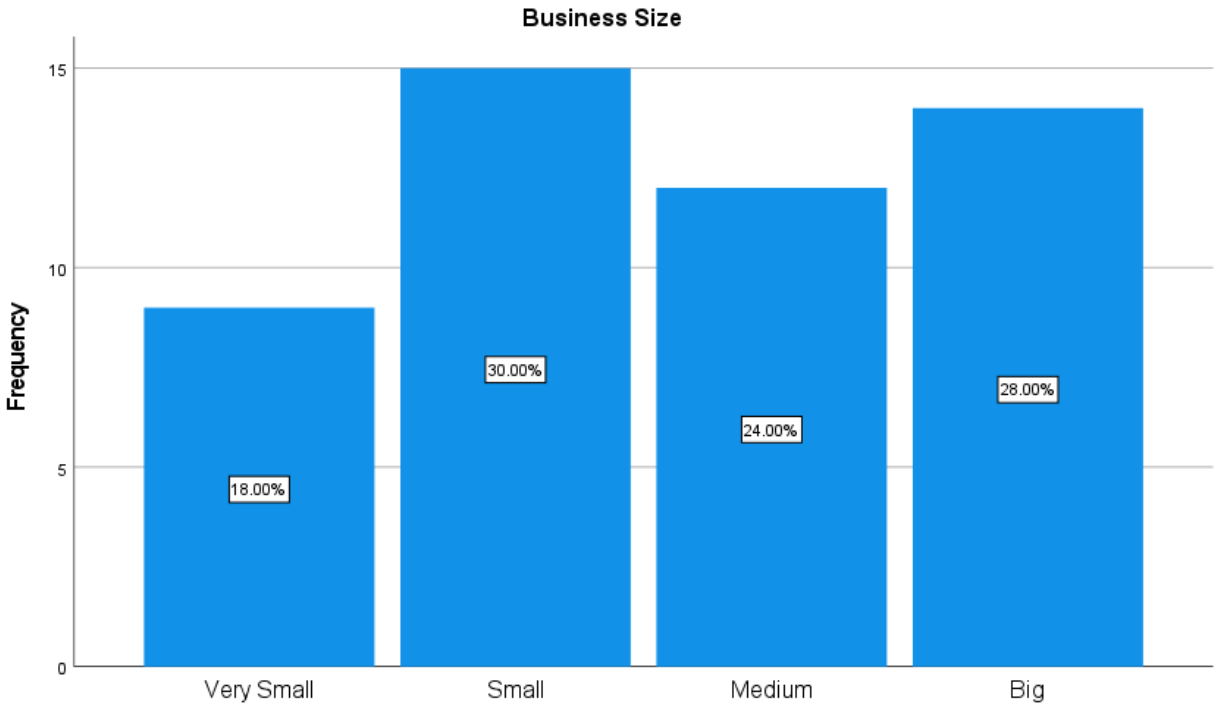

Figure 1: Question bar 1

The second question in the questionnaire of the present survey examines the number of employees working in the company. The results are listed in the table below.

Which is approximately the number of employees in your company?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Under 10	9	18.0	18.0	18.0
	10-50	18	36.0	36.0	54.0
	51-250	10	20.0	20.0	74.0
	Over 250	13	26.0	26.0	100.0
	Total	50	100.0	100.0	

Table 2: Frequency Table of question 2

As shown in the table above, the majority of companies have between 10 and 50 employees (36%), followed by companies with over than 250 employees with a percentage of 26%. This is followed by companies with employees between 51 and 250, while the lowest percentage was recorded for companies with under 10 employees. The above results are also presented diagrammatically.

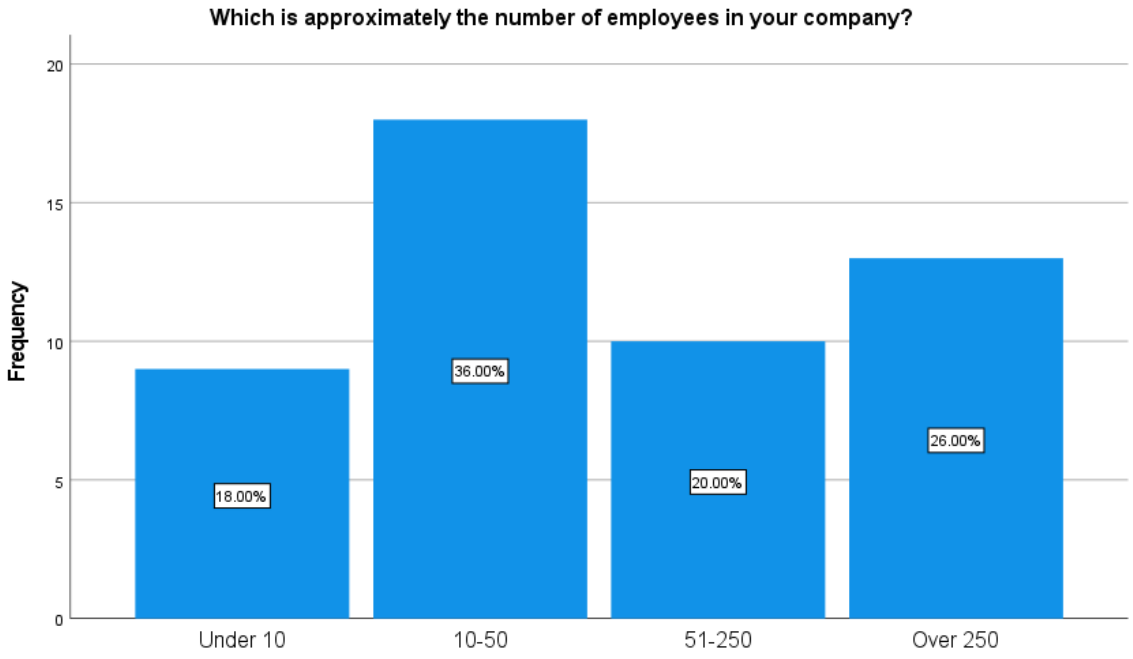

Figure 2: Question bar 2

Then, with question 3, the position of the respondent in the company is investigated. The results are displayed in the table below.

Depending on the size of your company, you may want to respond to the questions in this survey for the whole enterprise or for a specific division. To which of the following will your answers apply?

	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	The entire company	25	50.0	50.0	50.0
	My department	20	40.0	40.0	90.0
	A division	5	10.0	10.0	100.0
	Total	50	100.0	100.0	

Table 3: Frequency Table of question 3

According to the results, most of the participants that took part in the survey, with 25 out of a total of 50 responses (50%), were referring to the entire company, followed by 40% who were answering the questions regarding the department they belong and lastly 10% of them were speaking about a division of the whole company. The following diagram also graphically presents the results of the question.

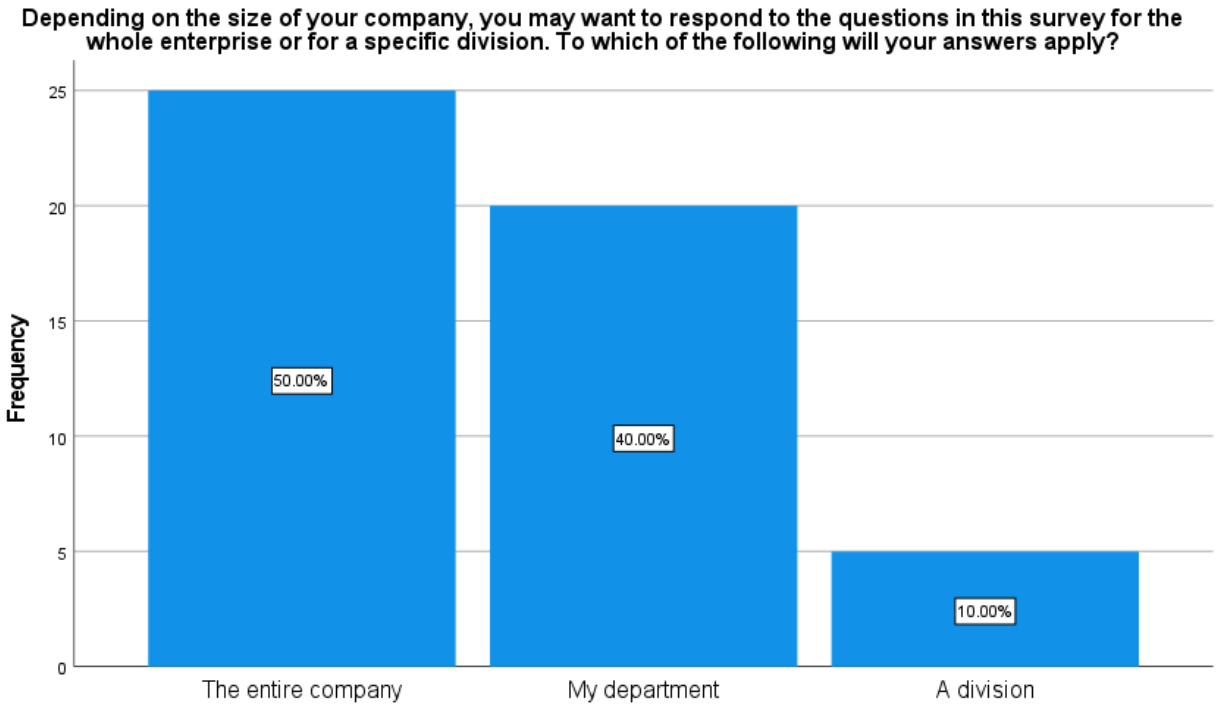

Figure 3: Question bar 3

Question 4 examines the extent in which the respondent is familiar with Blockchain Technology. The results are shown on the table below.

To what extent are you familiar with Blockchain Technology?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor knowledge	23	46.0	46.0	46.0
	Poor knowledge	14	28.0	28.0	74.0
	Average knowledge	8	16.0	16.0	90.0
	Good knowledge	5	10.0	10.0	100.0
	Excellent knowledge	.0	.0	.0	100.0
	Total	50	100.0	100.0	

Table 4: Frequency Table of question 4

Based on the data collected, it is obvious that the majority of companies are not familiar to a very large extent (46%) with Blockchain Technology. This is followed by a large percentage of companies (28%) which have poor knowledge of this innovative technology. Only 8 of the 50 respondents (16%) chose the answer "Average knowledge", while the percentage that has good knowledge of it, is 10%. Lastly, there is no one who answered this questionnaire, who believes that their knowledge on this technology is excellent. The above analysis is also presented graphically in the diagram that follows.

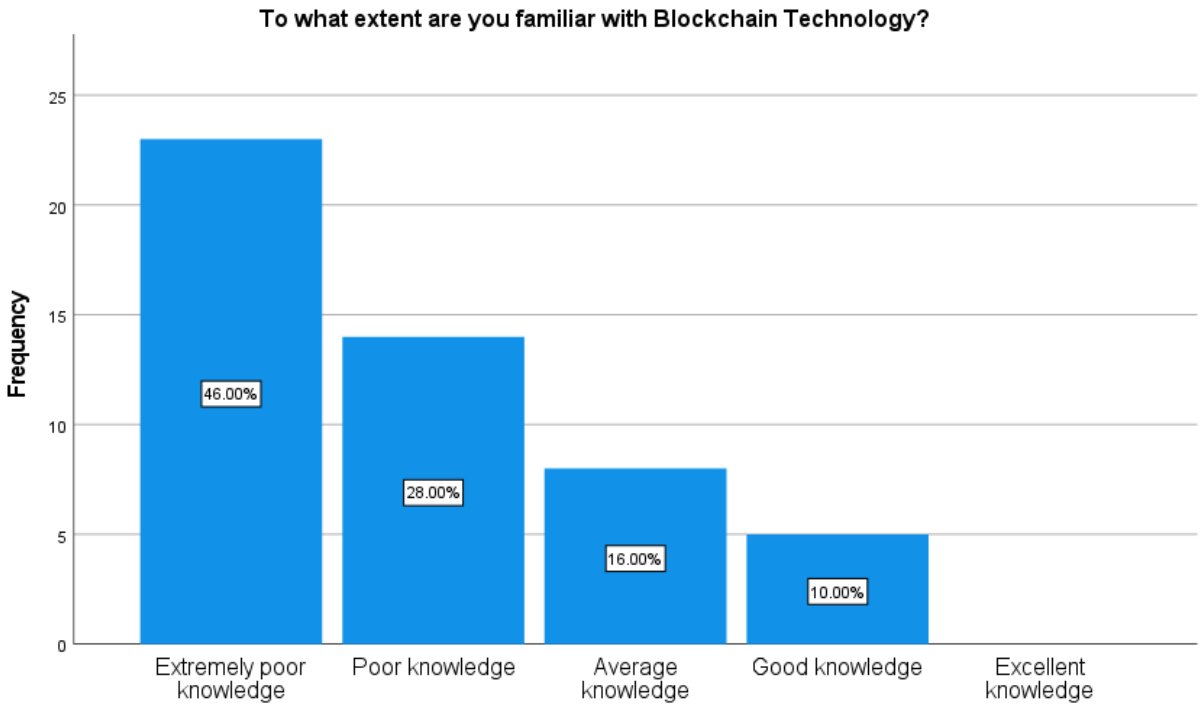

Figure 4: Question bar 4

Question 5 examines the extent in which the respondent is familiar with Pre-warning systems. The results are shown on the table below.

To what extent are you familiar with the Pre-warning Systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor knowledge	18	36.0	36.0	36.0
	Poor knowledge	17	34.0	34.0	70.0
	Average knowledge	9	18.0	18.0	88.0
	Good knowledge	5	10.0	10.0	98.0
	Excellent knowledge	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Table 5: Frequency Table of question 5

By examining the table and diagram above, we can conclude that the participants do not have any knowledge regarding the Pre-warning Systems (36%). This is followed by an almost equally large percentage of people (34%) who have poor knowledge of these systems. 18% of the participants stated that they have an average knowledge and 10% mentioned having good knowledge. Finally, there was only 2% of the people who took part in this survey who have excellent knowledge of them.

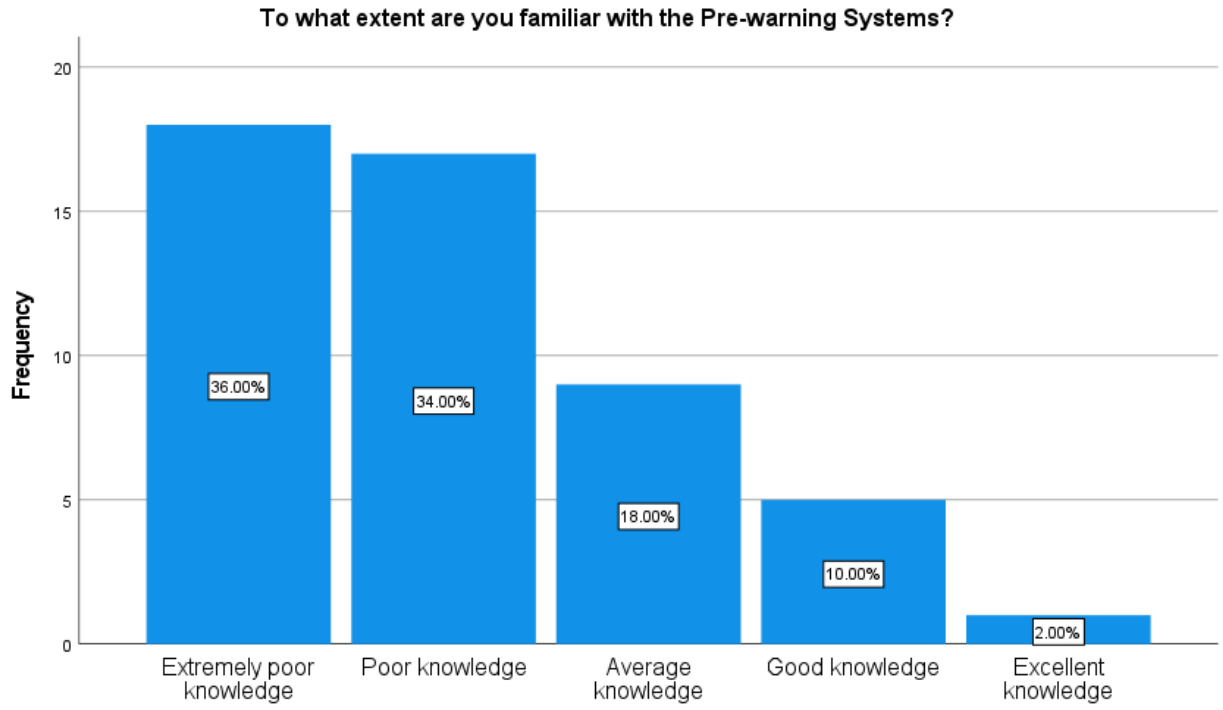

Figure 5:Question bar 5

Question 6 assesses the degree to which the respondents have attended a seminar on better knowledge of Blockchain Technology. The results are indicated on the table below.

To what extent have you attended a seminar on better knowledge of Blockchain Technology?

	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	Extremely poor	31	62.0	62.0	62.0
	Bad	7	14.0	14.0	76.0
	Average	9	18.0	18.0	94.0
	Good	3	6.0	6.0	100.0
	Excellent	0	.0	.0	100.0
	Total	50	100.0	100.0	

Table 6: Frequency Table of question 6

Cumulatively, the percentages calculated for the "Extremely poor" and "Average" options tend to exceed 70% of our research sample (62% and 18% respectively). This fact reminds us that the majority of people working in business have not attended seminars to expand their knowledge on Blockchain technology. Only 14% chose the answer "Bad", followed by the option "Good", a pattern similar to that observed in the answers to the question about how familiar people are with Blockchain technology. Lastly, it is worth mentioning that no one answered "Excellent", which justifies the poor knowledge on this innovation. The following diagram also graphically presents the results of the question.

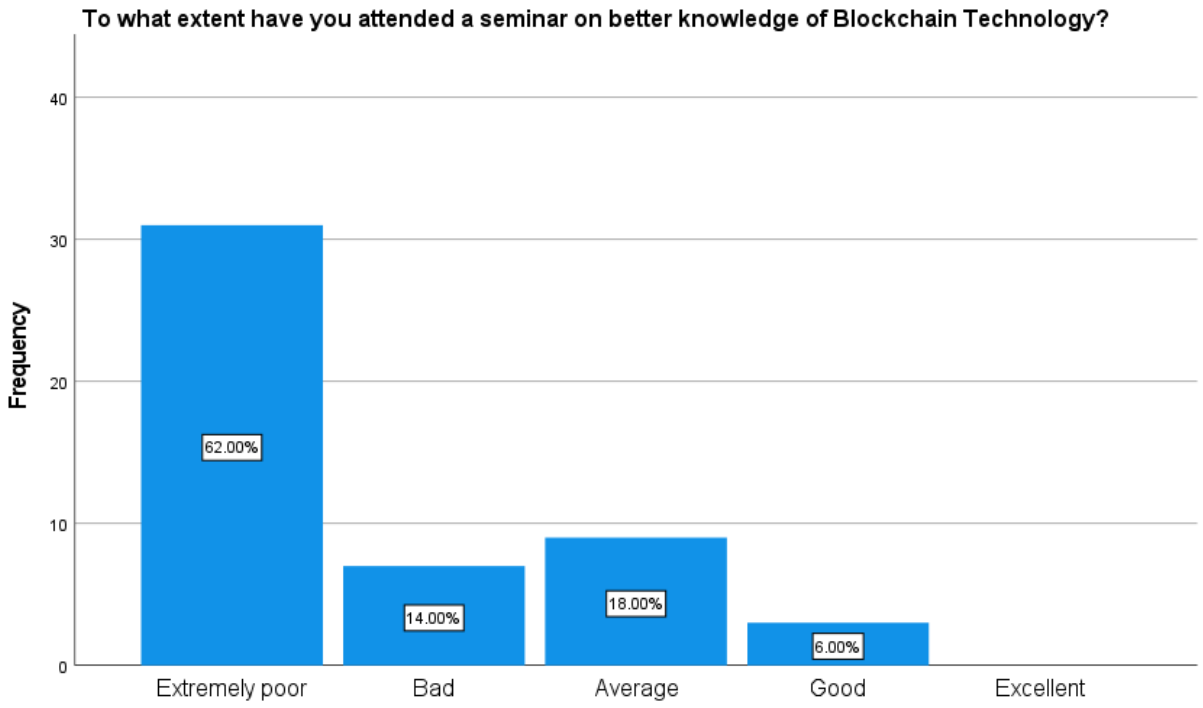

Figure 6: Question bar 6

The next question examines the extent to which respondents have knowledge and skills regarding Blockchain technology. The answers to question 7 are presented in the table below.

To what extent do you have knowledge and skills regarding Blockchain Technology?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	26	52.0	52.0	52.0
	Bad	10	20.0	20.0	72.0
	Average	8	16.0	16.0	88.0
	Good	4	8.0	8.0	96.0
	Excellent	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

Table 7: Frequency Table of question 7

Based on the above table, we can conclude that the majority of the sample of the present research possesses "Extremely poor" knowledge and skills regarding Blockchain technology. Both the answer "Bad" and the answer "Average" gathered almost the same percentage, of 20% and 16% respectively. Finally, the "Good" option collected 8%, while only two answers were recorded for the "Excellent" option. The following diagram also graphically presents the results of the question.

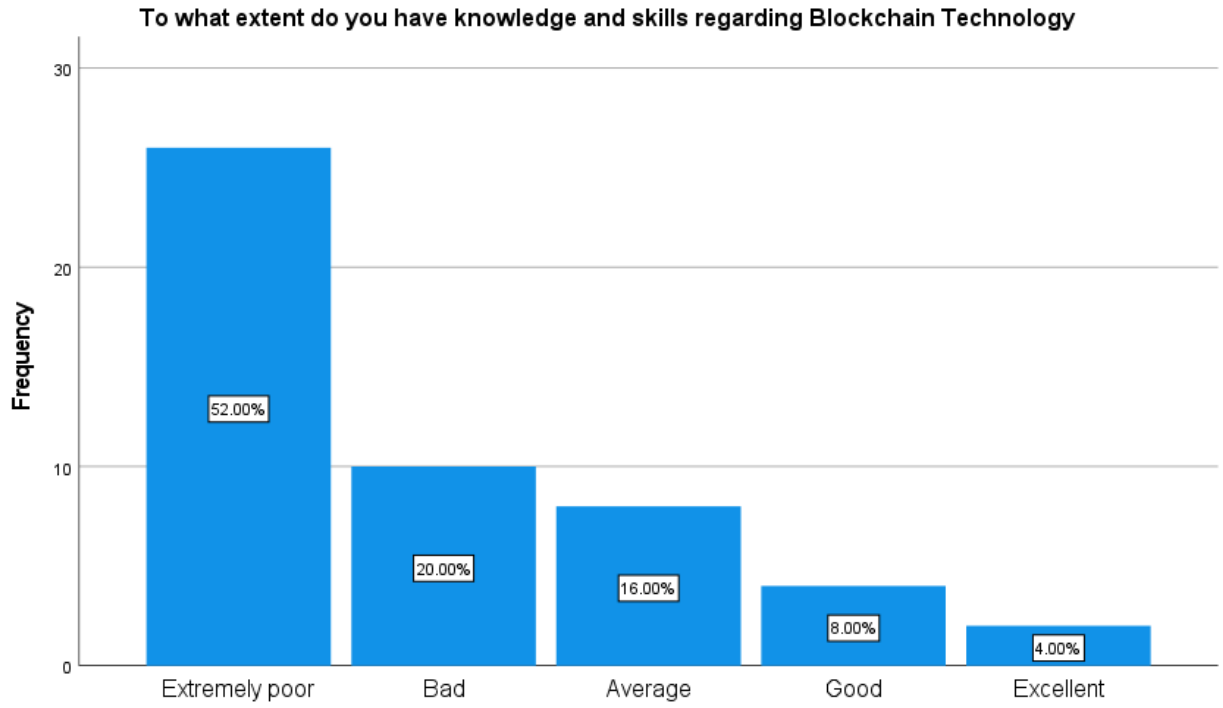

Figure 7: Question bar 7

Question 8 assesses the degree to which the respondent thinks he/she is handling Blockchain Technology correctly. The answers to question 8 are demonstrated in the table below.

To what extent do you implement Blockchain Technology correctly?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	30	60.0	60.0	60.0

	Bad	6	12.0	12.0	72.0
	Average	12	24.0	24.0	96.0
	Good	2	4.0	4.0	100.0
	Excellent	0	.0	.0	100.0
	Total	50	100.0	100.0	

Table 8: Frequency Table of question 8

Based on the data collected, it is obvious that the majority of companies do not implement correctly to a very large extent (60%) Blockchain technology in their operation. This is followed by an average percentage of companies (24%) which use it correctly to a great extent. Only 6 of the 50 respondents (12%) chose the answer "Bad", while the percentage they use from good to excellent implementation is 4% and 0%, respectively. The above analysis is also presented graphically in the diagram that follows.

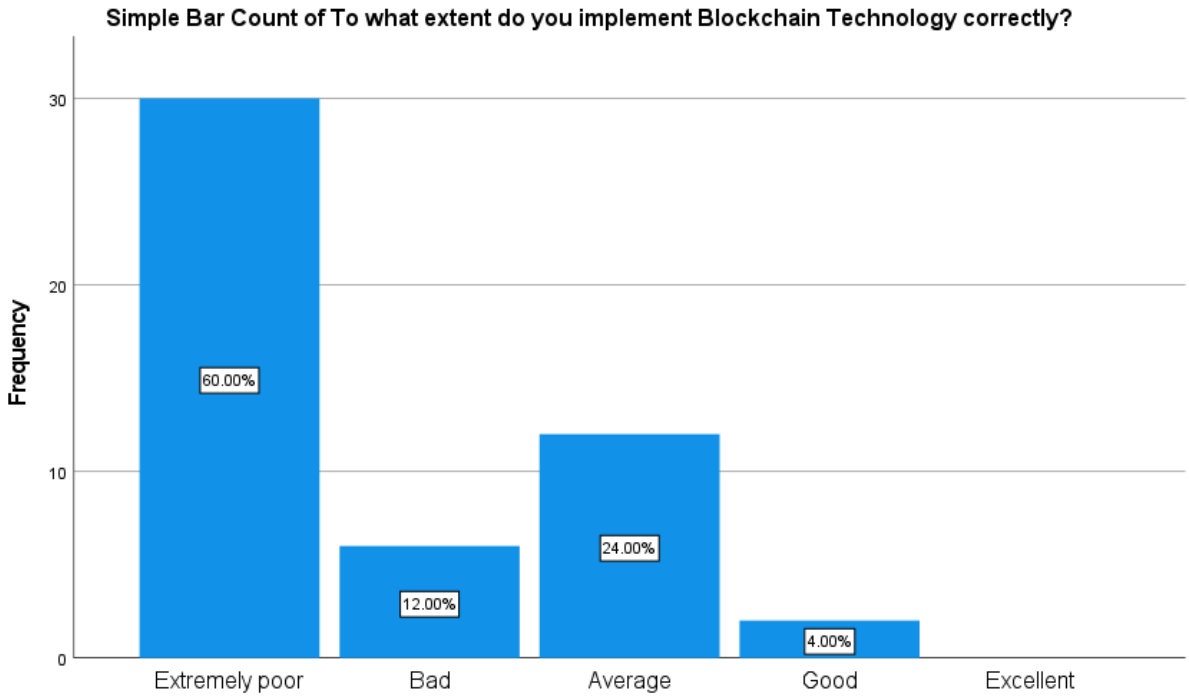

Figure 8: Question bar 8

Question 9 investigated the extent to which a business is controlled by Blockchain Technology. The answers to the question are described in the table below.

To what extent is the company controlled through Blockchain Technology?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	30	60.0	60.0	60.0
	Bad	10	20.0	20.0	80.0
	Average	5	10.0	10.0	90.0
	Good	4	8.0	8.0	98.0
	Excellent	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Table 9: Frequency Table of question 9

The collected responses created a negative image, as 60% of the respondents answered that the company, they work at is not controlled by Blockchain technology, while 20% and 10% answered "Bad" and "Average" respectively. Only 4 out of 50 respondents (8%) expressed the opinion that their company is controlled by Blockchain technology. There was only one person who noted for the answer "Excellent". The above results are also presented diagrammatically.

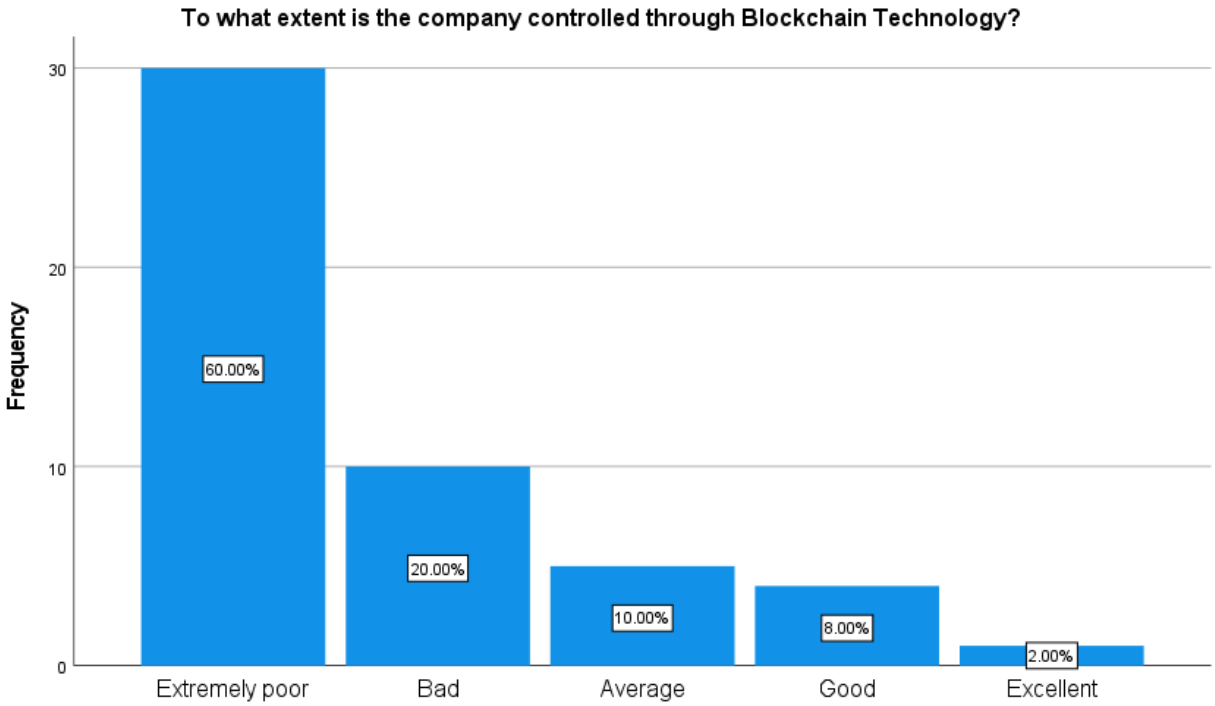

Figure 9: Question bar 9

Question 10 then asked to what extent in which the company the responded works, implement Blockchain Technology. The answers to this question are presented in the table below.

To what extent has your company implemented Blockchain Technology?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	25	50.0	50.0	50.0
	Bad	11	22.0	22.0	72.0
	Average	8	16.0	16.0	88.0

	Good	4	8.0	8.0	96.0
	Excellent	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

Table 10: Frequency Table of question 10

The responses indicate that implementation of blockchain technology within companies is still limited, with 72% of respondents stating that their company implementation is either "Extremely poor" or "Bad" (50% and 22% respectively). Conversely, only 12% of respondents answered that their companies use of blockchain technology is "Good" or "Excellent" (8% and 4% respectively). The above results are also presented diagrammatically. 16% of those surveyed indicated that their company use of Blockchain technology was "Average".

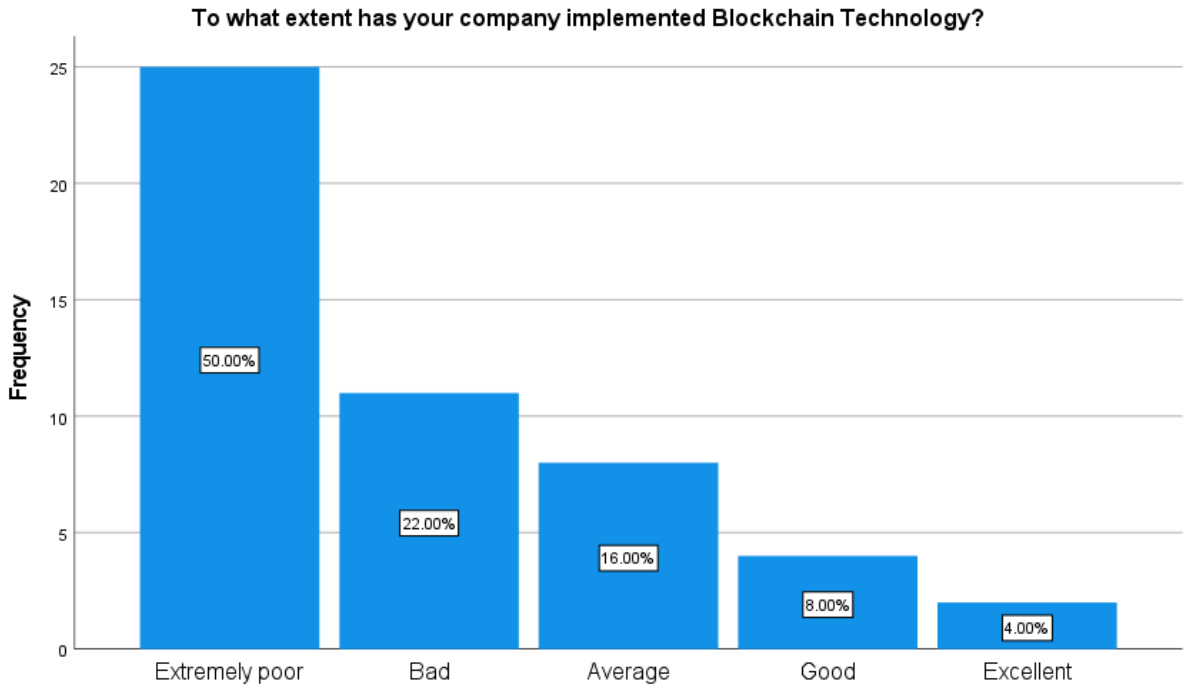

Figure 10: Question bar 10

Question 11 examines the extent in which the company has established a dedicated group to support Blockchain Technology. The results of the question are shown in the table below.

To what extent has your company established a dedicated group to support Blockchain Technology?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	31	62.0	62.0	62.0
	Bad	5	10.0	10.0	72.0
	Average	8	16.0	16.0	88.0
	Good	4	8.0	8.0	96.0
	Excellent	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

Table 11: Frequency Table of question 11

When surveyed about the extent to which their company had established a dedicated group to support blockchain technology, the overwhelming majority of respondents stated that their company provision was "Extremely Poor" (62%). However, when taken together, almost a third (28%) of those who completed the questionnaire indicated that their provision ranged from "Average" (16%) to "Excellent" (4%). A limited percentage of 10% indicated that they feel support on the implementation of blockchain is currently "Bad".

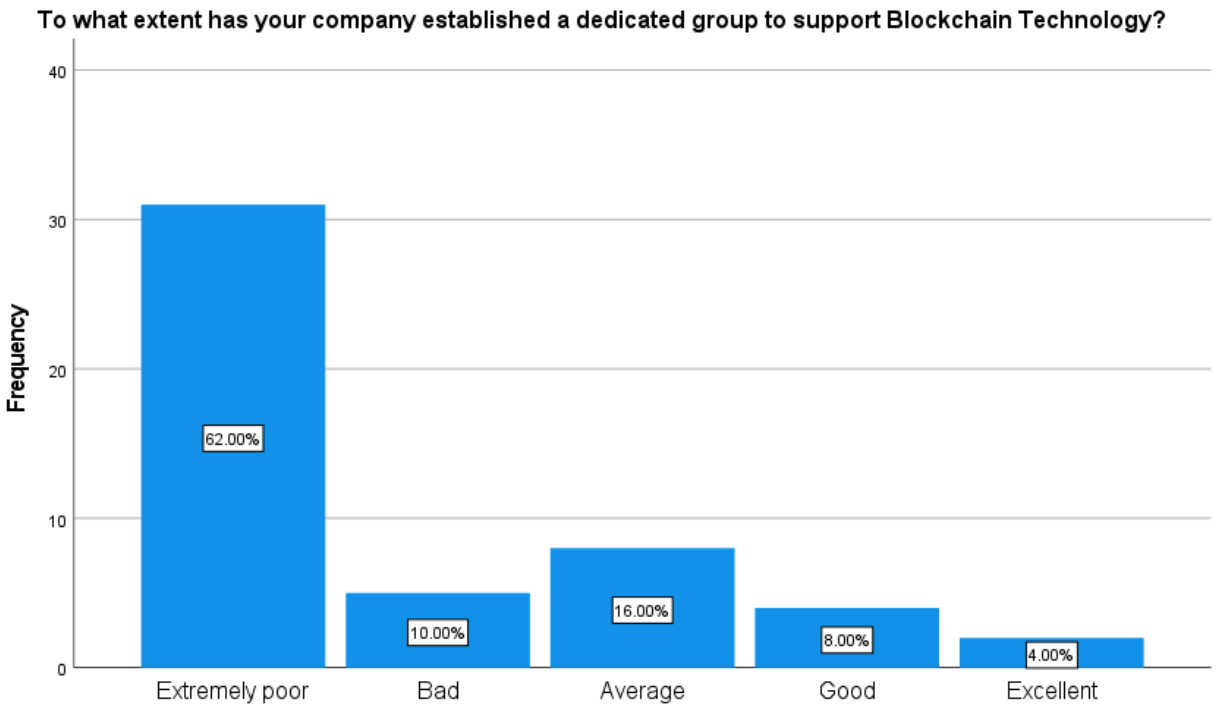

Figure 11: Question bar 11

Question 12 considers the degree in which the company has developed a budget for its Blockchain efforts. These results are presented below.

To what extent has your company developed a budget for its Blockchain efforts?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	27	54.0	54.0	54.0
	Bad	8	16.0	16.0	70.0
	Average	12	24.0	24.0	94.0
	Good	3	6.0	6.0	100.0
	Excellent	0	.0	.0	100.0
	Total	50	100.0	100.0	

Table 12: Frequency Table of question 12

Allocation of company funds to Blockchain efforts remains in its infancy, with 70% of those surveyed stating that company budgeting for this is "Extremely Poor" or "Bad". Similarly, none of those who completed the questionnaire declared that their company budget is "Excellent" (0%), with only 6% asserting that it is "Good". The relatively high number of "Average" answers (24%), however does suggest that companies are increasingly aware of the need to implement increased investment in order to keep up with competing companies.

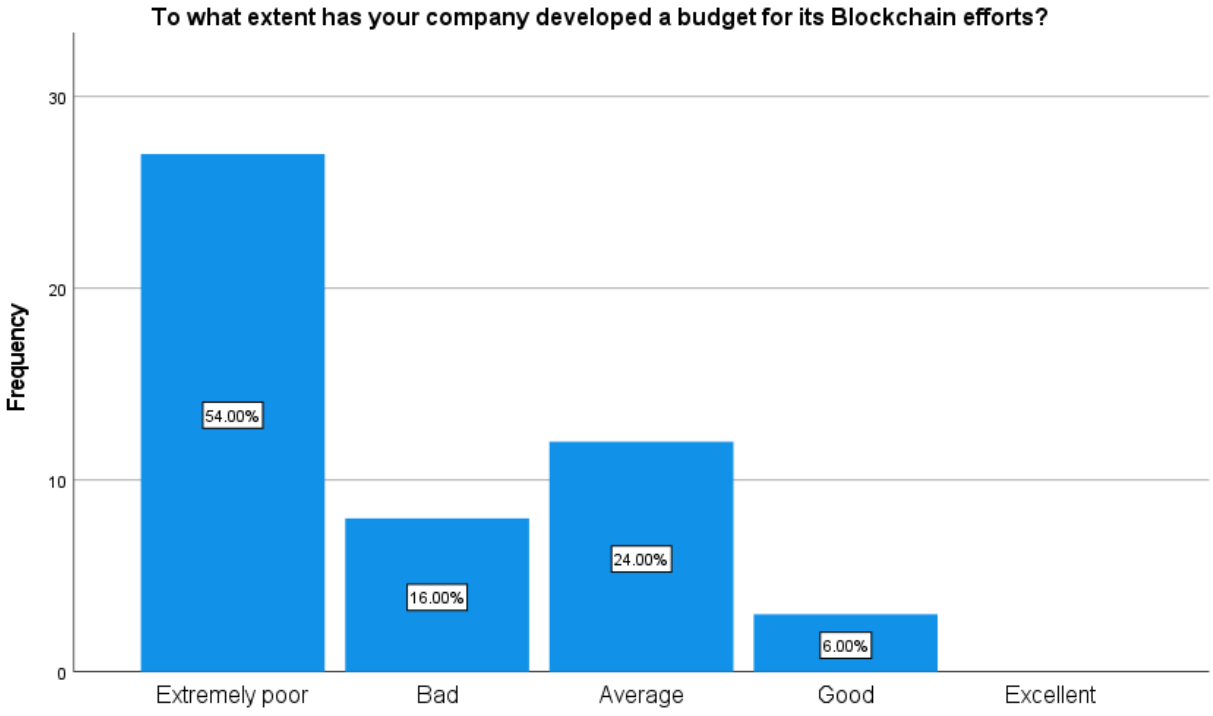

Figure 12: Question bar 12

Question 13 focuses on the advantages of Blockchain Technology. These conclusions are displayed below.

What various advantages do you intend to receive from Blockchain Technology for your organization/industry?

		Responses		Percent of Cases
		N	Percent	
What various advantages do you intend to receive from Blockchain Technology for your organization/industry?	Increased business productivity	18	11.6%	100.0%
	Identifying innovative methods for partners to automate business operations	15	9.7%	83.3%
	Improved transaction transparency and integrity	17	11.0%	94.4%
	Improved transaction speed	13	8.4%	72.2%
	The potential of Blockchain to eliminate points of failure in corporate networks provides better data safety	7	4.5%	38.9%
	Reduced transaction cost	13	8.4%	72.2%
	Improved working relationships with collaborators	13	8.4%	72.2%
	Facilitating the development of innovative business concepts	11	7.1%	61.1%
	Time savings	17	11.0%	94.4%
	Risks are minimized	15	9.7%	83.3%
	Don't know	16	10.3%	88.9%
	Other	0	0%	0%
Total		155	100.0%	861.1%

Table 13: Frequency Table of question 13

The responses regarding intended advantages from blockchain technology illustrate both the varied potential benefits of blockchain technology and also that companies are interested in utilizing the technology for company-specific reasons. This is reflected in the relatively narrow spread from the most selected use case ("Increased Business Productivity" – 11.6%) to the least selected option ("The potential of Blockchain to eliminate points of failure in corporate networks provides better data safety" – 4.5%).

By grouping the question options into categories, we can see that Productivity/Efficiency (comprising the questions "Increased business productivity", "Time savings" and "Improved working relationships with collaborators") was the most selected category with 31% of responses. After this, Transaction Improvements (comprising "Improved transaction transparency and integrity", "Improved transaction speed", and "Reduced transaction cost") was the next most selected with 27.8% respondents choosing these advantages. Innovation (comprising "Identifying innovative methods for partners to automate business operations" and "Facilitating the development of innovative business concepts") was then next with 16.8%, followed by Risk/Data Management (comprising "The potential of Blockchain to eliminate points of failure in corporate networks provides better data safety" and "Risks are minimized") with 14.2%.

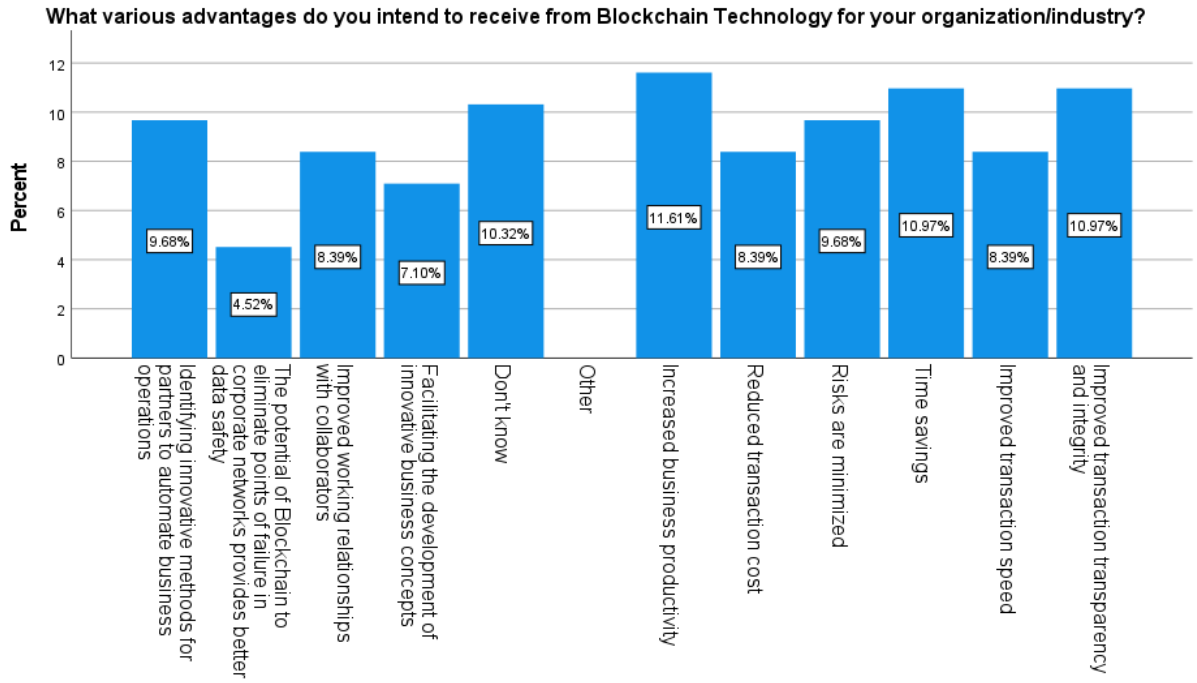

Figure 13: Question bar 13

Question 14 focuses on the disadvantages of Blockchain Technology. These results are revealed below.

What are the most significant barriers to your organization's use of Blockchain technology?

		Responses		Percent of Cases
		N	Percent	
What are the most significant barriers to your organization's use of Blockchain technology?	Blockchain technology is still in its infancy	10	9.8%	50.0%
	A lack of knowledge of what Blockchain can and can't achieve	17	16.7%	85.0%
	Not enough specialists who know how to use Blockchain technology	16	15.7%	80.0%
	Lack of industry standards	13	12.7%	65.0%
	Regulatory restrictions	6	5.9%	30.0%
	Concerns about privacy and security	7	6.9%	35.0%
	Limited market for available Blockchain solutions	12	11.8%	60.0%
	Don't know	20	19.6%	100.0%
	Others	1	1.0%	5.0%
Total		102	100.0%	510.0%

Table 14: Frequency Table of question 14

Regarding perceived barriers to utilization of blockchain technology by companies, the most popular response was "Don't know" (19.6%), which demonstrates the uncertainty and lack of clarity that remains about effective use of this technology by organizations.

This response can also be combined with "A lack of knowledge of what Blockchain can and can't achieve" (16.7%), "Not enough specialists who know how to use Blockchain technology" (15.7%), "Lack of industry standards" (12.7%), and "Blockchain technology is still in its infancy"

(9.8%). In this light, it is clear that the main obstacle to widespread adoption of blockchain technology is both a lack of understanding of the role it can play for businesses, as well as a perception that the technology is still not yet ready for significant deployment.

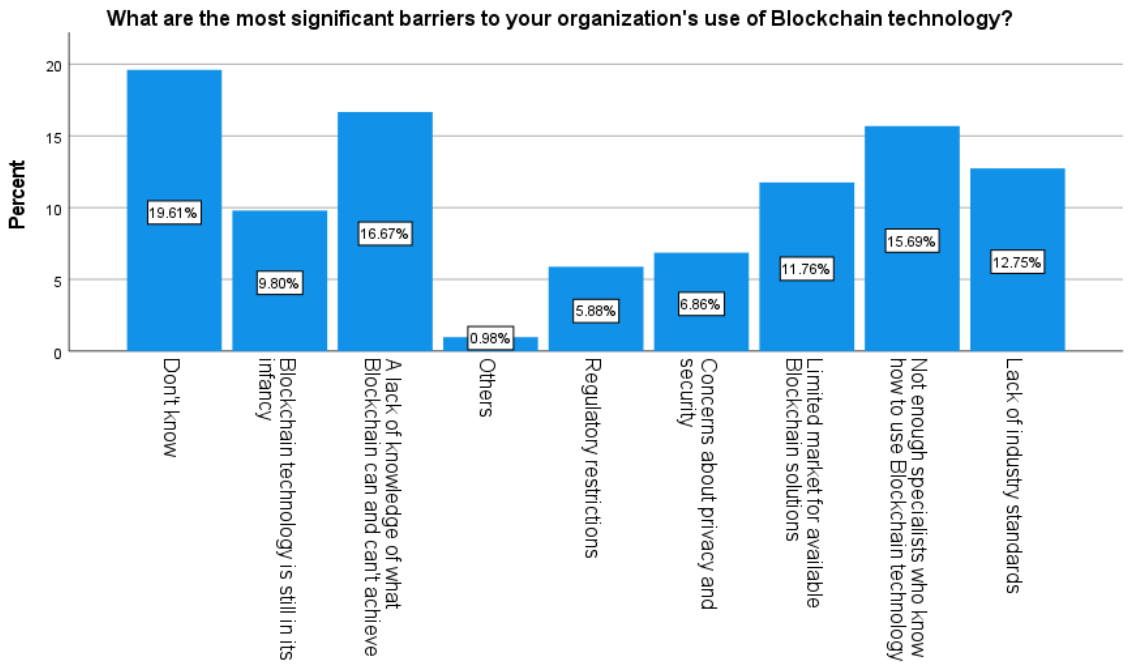

Figure 14: Question bar 14

The next question in the questionnaire is question 15, which examines the degree to which the respondents have attended a seminar on better knowledge of Pre-warning systems. The answers to the above question are presented in the table below.

To what extent have you attended a seminar on better knowledge of Pre-Warning Systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	28	56.0	56.0	56.0
	Bad	7	14.0	14.0	70.0
	Average	9	18.0	18.0	88.0

	Good	3	6.0	6.0	94.0
	Excellent	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

Table 15: Frequency Table of question 15

The majority of the people who completed the questionnaire with a cumulative percentage of 70% believe that they have not attended enough seminars on better knowledge of the Pre-warning systems. The answers "Average", "Good" and finally "Excellent" follow, with the respective percentages of these answers being 18%, 6% and 6%. The following diagram also graphically presents the results of the question.

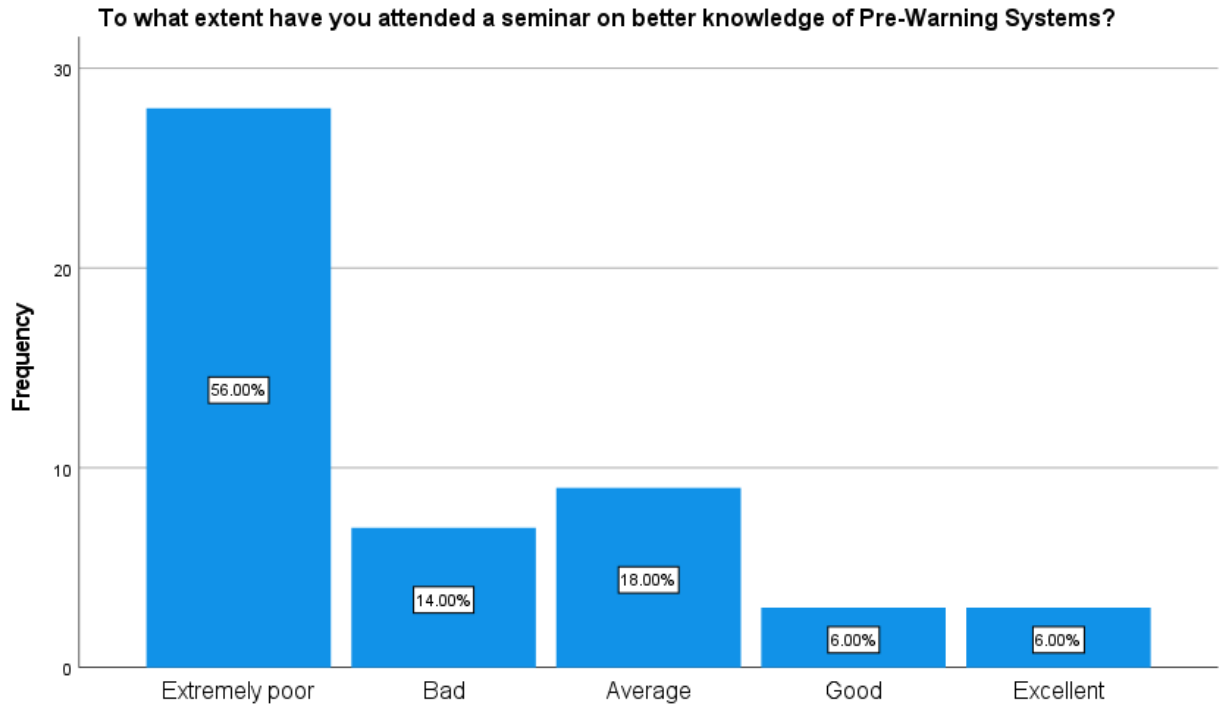

Figure 15: Question bar 15

Question 16 assesses the degree to which the respondent has knowledge and skills regarding Pre-warning systems. The answers to the above question are presented in the table below.

To what extent do you have knowledge and skills regarding Pre-Warning Systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	26	52.0	52.0	52.0
	Bad	7	14.0	14.0	66.0
	Average	14	28.0	28.0	94.0
	Good	2	4.0	4.0	98.0
	Excellent	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Table 16: Frequency Table of question 16

From the compilation of the questionnaires, we can conclude that there is a particularly large percentage of people, 52% of the sample, who stated that they have "Extremely poor" knowledge regarding Pre-warning systems. Only 4% and 2% of the respondents respectively, stated that their knowledge is "Good" and "Excellent", while 28% declared that they have "Average" awareness of these systems.

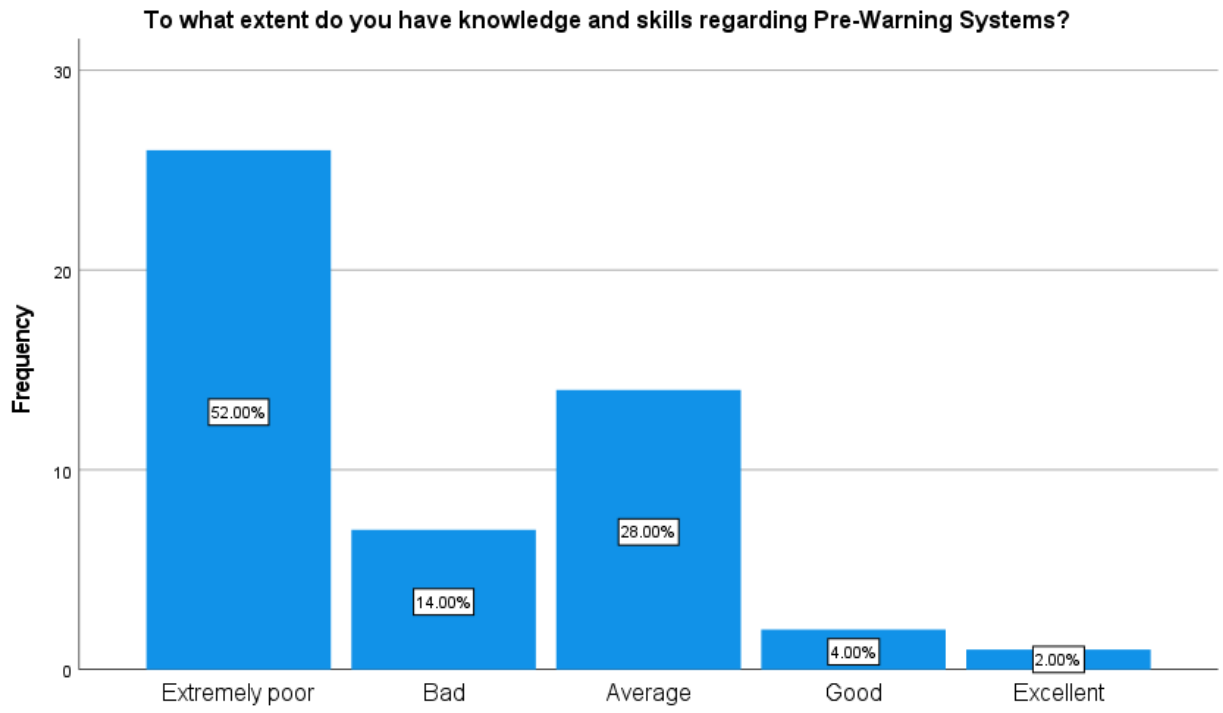

Figure 16: Question bar 16

Question 17 assesses the degree to which the person completing the survey is handling Pre-warning systems correctly. The replies to this question are listed below.

To what extent do you implement Pre-Warning Systems correctly?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	23	46.0	46.0	46.0
	Bad	8	16.0	16.0	62.0
	Average	13	26.0	26.0	88.0
	Good	5	10.0	10.0	98.0
	Excellent	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Table 17: Frequency Table of question 17

Almost half of the sample of the present survey (46%) answered that they are not at all aware of the Pre-warning systems, while the percentage of those who can handle those systems moderately was at 26%. 16% have bad knowledge on operating these systems and only 10% have good knowledge of these systems. Of course, there is a very low percentage of 2% who are very aware of the operation of those systems. The above results are also presented diagrammatically.

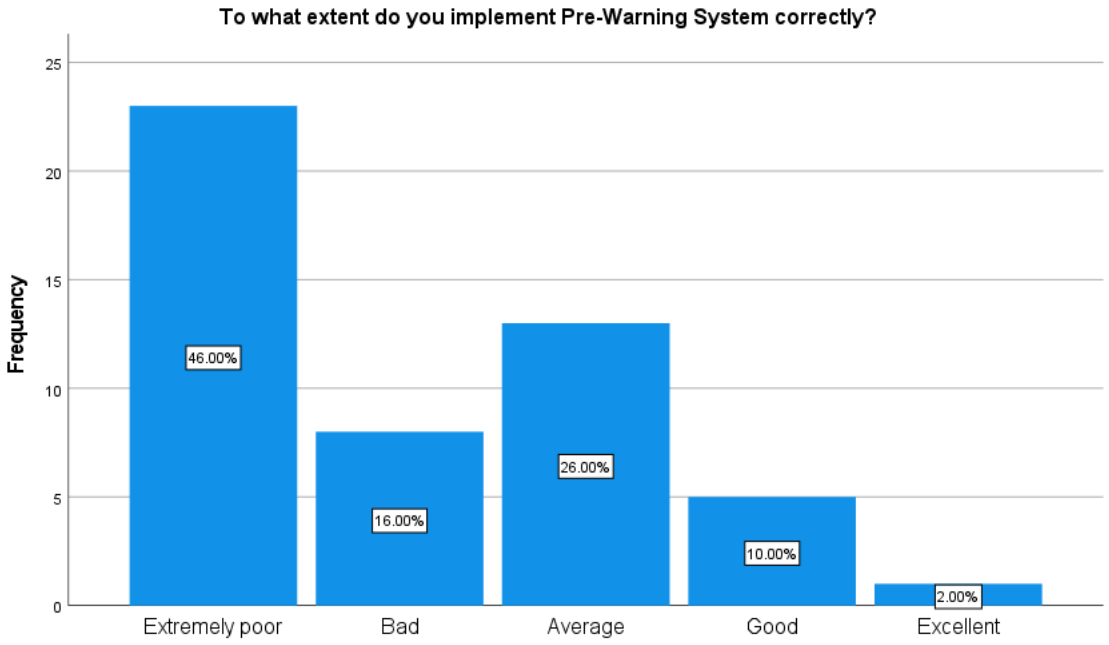

Figure 17: Question bar 17

Question 18 examines the extent to which a business is controlled by Pre-warning systems. These results are established below.

To what extent is the company controlled through Pre-Warning Systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	24	48.0	48.0	48.0
	Bad	8	16.0	16.0	64.0

	Average	11	22.0	22.0	86.0
	Good	3	6.0	6.0	92.0
	Excellent	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Table 18: Frequency Table of question 18

The results obtained for this question are similar to the results presented for the above question. Again, the option "Extremely poor" gathers the largest percentage (48%) and follows the option "Average" with a percentage of 22%. Therefore, it is understood that companies are not controlled through Pre-warning systems. The "Good" and "Excellent" options range between 6% and 8%, while a percentage of around 16%, consider that companies are badly controlled by Pre-warning systems. The above analysis is also presented graphically in the diagram that follows.

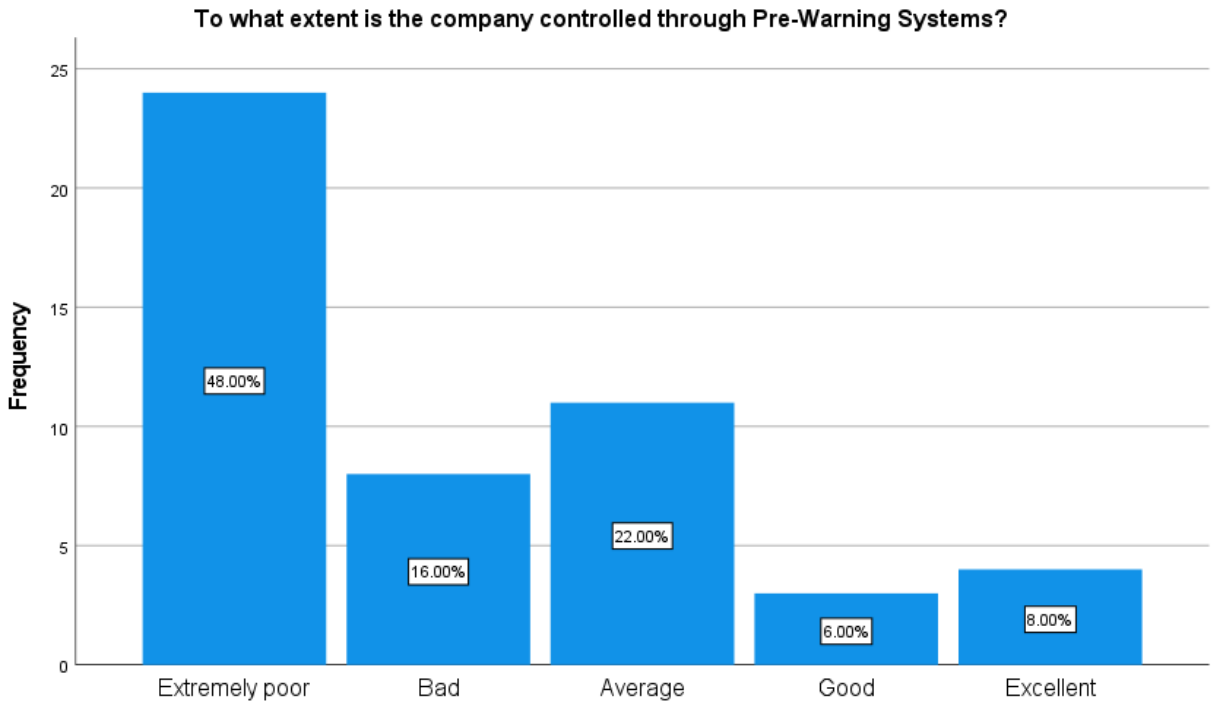

Figure 18: Question bar 18

Question 19 explores the extent in which the company the responded works implement Pre-warning systems. The results to this question are exhibited in the table below.

To what extent has your company implemented Pre-Warning Systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	22	44.0	44.0	44.0
	Bad	12	24.0	24.0	68.0
	Average	9	18.0	18.0	86.0
	Good	6	12.0	12.0	98.0
	Excellent	1	2.0	2.0	100.0
	Total	50	100.0	100.0	

Table 19: Frequency Table of question 19

Regarding the implementation of Pre-warning systems, the option "Extremely poor" gathers the overwhelming percentage of 44%, followed by the option "Bad" with a percentage of 24%, emphasizing that in the majority of companies these systems are not efficiently applied. However, only a very small percentage of 2% believe that those systems are efficient in their workplace. The answers "Average" and "Good", in total, make up about 30% of the answers. The above analysis is also presented graphically in the diagram that follows.

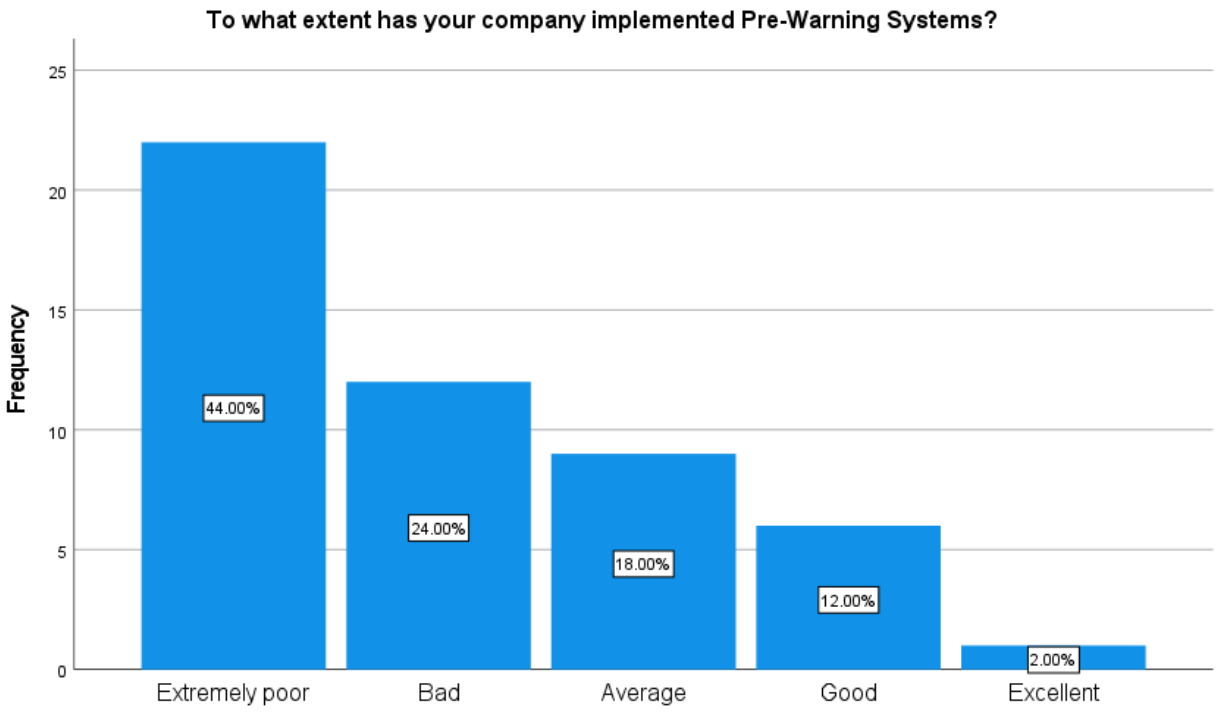

Figure 19: Question bar 19

Question 20 investigates the extent in which the company has established a dedicated group to support Pre-warning systems. The results are shown below.

To what extent has your company established a dedicated group to support Pre-Warning Systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	28	56.0	56.0	56.0
	Bad	5	10.0	10.0	66.0
	Average	10	20.0	20.0	86.0
	Good	3	6.0	6.0	92.0
	Excellent	4	8.0	8.0	100.0
	Total	50	100.0	100.0	

Table 20: Frequency Table of question 20

The effective support group for Pre-warning systems application is considered "Extremely poor" or "Bad" by the employees, as the largest percentage of the sample (56% and 10% respectively) voted for these answers. 20% of the respondents assessed that the support group of their company is "Average". On the contrary, 6% and 8% of the sample considers that the establishment of that group is "Good" and "Excellent" respectively.

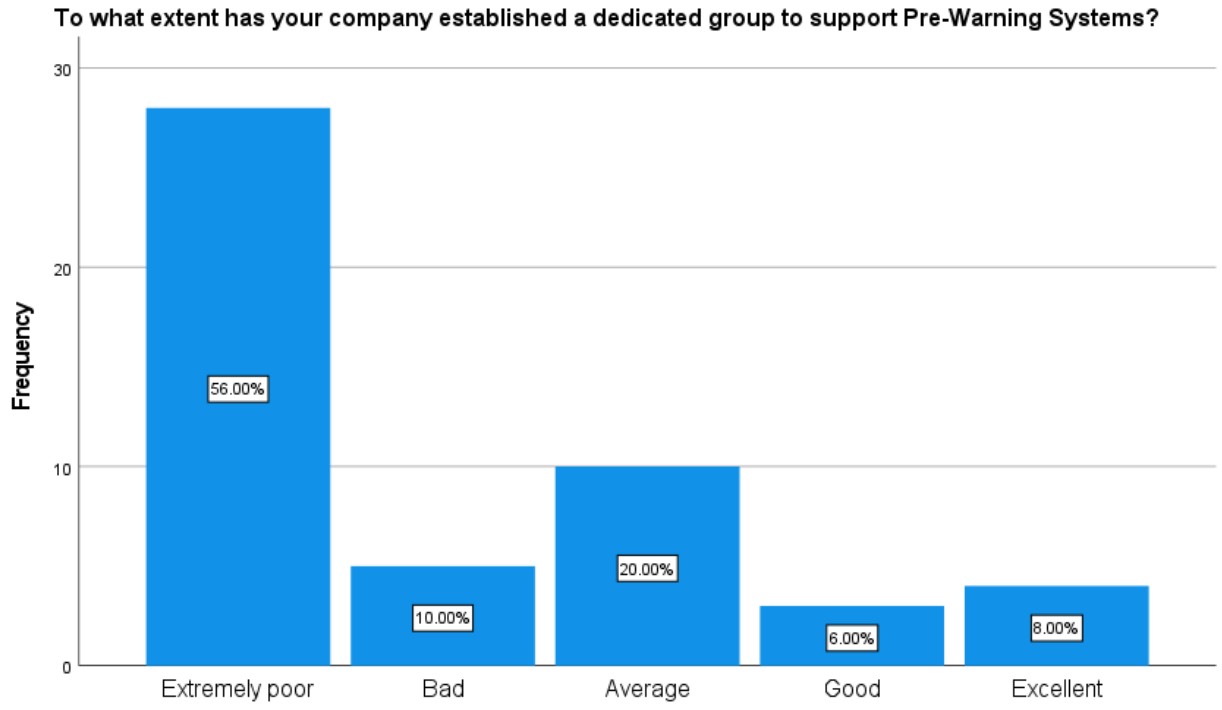

Figure 20: Question bar 20

Question 21 considers the degree in which the company has developed a budget for its Pre-warning systems efforts. The results are shown in the table below.

To what extent has your company developed a budget for its Pre-Warning efforts?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extremely poor	26	52.0	52.0	52.0

	Bad	7	14.0	14.0	66.0
	Average	11	22.0	22.0	88.0
	Good	4	8.0	8.0	96.0
	Excellent	2	4.0	4.0	100.0
	Total	50	100.0	100.0	

Table 21: Frequency Table of question 21

We observe that a large percentage (52%) of the sample finds "Extremely poor" the budget developed for the Pre-warning efforts, with the percentage of 14% who trust that they should invest more in these endeavors, as they characterize the current budget as "Bad". The options "Good" and "Excellent" recorded almost the same percentage of answers of 8% and 4% respectively. Finally, the percentage of 22% was noted for the answer "Average". The following diagram also graphically presents the results of the question.

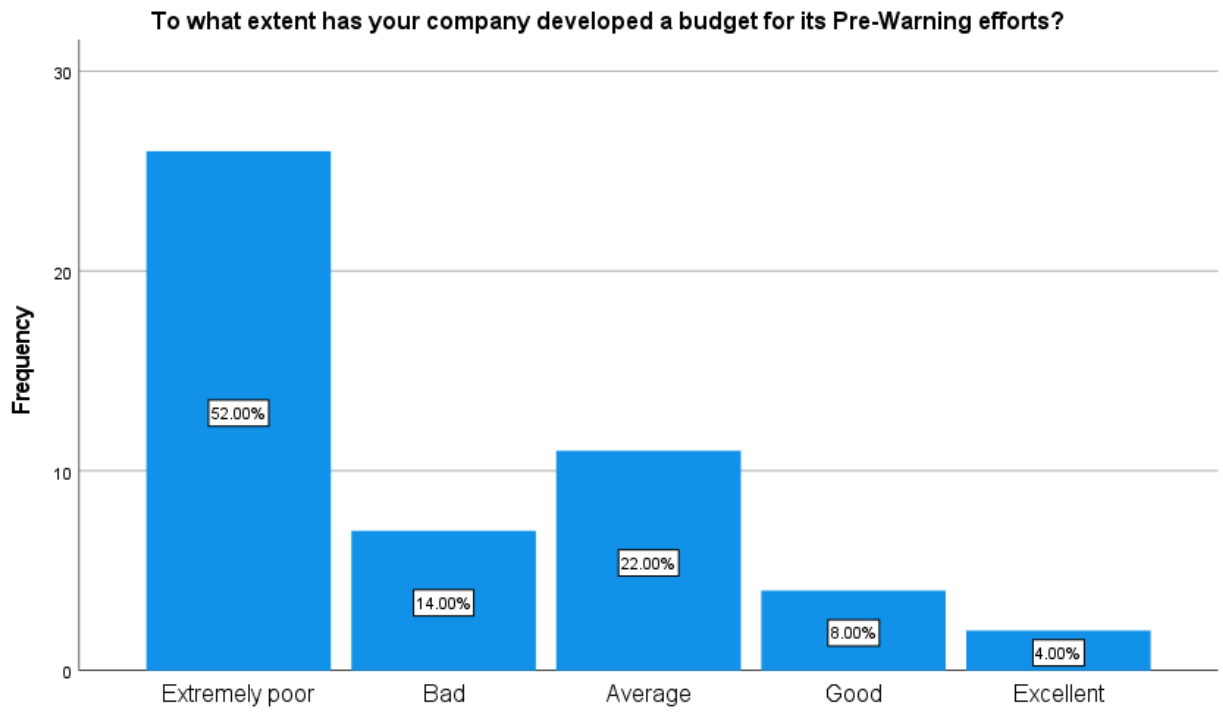

Figure 21: Question bar 21

Question 22 investigates the benefits of the Pre-warning systems. The results are shown in the table below.

What various advantages do you intend to receive from Pre-Warning Systems for your organization/industry?

		Responses		Percent of Cases
		N	Percent	
What various advantages do you intend to receive from Pre-Warning Systems for your organization/industry?	Increased business productivity	18	10.5%	75.0%
	Identifying innovative methods for partners to automate business operations	13	7.6%	54.2%
	Improved transaction transparency and integrity	17	9.9%	70.8%
	Improved transaction speed	16	9.3%	66.7%
	The potential of Pre-warning Systems to eliminate points of failure in corporate networks provides better data safety	13	7.6%	54.2%
	Reduced transaction cost	16	9.3%	66.7%
	Improved working relationships with collaborators	14	8.1%	58.3%
	Facilitating the development of innovative business concepts	7	4.1%	29.2%
	Time savings	20	11.6%	83.3%
	Risks are minimized	24	14.0%	100.0%
	Don't know	0	8.1%	58.3%
	Other	0	0%	0%
Total		172	100.0%	716.7%

Table 22: Frequency Table of question 22

The survey responses regarding potential benefits from Pre-Warning systems indicate that the application of these systems would benefit companies in multiple ways. According to the results, the most selected option was "Risks are minimized" (14%), an indication that businesses realize the importance of these systems in achieving reduced risk in the supply chain. The next most popular options of "Time savings" (11.6%) and "Increased business productivity" (10.5%). This illustrates the value of Pre-Warning systems beyond simply reducing risk level, but also potentially delivering increased efficiency.

The closely related options of "Improved transaction transparency and integrity" (9.9%), "Improved transaction speed" (9.3%), and "Reduced transaction cost" (9.3%), were unsurprisingly selected by respondents at similar rates, indicating that transaction improvements are of interest to a significant portion of respondents.

The options "Identifying innovative methods for partners to automate business operations" and "The potential of Pre-warning Systems to eliminate points of failure in corporate networks provides better data safety" both received 7.6% of survey responses. Finally, 8.1% of respondents selected "Don’t know" - a fact that indicates that most Greek companies are not aware of the benefits that these systems may confer. The above analysis is also presented graphically in the diagram that follows.

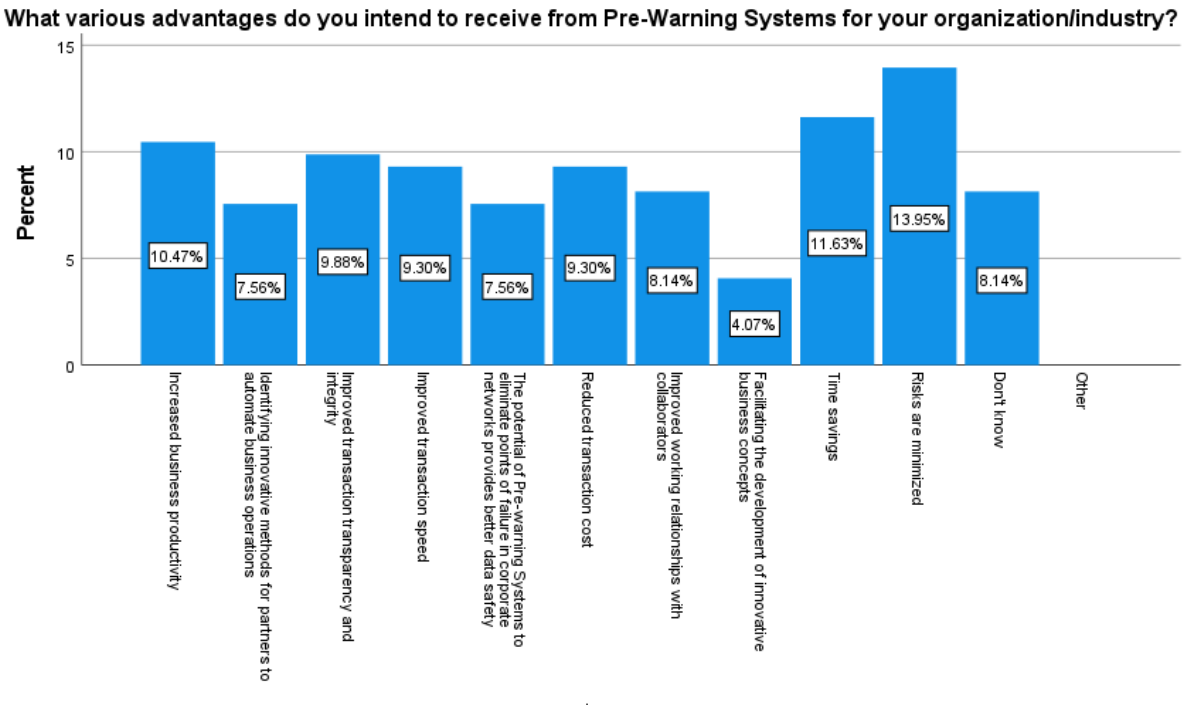

Figure 22: Question bar 22

Finally question 23 investigates the drawbacks of the Pre-warning systems. The results are shown in the table below.

What are the most significant barriers to your organization's use of Pre-warning Systems?

		Responses		Percent of Cases
		N	Percent	
What are the most significant barriers to your organization's use of Pre-warning Systems?	Pre-warning Systems are still in their infancy	9	8.7%	47.4%
	A lack of knowledge of what Pre-warning Systems can and can't achieve	19	18.3%	100.0%
	Not enough specialists who know how to use Pre-warning Systems	16	15.4%	84.2%

	Lack of industry standards	9	8.7%	47.4%
	Regulatory restrictions	11	10.6%	57.9%
	Concerns about privacy and security	7	6.7%	36.8%
	Limited market for available Pre-Warning System solutions	12	11.5%	63.2%
	Don't know	19	18.3%	100.0%
	Others	2	1.9%	10.5%
Total		104	100.0%	547.4%

Table 23: Frequency Table of question 23

It is clear that the greatest impediment to adoption of Pre-warning systems is a lack of knowledge regarding their application. The two most popular responses, "A lack of knowledge of what Pre-warning Systems can and can't achieve" and "Don't know" (18.3% respectively), justify the above conclusion. Furthermore, the two next most selected options " Not enough specialists who know how to use Pre-warning Systems" (15.4%) and "Limited market for available Pre-Warning System solutions" (11.5%), denote that even if there is awareness on the benefits of Pre-warning systems, there are not currently enough people in Greece who specialize in this field, nor enough of a market available.

Both "Pre-warning Systems are still in their infancy" and "Lack of industry standards" options obtained 8.7% of the survey answers, highlighting that this technology is still perceived to be not fully developed.

Two of the fifty answers collected, also responded with additional considerations, choosing the option "Others". These respondents stated that "Their use is not widely known to all staff of the company, so their functionality is reduced" and "I'm not in charge of the matter", further emphasizing that companies feel that there are yet many things to be learnt about these systems. The above analysis is also presented graphically in the diagram that follows.

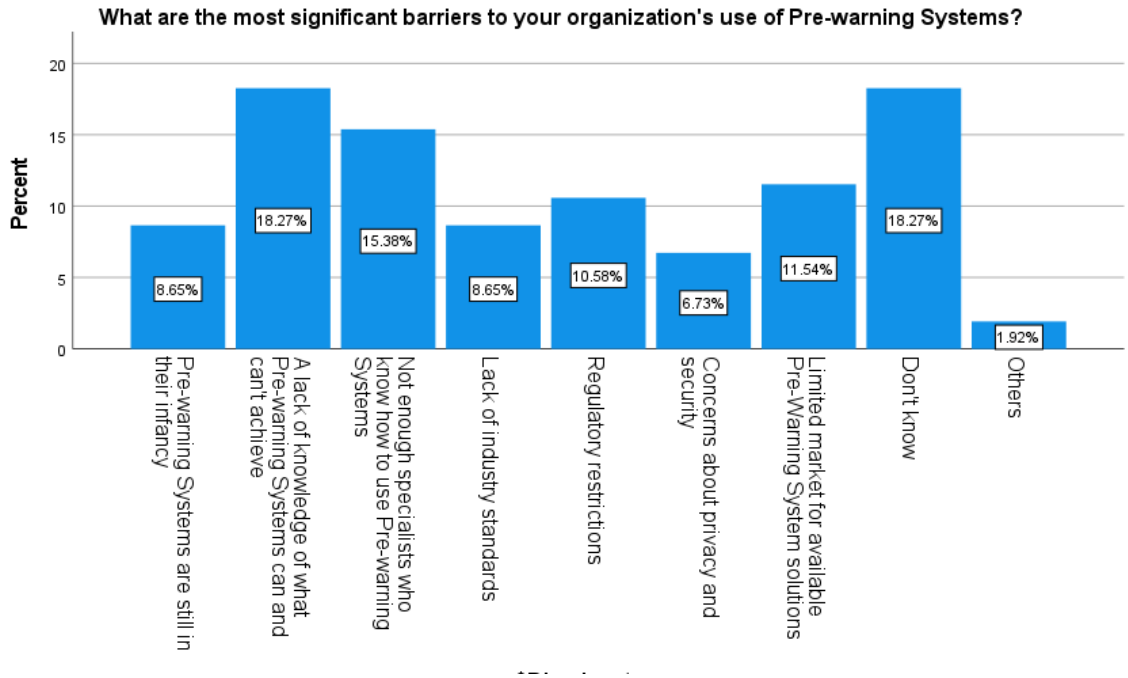

Figure 23: Question bar 23

The following table summarizes the results of the descriptive statistics for all the questions developed in the questionnaire of this research (1 to 23) and more specifically gives the information about the number of answers taken into account (N), the minimum (Minimum) and the Maximum possible value of the answer to each question, the average (Mean) and finally the standard deviation (Std Deviation).

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
Business size	1	4	2.62	1.086
Which is approximately the number of employees in your company?	0	3	1.54	1.073

Depending on the size of your company, you may want to respond to the questions in this survey for the whole enterprise or for a specific division. To which of the following will your answers apply?	0	2	.60	.670
To what extent are you familiar with Blockchain Technology?	0	3	.90	1.015
To what extent are you familiar with the Pre-warning Systems?	0	4	1.08	1.066
To what extent have you attended a seminar on better knowledge of Blockchain Technology?	0	3	.68	.978
To what extent do you have knowledge and skills regarding Blockchain Technology?	0	4	.92	1.175
To what extent do you implement Blockchain Technology correctly?	0	3	.72	.970
To what extent is the company controlled through Blockchain Technology?	0	4	.72	1.070
To what extent has your company implemented Blockchain Technology?	0	4	.94	1.168
To what extent has your company established a dedicated group to support Blockchain Technology?	0	4	.82	1.207

To what extent has your company developed a budget for its Blockchain efforts?	0	3	.82	1.004
Increased business productivity	0	1	.36	.485
Identifying innovative methods for partners to automate business operations	0	1	.30	.463
Improved transaction transparency and integrity	0	1	.34	.479
Improved transaction speed	0	1	.26	.443
The potential of Blockchain to eliminate points of failure in corporate networks provides better data safety	0	1	.14	.351
Reduced transaction cost	0	1	.26	.443
Improved working relationships with collaborators	0	1	.26	.443
Facilitating the development of innovative business concepts	0	1	.22	.418
Time savings	0	1	.34	.479
Risks are minimized	0	1	.30	.463
Don't know	0	1	.32	.471
Other	0	0	.00	.000
Blockchain technology is still in its infancy	0	1	.20	.404
A lack of knowledge of what Blockchain can and can't achieve	0	1	.34	.479
Not enough specialists who know how to use Blockchain technology	0	1	.32	.471
Lack of industry standards	0	1	.26	.443
Regulatory restrictions	0	1	.12	.328
Concerns about privacy and security	0	1	.14	.351
Limited market for available Blockchain solutions	0	1	.24	.431
Don't know	0	1	.40	.495

Others	0	1	.02	.141
To what extent have you attended a seminar on better knowledge of Pre-Warning Systems?	0	4	.92	1.243
To what extent do you have knowledge and skills regarding Pre-Warning Systems?	0	4	.90	1.074
To what extent do you implement Pre-Warning System correctly?	0	4	1.06	1.150
To what extent is the company controlled through Pre-Warning Systems?	0	4	1.10	1.298
To what extent has your company implemented Pre-Warning Systems?	0	4	1.04	1.142
To what extent has your company established a dedicated group to support Pre-Warning Systems?	0	4	1.00	1.325
To what extent has your company developed a budget for its Pre-Warning efforts?	0	4	.98	1.204
Increased business productivity	0	1	.36	.485
Identifying innovative methods for partners to automate business operations	0	1	.26	.443

Improved transaction transparency and integrity	0	1	.34	.479
Improved transaction speed	0	1	.32	.471
The potential of Pre-warning Systems to eliminate points of failure in corporate networks provides better data safety	0	1	.26	.443
Reduced transaction cost	0	1	.32	.471
Improved working relationships with collaborators	0	1	.28	.454
Facilitating the development of innovative business concepts	0	1	.14	.351
Time savings	0	1	.40	.495
Risks are minimized	0	1	.48	.505
Don't know	0	1	.28	.454
Other	0	0	.00	.000
Pre-warning Systems are still in their infancy	0	1	.18	.388
A lack of knowledge of what Pre-warning Systems can and can't achieve	0	1	.38	.490
Not enough specialists who know how to use Pre-warning Systems	0	1	.32	.471
Lack of industry standards	0	1	.18	.388
Regulatory restrictions	0	1	.22	.418

Concerns about privacy and security	0	1	.14	.351
Limited market for available Pre-Warning System solutions	0	1	.24	.431
Don't know	0	1	.38	.490
Others	0	1	.04	.198

Table 24: Table of Descriptive Statistics

6. DISCUSSION AND CONCLUSIONS

6.1. Introduction

This chapter summarizes the conclusions of the dissertation, as evidenced by both the literature review and the analysis of the answers to the questionnaire. Next, reference is made on the constraints and suggestions for further research on the benefits and barriers of Blockchain Technology and Pre-warning systems.

6.2. Empirical Research Conclusions

Risk exists in almost every organization and has been thoroughly researched in a wide range of business scenarios. Risks have shifted around supply networks as a result of contemporary business trends such as increased product/service intricacy, outsourcing, globalization, and e-commerce, which have led in increasingly complex, unpredictable supply networks. Managers must be able to detect, evaluate, and handle threats and possibilities from a wider range of sources and situations (Singh, Jain and Mishra, 2009).

The literature review found that technologies can significantly reduce the negative effects of potential food supply chain threats, as well as provide useful advice and suggestions for their prevention. It is obvious that through the innovation of these technologies, food companies are able to detect a potential risk in time before it spreads and causes overwhelming consequences (Duan *et al.*, 2020).

The empirical research conducted by distributing questionnaires in food industries and food processing companies, showed that the majority of them consider the systems for identifying and combating potential risks to be important and useful.

Initially, based on the collected demographic data, it was observed that out of the 50 respondents, the majority work in medium-sized food companies, while the questionnaires were answered mainly taking into account the whole company and not a specific department. A first attempt to discover if the respondents are aware of the 2 technologies was made. According to the

results of the descriptive statistics, the respondents seemed to be unfamiliar in a very big percentage of the systems for detecting and dealing with an impending danger. It also seemed that they do not use some of them in the company where they work at.

Then, analyzing the second and third part of the questionnaire, where an attempt is made to approach the respondents about their personal skills regarding the proposed systems, we can conclude that the majority does not know how to handle the systems properly and efficiently, but considers that they provide useful information and suggestions and that due to the difficulty in using them need proper information and training. More specifically in the second and third part of the questionnaire the respondents answered that the company in which they operate is not controlled by neither Blockchain technology nor any Pre-warning systems and does not have staff who know their operation. However, the respondents recognize the potential benefits that these technologies could bestow, despite being aware of possible difficulties in implementing these systems within their existing structures.

In summary, risk management systems are a very important tool in dealing with a potential threat, as well as in their prevention. With the proper use of the above systems, risks can be minimized and possibly even prevented from happening by also increasing each organization's efficiency.

6.3. Limitations and suggestions for future research

Despite the important conclusions drawn, the present work and its results are subject to some limitations. Initially, a significant limitation arises from the limited time period in which the empirical research was conducted. At the same time, the fact that the questionnaire was answered by a relatively small sample size and a large percentage of those who answered were business managers may affect the impartiality and objectivity of the answers. Another important fact that can be taken into account as a limiting factor is that the majority of responses were collected from employees in the private sector, and more specifically in the service sector, which does not allow the generalization of responses to all companies and of Greek organizations. Finally, the last limitation that needs to be considered is the fact that this research was restricted to Greek

companies only, and so may not capture different levels of familiarity and engagement internationally.

Future research is proposed to focus its interest individually on one sector of Greece, in order to produce different results for the private or public sector of the country. At the same time, it is proposed to conduct empirical research over a longer period of time using a larger sample to extract more specialized and representative results, as well as the use of an additional research tool, such as the personal interview tool.

7. REFERENCES

Abad, E. *et al.* (2009) "RFID smart tag for traceability and cold chain monitoring of foods: Demonstration in an intercontinental fresh fish logistic chain," *Journal of Food Engineering*, 93(4), pp. 394–399.

Abhijit, B., Rubi, D. and Pijus, K.D. (2021) "Impact of COVID-19 in food supply chain: Disruptions and recovery strategy," *Current Research in Behavioral Sciences*, 2(100017), pp. 1–5.

Aday, S. and Aday, S.M. (2020) "Impact of COVID-19 on the food supply chain," *Food Quality and Safety*, (4), pp. 167–180.

Agrilinks (2020) *Preventing global food security crisis under COVID-19*. Available at: https://www.agrilinks.org/post/preventing-global-food-securitycrisis- under-covid-19-emergency (Accessed: February 8, 2022).

Ahumada, O. and Villalobos, J.R. (2009) "Application of planning models in the agri-food supply chain: A review," *European Journal of Operational Research*, 196(1), pp. 1–20.

Almena, A., Fryer, P.J. and Bakalis, S. (2019) "Centralized and distributed food manufacture: a modeling platform for technological, environmental and economic assessment at different production scales," *Sustainable Production and Consumption*, 19, pp. 181–193.

Alonso, E. *et al.* (2007) "Material availability and the supply chain: risks, effects, and responses," *Environmental Science and Technology*, 41, pp. 6649–6656.

Applequist, G.E., Pekny, J.F. and Reklaitis, G.V. (2000) "Risk and uncertainty in managing chemical manufacturing supply chains," *Computers & Chemical Engineering*, 24(9), pp. 2211–2222.

Arianina, K. and Morris, P. (2020) *COVID-19 Export Restrictions Threaten Global Food Supply*. Available at: https://www.squirepattonboggs.com/-/ media/files/insights/publications/2020/05/covid-19-export-restrictionsthreaten- global-food supply/law360covid19exportrestrictionsthreatenglo balfoodsupply.pdf (Accessed: February 8, 2022).

Artiga, S. and Rae, M. (2020) *The COVID-19 Outbreak and Food Production Workers: Who is at Risk?*, *Kaiser Family Foundation*. Available at: https:// www.kff.org/coronavirus-covid-19/issue-brief/the-covid-19-outbreakand- food-production-workers-who-is-at-risk/ (Accessed: February 3, 2022).

Ashton, D. (1998) "Systematic risk and empirical research," *Journal of Business Finance and Accounting*, 25(9/10), pp. 1325–1356.

Ashton, M.C. (1998) "Personality and job performance: the importance of narrow traits," *Journal of Organizational Behavior* [Preprint].

Aste, T., Tasca, P. and di Matteo, T. (2017) "Blockchain technologies: The foreseeable impact on society and industry," *Computer*, 50(9), pp. 18–28.

Atzori, L., Iera, A. and Morabito, G. (2010) "The Internet of Things: A survey," *Computer Networks*, 54(15), pp. 2787–2805.

Aung, M.M. and Chang, Y.S. (2014a) "Traceability in a food supply chain: Safety and quality perspective," *Food Control*, 39, pp. 172–184.

Aung, M.M. and Chang, Y.S. (2014b) “Traceability in a food supply chain: Safety and quality perspective,” *Food Control*, 39, pp. 172–184.

Bakalis, S., Valdramidis, V.P. and Argyropoulos, D. (2020) “Perspectives from CO+RE: how COVID-19 changed our food systems abd food security oaradigms,” *Current Research in Food Science*, pp. 166–172.

Baldos, U.L.C. and Hertel, T.W. (2015) “The role of international trade in managing food security risks from climate change,” *Food Security*, 7, pp. 275–290.

Barboza, D. (2018) *China Milk Cover-Up Started Last Year*, *The New York Times*. Available at: https: //www.nytimes.com/2008/09/23/world/asia/23iht-24milk-new.16423573.html (Accessed: March 15, 2022).

Barman, A., Das, R. and Kanti De, P. (2021) “Logistics and supply chain management of food industry during COVID-19: disruptions and a recovery plan,” *Environment Systems and Decisions*, pp. 1–13.

Baucus, D.A., Golec, J.H. and Cooper, J.R. (1993) “Estimating risk-return relationships: an analysis of measures,” *Strategic Management Journal*, 14(5), pp. 387–396.

Baucus, M.S. *et al.* (2008) “Fostering Creativity and Innovation without Encouraging Unethical Behavior,” *Journal of Business Ethics*, 81, pp. 97–115.

BBC (British Broadcasting Corporation) (2020) *Coronavirus: Five ways the outbreak is hitting global food industry.* Available at: https://www.bbc.com/ news/world-52267943 (Accessed: January 14, 2022).

Biswas, K., Muthukkumarasamy, V. and Tan, W.L. (2017) “Blockchain based wine supply chain traceability system,” in *In Proceedings of the Future Technologies Conference (FTC) 2017*. Vancouver, BC, Canada, pp. 56–62.

Bosona, T. and Gebresenbet, G. (2013) “Food traceability as an integral part of logistics managemnt in food and agricultural supply chain,” *Food Control*, 33, pp. 32–48.

Cagle, S. (2020) *A disastrous situation’: mountains of food wasted as coronavirus scrambles supply chain*, *The Guardian*. Available at: https://www.theguardian.com/world/2020/apr/ 09/us-coronavirus-outbreak-agriculture-food-supply-waste?CMP5share_btn_fb (Accessed: January 14, 2022).

Caro, M.P. *et al.* (2018) “Blockchain-based traceability in agri-food supply chain management: A practical implementation,” in *In Proceedings of the 2018 IoT Vertical and Tropical Summit on Agriculture*. Tuscany, Italy.

CBH Group and AgriDigital (2019) *Pilot Report: Solving for Supply Chain Inefficiencies and Risks with Blockchain in Agriculture*. Available at: https://www.agridigital.io/reports/blockchain-pilot-report (Accessed: March 15, 2022).

Celly, K.S. and Frazier, G.L. (1996) “Outcome-based and behavior-based coordination efforts in channel relationships,” *Journal of Marketing Research*, 33(2), pp. 200–210.

Charles, D. (2020) *Food shortages? Nope, too much food in the wrong places*, *The Salt, on National Public Radio*. Available at: https://www.npr.org/sections/thesalt/2020/04/03/ 826006362/food-shortages-nope-too-much-food-in-the-wrong-places?utm_campaign5storyshar %E2%80%A6 (Accessed: January 14, 2022).

Chow, K.V. and Denning, K.C. (1994) "On variance and lower partial movement betas: the equivalence of systematic risk measures," *Journal of Business Finance and Accounting*, 21(2), pp. 231–241.

Chowdhury, S. *et al.* (2022) "Blockchain technology adoption for managing risks in operations and supply chain management: evidence from the UK," *Annals of Operations Research*, pp. 1–37.

Coindesk (2019) *How Will Ethereum Scale?* Available at: https://www.coindesk.com/information/willethereum-scale (Accessed: March 15, 2022).

Corkery, M. and Yaffe-Bellany, D. (2020a) *U.S. food supply chain is strained as virus spreads, The New York TImes*. Available at: https://www.nytimes.com/2020/04/13/business/ coronavirus-food-supply.html?referringSource5articleShare (Accessed: January 14, 2022).

Corkery, M. and Yaffe-Bellany, D. (2020b) *We had to do something' trying to prevent massive food waste, New York Times* . Available at: https://www.nytimes.com/2020/05/02/ business/coronavirus-food-waste-destroyed.html?referringSource5articleShare (Accessed: January 14, 2022).

Croom, S., Romano, P. and Giannakis, M. (2000) "Supply chain management: an analytical framework for critical literature review," *European Journal of Purchasing and Supply Management*, 6, pp. 67–83.

Dabbene, F., Gay, P. and Tortia, C. (2014) "Traceability issues in food supply chain management: A review," *Biosystems Engineering*, 120, pp. 65–80.

Deconinck, K., Avery, E. and Jackson, A. (2021) "Food Supply Chain and Covid-19: Impacts and Policy Lessons," *Agricultural Economics Society and European Association of Agricultural Economists*, 19(3), pp. 34–39.

Deloach, J. (2000) "Entreprise - wide risk management - an executive summary," *Arthur Anderson. Financial Times, Prentice Hall. London* [Preprint].

Devereux, S., Béné, C. and Hoddinott, J. (2020) "Conseptualising COVID-19's impacts on household food security," *Food Security*, 12, pp. 769–772.

Duan, J. *et al.* (2020) "A Content-Analysis Based Literature Review in Blockchain Adoption within Food Supply Chain," *International Journal of Environmental Research and Public Health*, 17(1784), pp. 1–17.

Dunkley, D. (2020) *Cashierless stores and online deliveries are the future of supermarket shopping, Stuff.co.nz*. Available at: https://www.stuff.co.nz/business/better-business/ 120587848/cashierless-stores-and-online-deliveries-are-the-future-of-supermarket-shopping?r% E2%80%A6 (Accessed: January 14, 2022).

Erridge, A., Fee, R. and McIlroy, J. (1998) "European union public procurement policy and electronic commerce: problems and opportunities," *European Business Review*, 5, pp. 252–259.

Espitia, A., Rocha, N. and Ruta, M. (2020) "Covid-19 and food protectionism: the impact of the pandemic and export restrictions on world food markets. Policy Research Working Paper, No. 9253, World Bank," pp. 1–30.

FAO (Food and Agriculture Organisation of the United Nations) (2020) *Impacts of coronavirus on food security and nutrition in Asia and the Pacific: building more resilient food systems*. Available at: http://www.fao.org/3/ ca9473en/CA9473EN.pdf (Accessed: February 3, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2011) *Lessons from the world food crisis of 2006-08, Food and Agriculture Organization*. Available at: http://www.fao.org/3/i2330e/i2330e04.pdf (Accessed: February 8, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2014) *Traceability*. Available at: https://www.unglobalcompact.org/docs/issues_doc/supply_ chain/Traceability/Guide_to_Traceability.pdf (Accessed: March 4, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2020a) "Adjusting business models to sustain agri-food enterprises during covid-19," *FAO* [Preprint]. Available at: http://www.fao.org/3/ca8466en/ CA8466EN.pdf (Accessed: January 14, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2020b) *Ample supplies to help shield food markets from the COVID-19 crisis*. Available at: http://www.fao.org/documents/card/en/c/ca8445en (Accessed: February 8, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2020c) *COVID-19 and the risk to food supply chains: How to respond?* Available at: http://www.fao.org/3/ca8388en/CA8388EN.pdf (Accessed: January 14, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2020d) *Legal mechanisms to contribute to safe and secured food supply chains in time of COVID-19*. Available at: http://www.fao.org/3/ca9121en/CA9121EN. pdf (Accessed: February 3, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2020e) *Policy responses to keep input markets flowing in times of COVID-19.* Available at: http://www.fao.org/3/ca8979en/CA8979EN.pdf.

FAO (Food and Agriculture Organization of the United Nations) (2020f) *Policy responses to keep input markets flowing in times of COVID-19.* Available at: http://www.fao.org/3/ca8979en/CA8979EN.pdf (Accessed: January 14, 2022).

FAO (Food and Agriculture Organization of the United Nations) (2020g) *Responding to the impact of the COVID-19 outbreak on food value chains through efficient logistics*. Available at: http://www.fao.org/3/ca8466en/ CA8466EN.pdf (Accessed: January 14, 2022).

Fitton, N. *et al.* (2019) "The vulnerabilities of agricultural land and food production to future water scarcity," *Global Environmental Change*, 58(101944), pp. 1–10.

Flynn, D. (2020) *CDC provides first guidance to a specific meat plant for combating COVID-19 among employees, Food Safety News*. Available at: https://www. foodsafetynews.com/2020/04/cdc-provides-first-guidance-to-a-specificmeat- plant-for-combating-covid-19-among-employees/ (Accessed: February 3, 2022).

Folkerts, H. and Koehorst, H. (1997) "Challenges in international food supply chains: Vertical co-ordination in the European agribusiness and food industries," *Supply Chain Management International Journal*, 2, pp. 11–14.

Foster, S.T. (2008) "Towards an understanding of supply chain quality management," *Journal of Operations Management*, 26(4), pp. 461–467.

Fyles, H. and Madramootoo, C. (2016) "Key drivers of food insecurity, In Emerging Technologies for Promoting Food Security," *Woodhead Publishing*, pp. 1–19.

Galanakis, C.M. (2020) “The food systems in the Era of the Coronavirus (COVID-19) Pandemic Crisis,” *Food*, 9(523), pp. 1–10.

Galvez, J.F., Mejuto, J.C. and Gandara, J.S. (2018) “Future challenges on the use of blockchain for food traceability analysis,” *Trends in Analytical Chemistry*, 107, pp. 222–232.

Ganesham, R. and Harrison, P.T. (2002) “An Introduction to Supply Chain Management,” pp. 1–7.

Golan, E., Krissoff, B. and Kuchler, F. (2004) *Food Traceability: One Ingredient in a Safe and Efficient Food Supply*, *Economic Research Serice/USDA*. Available at: https://www.ers.usda.gov/amber-waves/2004/april/ food-traceability-one-ingredient-in-a-safe-and-efficient-food-supply/ (Accessed: March 4, 2022).

Gomes-Casseres, B. (1994) “Group versus group: how alliance networks compete,” *Harvard Business Review*, 72(4), pp. 62–67.

Gulland, A. (2020) *Revealed: why meat processing plants are the ideal incubator of the coronavirus*, *The Telegraph*. Available at: https://www.telegraph. co.uk/global-health/science-and-disease/revealed-meat-processing-plantsideal- incubator-coronavirus/ (Accessed: February 3, 2022).

Hackius, N. and Petersen, M. (2017) *Blockchain in logistics and supply chain: Trick or Treat?*, *n Digitalization in Supply Chain Management and Logistics.* . Available at: https://tore.tuhh.de/bitstream/11420/1447/1/petersen_ hackius_blockchain_in_scm_and_logistics_hicl_2017.pdf (Accessed: March 15, 2022).

Haishui, J. and Jun, W. (2018) “Research on Food Supply Chain Risk and Its Management,” *International Journal of Food Science and Biotechnology*, 3(4), pp. 102–108.

Hall, C.M. *et al.* (2020) “Beyond panic buying: consumption displacement and COVID-19,” *Journal of Service Management*, 32(1), pp. 113–128.

Hamilton, G. (1996) “Risk Management,” *Lund: Studentliteratur* [Preprint].

Hastig, G. and Sodhi, M.S. (2019) “Blockchain for supply chain traceability: Business requirements and critical success factors,” *Production and Operations Management*, pp. 1–45.

Heising, J.K. *et al.* (2013) “Monitoring the Quality of Perishable Foods: Opportunities for Intelligent Packaging,” *Critical Reviews in Food Science and Nutrition*, 54(5), pp. 645–654.

Ho, S.S. and Pike, R.H. (1992) “Adoption of probabilistic risk analysis in capital budgeting and corporate investment,” *Journal of Business Finance and Accounting*, 19(3), pp. 387–405.

Hobbs, J.E. (2020) “Food supply chains during the COVID-19 pandemic,” *Canadian Journal of Agricultural Economics/Revue canadienne d’agroeconomie*, 68, pp. 171–176.

Hua, J. *et al.* (2018) “Blockchain based Provenance for Agricultural Products: A Distributed Platform with Duplicated and Shared Bookkeeping.,” in *In Proceedings of the IEEE Intelligent Vehicles Symposium (IV)*. Changshu, China.

Hueston, W. and McLeod, A. (2012) “Overview of the global food system: changes over time/space and lessons for future food safety. In: Institute of Medicine (US). Improving Food Safety Through a One Health Approach: Workshop Summary.,” *National Academies Press (US), Washington (DC)* [Preprint].

IBM (2020) *What Is Blockchain Technology?* Available at: https://www.ibm.com/uk-en/blockchain/whatis-blockchain (Accessed: March 2, 2022).

ILO (International Labour Organization) (2020) *COVID-19and the impact on agriculture and food security.* Available at: https://www.ilo.org/ wcmsp5/groups/public/---ed_dialogue/---sector/documents/briefingnote/ wcms_742023.pdf (Accessed: January 14, 2022).

IPES (The International Panel of Experts on Sustainable Food System) (2020) *COVID-19 and the crisis in food systems: Symptoms, causes, and potential solutions*. Available at: http://www.ipes-food.org/_img/upload/files/COVID- 19_CommuniqueEN.pdf (Accessed: February 8, 2022).

Ismagilova, E. *et al.* (2019) "Smart cities: Advances in research—An information systems perspective," *International Journal of Information Management*, 47, pp. 88–100.

Jeppsson, A. and Olsson, O. (2017) *Blockchains as a Solution for Traceability and Transparency*.

Kamble, S.S., Gunasekaran, A. and Sharma, R. (2019) "Modeling the blockchain enabled traceability in agriculture supply chain," *International Journal of Information Management*, 52(101967), pp. 1–16.

Kamilaris, A., Fonts, A. and Prenafeta-Boldv, F.X. (2019) "The rise of blockchain technology in agriculture and food supply chain," *Trends in Food Science & Technology Journal*, 91, pp. 640–652.

Kayikci, Y. *et al.* (2020) "Food supply chain in the era of Industry 4.0: blockchain technology implementation opportunities and impediments from the perspective of people, process, performance, and technology," *Production Planning & Control*, 302, pp. 1–21.

Kouhizadeh, M. and Sarkis, J. (2018) "Blockchain Practices, Potentials, and Perspectives in Greening supply chains.," *Sustainability*, 10(3652), pp. 1–16.

Kshetri, N. (2018a) "1 Blockchain's roles in meeting key supply chain management objective," *International Journal of Information Management*, 39, pp. 80–89.

Kshetri, N. (2018b) "Blockchain's roles in meeting key supply chain management objectives," *International Journal of Information Management*, 39, pp. 80–89.

Kuo, J.C. and Chen, M.C. (2010) "Developing an advanced Multi-Temperature Joint Distribution System for the food cold chain," *Food Control*, 21(4), pp. 559–566.

Lamarre, E. and Pergier, M. (2009) "Risk: Seeing around the corner," *McKinsey Quarterly* [Preprint].

Lassar, W.M. and Kerr, J.L. (1996) "Strategy and control in supplier distributor relationships: an agency perspective," *Strategic Management Journal*, 17(8), pp. 613–632.

Leong, C., Viskin, T. and Stewart, R. (2018) "Tracing the Supply Chain: How Blockchain Can Enable Traceability in the Food Industry," *Accenture*. Available at: https://www.accenture.com/t20190115T192110Z__w_ _/us-en/_acnmedia/PDF-93/Accenture-Tracing-Supply-Chain-Blockchain-Study-PoV.pdf (Accessed: March 15, 2022).

Levany, S. (2020) *US producers "'in tears'" at having to cull livestock on their farms.*, *The Guardian*. Available at: https://www.theguardian.com/environment/ 2020/jun/10/us-producers-in-tears-at-having-to-cull-livestock-ontheir- farms (Accessed: February 3, 2022).

Lin, I.C. *et al.* (2017) "Food traceability system using blockchain," in *In Proceedings of the 79th IASTEM International Conference*. Tokyo, Japan. Available at:

https://www.accenture.com/t20190115T192110Z__w_ _/us-en/_acnmedia/PDF-93/Accenture-Tracing-Supply-Chain-Blockchain-Study-PoV.pdf (Accessed: March 15, 2022).

Lin, J. *et al.* (2018a) "Blockchain and IoT based food traceability for smart agriculture.," in *In Proceedings of the 3rd International Conference on Crowd Science and Engineering, Singapore*. In Proceedings of the 3rd International Conference on Crowd Science and Engineering, Singapore, pp. 28–31.

Lin, J. *et al.* (2018b) "Blockchain and IoT based food traceability for smart agriculture," in *In Proceedings of the 3rd International Conference on Crowd Science and Engineering*. Singapore.

Lonsdale, C. (1999) "Effectively managing vertical supply relationships: a risk management model for outsourcing," *Supply Chain Management: An International Journal*, 4(4), pp. 176–183.

Lu, Q. and Xu, X. (2017) "Adaptable blockchain-based systems: A case study for product traceability," *IEEE Software*, 34(6), pp. 21–27.

Mach, J.G. and Shapira, Z. (1992) "Variable Risk Preferences and the Focus of Attention," *Psychological Review*, 99(1), pp. 172–183.

Mao, D. *et al.* (2018) "Credit evaluation system based on Blockchain for multiple stakeholders in the food supply chain," *International Journal of Environmental Research and Public Health*, 15, p. 1627.

March, J.G. and Shapira, Z. (1987) "Managerial perspectives on risk and risk taking," *Management Science*, 33(11), pp. 1404–1418.

McAnelly, J.K. (1994) "In HACCP: Total quality system for assuring food safety and quality. In proceedings of the reliability and maintainability symposium," 1, pp. 31–36.

Mccallister, D. (2017) *FDA Takes too Long to Recall Tainted Food, Federal Investigators Say, NPR*. Available at: https://www.npr.org/sections/thetwo-way/2017/12/28/573987023/fda-takes-too-long-to-recall-taintedfood-federal-investigators-say?t=1553556458691 (Accessed: March 4, 2022).

Menon, S. and Jain, K. (2021) "Blockchain Technology for Transparency in Agri-food Supply Chain: Use Cases, Limitations and Future Directions," *IEEE Transactions on Engineering Management*, pp. 1–38.

Mishra, D. and Singh, G. (2019) "Supply Chain Management of Technical Education," *International Journal of Computer Science and Electronics Engineering (IJCSEE)*, 1(3), pp. 433–435.

Mollenkopf, D.A. and Ozanne, L.K. (2020) "A transformative supply chain response to COVID-19," *Journal of Service Management*, 32(2), pp. 190–202.

Murphy, C. (2020) *Costco to temporarily limit meat purchases to 3 items per person, USA Today*. Available at: https://www.usatoday.com/ story/money/2020/05/04/costco-limits-meat-purchases-3-items-perperson/ 3078198001/ (Accessed: February 3, 2022).

Nakamoto, S. (2008) "Bitcoin: A peer-to-Peer electronic cash system."

Nature Plants (2020) "Food in a time of COVID-19," *Nat. Plants*, 6, p. 429.

Ndemezo, E., Ndikubwimana, J.B. and Dukunde, A. (2018) "Determinants of capacity utilization of food and beverage manufacturing firms in rwanda: do tax incentives matter?," *SSRN*, pp. 1–21.

Newman, W.R., Hanna, M. and Maffei, M.J. (1993a) “Dealing with the uncertainties of manufacturing: flexibility, buffers and integration,” *International Journal of Operations and Production Management*, 13(1), pp. 19–34.

Newman, W.R., Hanna, M. and Maffei, M.J. (1993b) “Dealing with the uncertainties of manufacturing: flexibility, buffers and integration,” *International Journal of Operations and Production Management*, 13(1), pp. 19–34.

Nicola, M., Alsafi, Z. and Sohrabi, C. (2020) “The socio-economic implications of the coronavirus pandemic (COVID-19): a review,” *International Journal of Surgery*, 78, pp. 185–193.

O’Donnell, J. (2019) *Inspector General Report: FDA Food Recalls Dangerously Slow, Procedures Deeply Flawed, USA Today*. Available at: https://eu.usatoday.com/story/news/politics/2017/12/26/inspectorgeneral-report-fda-food-recalls-dangerously-slow-procedures-deeply-flawed/975701001/ (Accessed: March 4, 2022).

OECD (The Organisation for Economic Co-operation and Development) (2020) *COVID-19 and international trade: Issues and actions*. Available at: http://www.oecd.org/coronavirus/policy-responses/covid-19-andinternational- trade-issues-and-actions-494da2fa/ (Accessed: February 8, 2022).

Oh, J. and Shong, I. (2017) “A case study on business model innovations using Blockchain: Focusing on financial institutions,” *Asia Pacific Journal of Innovation and Entrepreneurship*, 11(3), pp. 335–344.

Olsen, P. and Borit, M. (2013) “How to define traceability,” *Trends in Food Science & Technology*, 29(2), pp. 142–150.

Ometoruwa, T. (2018) *Solving the Blockchain Trilemma: Decentralization, Security & Scalability*, *CoinBureau*. Available at: https://www.coinbureau.com/analysis/solving-blockchain-trilemma/ (Accessed: March 15, 2022).

Pagell, M. and Krause, D.R. (1999) “A multiple method study of environmental uncertainty and manufacturing flexibility,” *Journal of Operations Management*, 17(3), pp. 307–326.

Panarello, A. *et al.* (2018) “Blockchain and IoT Integration: A systematic survey,” *Sensors*, 18(2575), pp. 2–37.

Park, K. (2018) *Cryptocurrencies, Blockchain Is about to Revolutionize the Shipping Industry, Bloomberg*. Available at: https://www.bloomberg.com/news/articles/2018-04-18/drowning-in-a-sea-of-paper-worlds-biggest-ships-seek-a-way-out (Accessed: March 2, 2022).

Pearson, C.M. and Clair, J.A. (1998) “Reframing crisis management,” *Academy of Management Review*, 211(1–2), pp. 59–76.

Pearson, S. *et al.* (2019) “Are distributed ledger technologies the panacea for food traceability?,” *Global Food Security*, 20, pp. 145–149.

Perboli, G., Musso, S. and Rosano, M. (2018) “Blockchain in logistics and supply chain: A lean approach for designing real-world use cases,” *IEEE Access*, 6, pp. 62018–62028.

Petersen, M., Hackuys, N. and See, V.B. (2018) “Mapping the sea of opportunities: Blockchain in Supply chain and Logistics,” *Information Technology*, 60, pp. 1–8.

Pournader, M. *et al.* (2019a) "Blockchain applications in supply chains, transport and logistics: A systematic review of the literature," *International Journal of Production Research*, 58(7), pp. 2063–2081.

Pournader, M. *et al.* (2019b) "Blockchain applications in supply chains, transport and logistics: A systematic review of the literature," *International Journal of Production Research*, pp. 1–19.

Prybila, C. *et al.* (2017) "Runtime verification for business processes utilizing the Bitcoin blockchain," *Future Generation Computer Systems* [Preprint].

Queiroz, M.M., Telles, R. and Bonilla, S.H. (2019a) "Blockchain and supply chain management integration a systematic review of the literature," *Supply Chain Management International Journal*, 25, pp. 241–254.

Queiroz, M.M., Telles, R. and Bonilla, S.H. (2019b) "Blockchain and supply chain management integration a systematic review of the literature," *Supply Chain Management: An International Journal*, 25(2), pp. 241–254.

Ray, P. *et al.* (2019) "Incorporating Block Chain Technology in Food Supply Chain," *International Journal of Management Studies*, 6(1), pp. 115–124.

Reddy, V.R., Singh, S.K. and Anbumozhi, V. (2016) "Food supply chain disruption due to natural disasters: entities, risks, and strategies for resilience.," *Economic Research Institute for ASEAN and East Asia*, pp. 1–36.

Reisch, J., Eberie, U. and Lorek, S. (2013) "Sustainable food consumption: an overview of contemporary issues and policies," *Sustainability: Science Practice & Police*, 9(2), pp. 7–25.

Rejeb, A. (2018) "Blockchain potential in Tilapia supply chain in Ghana," *Acta Technica Jaurinensis*, 11(2), pp. 104–118.

Rejeb, A., Keogh, H.G. and Treiblmaier, H. (2019) "Leveraging the internet of Things and blockchain technology in supply chain management," *Future Internet*, 11, pp. 1–22.

Reyna, A. *et al.* (2019a) "On blockchain and its integration with IoT. Challenges and opportunities," *Future Generation Computer Systems*, 88, pp. 173–190.

Reyna, A. *et al.* (2019b) "On blockchain and its integration with IoT. Challenges and opportunities," *Future Generation Computer Systems*, 88, pp. 173–190.

Reyna, A. *et al.* (2019c) "On blockchain and its integration with IoT. Challenges and opportunities," *Future Generation Computer Systems*, 88, pp. 173–190.

Richards, T.J. and Rickard, B. (2020) "COVID-19 impact on fruit and vegetable markets," *Canadian Journal*, 68, pp. 189–194.

Risius, M. and Spohrer, K. (2017) "A blockchain research framework: What we (don't) know, where we go from Here, and how we will get there," *Business & Information Systems Engineering*, 59(6), pp. 385–409.

Rodríguez-Pérez, C. *et al.* (2020) "Changes in Dietary Behaviours during the COVID-19 Outbreak Confinement in the Spanish COVIDiet Study," *Nutrients*, 12(1730), pp. 1–19.

Roth, A.V. *et al.* (2008) "Unraveling the food supply chain: strategic insights from China and the 2007 recalls," *Journal of Supply Chain Management*, 44(1), pp. 22–39.

Rude, J. (2020) "COVID-19 and the Canadian cattle/beef sector: some preliminary analysis," *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie*, 68, pp. 207–213.

Ruefli, T.W., Collins, J.M. and Lacugna, J.R. (1999) "Risk measures in strategic management: Auld Lang Syne?," *Strategic Management Journal*, 26(2), pp. 167–194.

Shahidi, F. (2020a) "Does COVID-19 affect food safety and security? A summary report on the Extraordinary Scientific Roundable of IUFoST-CIFST on March 21, 2020," *Journal of Food Bioactives*, 9, pp. 1–3.

Shahidi, F. (2020b) "Does COVID-19 affect food safety and security? A summary report on the Extraordinary Scientific Roundtable of IUFoST-CIFST on March 21, 2020," *Journal of Food Bioactives*, pp. 1–3.

Singh, A.R., Jain, R. and Mishra, P.K. (2009) "Risk in Supply Chain Management," *Proceedings of National Conference on Advances in Mechanical Engineering*, pp. 326–337.

Sitkin, S.B. and Pablo, A.L. (1992) "Reconceptualizing the determinants of risk behavior," *Academy of Management Review*, 17(1), pp. 9–38.

Smith, J. (2020) *Warehouse hiring surge defies crashing U.S. jobs market*, *Wall Street Journal*. Available at: https://www.wsj.com/articles/warehouse-hiring-surge-defiescrashing- u-s-jobs-market-11585939391 (Accessed: January 14, 2022).

Stephens, E.C. *et al.* (2020) "Editorial: impacts COVID-19 on agricultural and food systems worldwide and on progress to the sustainable development goals," *Agricultural Systems*, 183(102873), pp. 1–3.

Stewart, A., Kottasova, I. and Khaliq, A. (2020) *Why meat processing plants have become Covid-19 hotbeds*. Available at: https://edition.cnn.com/2020/06/27/ health/meat-processing-plants-coronavirus-intl/index.html (Accessed: February 3, 2022).

Tian, F. (2016a) "An Agri-food supply chain traceability system for China based on FRID & Blockchain technology," in *In Proceedings of the 13th International Conference on Service Systems and Service Management (ICSSSM 2016), Kunming, China*, pp. 24–26.

Tian, F. (2016b) "An Agri-food supply chain traceability system for China based on FRID & Blockchain technology," in *In Proceedings of the 13th International Conference on Service Systems and Service Management (ICSSSM 2016)*. Kunming, China.

Tian, F. (2017a) "A supply chain traceability system for food safety based on HACCP, blockchain & Internet of Things.," in *In Proceedings of the 14th International Conference on Service Systems and Service Management (ICSSM 2017), Dalian, China*, pp. 1–6.

Tian, F. (2017b) "A supply chain traceability system for food safety based on HACCP, blockchain & Internet of Things," in *In Proceedings of the 14th International Conference on Service Systems and Service Management (ICSSM 2017)*. Dalian, China, pp. 1–6.

Tieman, M. and Darun, M.R. (2017) "Leveraging Blockchain technology for Halal supply chain," *Islam and Civilisational Renewal (ICR) Journal*, 8(4), pp. 547–550.

Ting, S.L. *et al.* (2014a) "Mining logistics data to assure the quality in a sustainable food supply chain: A case in the red wine industry," *International Journal of Production Economics*, 152, pp. 200–209.

Ting, S.L. *et al.* (2014b) "Mining logistics data to assure the quality in a sustainable food supply chain: A case in the red wine industry," *International Journal of Production Economics*, 152, pp. 200–209.

Tse, D. *et al.* (2017) "Blockchain application in food supply information security," in *In Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2017)*. Singapore, pp. 1357–1361.

Tse, Y.K. and Tan, K.H. (2011) "Managing product quality risk in multi-tier global supply chain," *International Journal of Production Econimics*, 49(1), pp. 200–209.

Tse, Y.K. and Tan, K.H. (2012) "Managing product quality risk and visibility in multi-layer supply chain," *International Journal of Production Economics*, 139(1), pp. 49–57.

Tzounis, A. *et al.* (2017) "Internet of things in agriculture, recent advances and future challenges?," *Biosystems Engineering*, 164, pp. 31–48.

United Nations Global Compact (2014) *A Guide to Traceability: A Practical Approach to Advance Sustainability in Global Supply Chains*. Available at: https://www.unglobalcompact.org/docs/issues_doc/supply_ chain/Traceability/Guide_to_Traceability.pdf (Accessed: March 4, 2022).

dos (United States Department of State) (2011) *Food prices crisis of 2007-2008: Lessons learned*. Available at: https://reliefweb.int/report/world/ foodprices-crisis-2007-2008-lessons-learned (Accessed: February 8, 2022).

Valinsky, J. (2020) *One in five Wendy's is out of beef, analyst says*, *CNN (Cable News Network)*. Available at: https://edition.cnn.com/2020/05/05/ business/wendys-beef-shortage/index.html (Accessed: February 3, 2022).

Venuto, D. (2020) *COVID-19 coronavirus lockdown: your panic buying is putting other kiwis at risk*, *The New Zealand Herald*. Available at: https://www.nzherald.co.nz/business/ news/article.cfm?c_id=53&objectid=512319171 (Accessed: January 14, 2022).

Verdouw, C.N. *et al.* (2016) "Virtualization of food supply chains with the internet of things," *Journal of Food Engineering*, 176, pp. 128–136.

Verhoeven, P., Sinn, F. and Herden, T.T. (2018a) "Examples from Blockchain Implementations in Logistics and supply chain management exploring the mindful use of a new technology," *Logistics*, 2, pp. 1–19.

Verhoeven, P., Sinn, F. and Herden, T.T. (2018b) "Examples from Blockchain Implementations in Logistics and supply chain management exploring the mindful use of a new technology," *Logistics*, 2, pp. 1–19.

Wang, J. and Yue, H. (2017) "Food safety pre-warning system based on data mining for a sustainable food supply chain," *Food Control*, 73, pp. 223–229.

Wang, L., Luo Robert, X. and Lee, F. (2019) "Unveiling the interplay between blockchain and loyalty program participation: A qualitative approach based on Bubichain," *International Journal of Information Management*, 49, pp. 397–410.

Wang, Y. *et al.* (2019) "Making sense of blockchain technology: How will it transform supply chains," *International Journal of Production Economics*, 211, pp. 221–236.

Watsona, R.A. and Pauly, D. (2013) "The changing face of global fisheries—The 1950s vs. the 2000s," *Marine Policy*, 42, pp. 1–4.

WHO (World Health Organization) (2016) *10 Facts on Food Safety*. Available at: https://www.who.int/features/factfiles/food_safety/en/ (Accessed: March 1, 2022).

WHO (World Health Organization) (2020) *2019 Novel Coronavirus (2019-nCoV): Strategic preparedness and response plan*. Available at: https:// www.who.int/docs/default-source/coronaviruse/srp-04022020.pdf?sfvrsn =7ff55ec0_4&download=true (Accessed: February 8, 2022).

Wiseman, R.M. and Bromiley, P. (1991) "Risk-return associations: paradox or artifact? An empirically tested explanation," *Strategic Management Journal*, 12(3), pp. 231–341.

Wiseman, R.M. and Bromiley, P. (1996) "Toward a Model of Risk in Declining Organizations: An Empirical Examination of Risk, Performance and Decline," *Organization Science*, 7(5), pp. 524–543.

Yiannas, F. (2018a) "A new era of food transparency powered by blockchain," *Innovations / Blockchain for Global Development*, 12(1), pp. 46–56.

Yiannas, F. (2018b) "A new era of food transparency powered by blockchain," *Innovations / Blockchain for Global Development*, 12, pp. 46–56.

Yu, M. and Nagurney, A. (2013a) "Competitive food supply chain networks with application to fresh produce," *European Journal of Operational Research*, 224, pp. 273–282.

Yu, M. and Nagurney, A. (2013b) "Competitive food supply chain networks with application to fresh produce," *European Journal of Operational Research*, 224(2), pp. 273–282.

Zhao, G. *et al.* (2019a) "Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions," *Computers Industry*, 109, pp. 83–99.

Zhao, G. *et al.* (2019b) "Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions," *Computers in Industry*, 109, pp. 83–99.

8. APPENDIX

RESEARCH QUESTIONNAIRE

SECTION A: Company information

1. Business size
   - Very small
   - Small
   - Medium
   - Big

2. Which is approximately the number of employees in your company?
   - Under 10
   - 10 – 50
   - 51 – 250
   - Over 250

3. Depending on the size of your company, you may want to respond to the questions in this survey for the whole enterprise or for a specific division. To which of the following will your answers apply?
   - My department
   - The entire company
   - A division
   - Other (please specify)

     _____

4. To what extent are you familiar with Blockchain Technology?

- Extremely Poor Knowledge
- Poor Knowledge
- Average Knowledge
- Good Knowledge
- Excellent Knowledge

5. To what extent are you familiar with the Pre-warning Systems?
   - Extremely Poor Knowledge
   - Poor Knowledge
   - Average Knowledge
   - Good Knowledge
   - Excellent Knowledge

SECTION B: Knowledge, Implementation, Benefits, and Drawbacks of Blockchain Technology

To what extent:	Extremely Poor	Bad	Average	Good	Excellent
6. Have you attended a seminar on better knowledge of Blockchain Technology					
7. Do you have knowledge and skills regarding Blockchain Technology					
8. Do you implement Blockchain Technology correctly					
9. Is the company controlled through					

Blockchain Technology					

To what extent has your company:	Extremely Poor	Bad	Average	Good	Excellent
10. Implemented Blockchain Technology					
11. Established a dedicated group to support Blockchain Technology					
12. Developed a budget for its Blockchain efforts					

13. What various advantages do you intend to receive from Blockchain Technology for your organization/industry? (Please select all that apply)

- Increased business productivity
- Identifying innovative methods for partners to automate business operations
- Improved transaction transparency and integrity
- Improved transaction speed
- The potential of Blockchain to eliminate points of failure in corporate networks provides better data safety
- Reduced transaction cost
- Improved working relationships with collaborators
- Facilitating the development of innovative business concepts
- Time savings
- Risks are minimized
- Don't know
- Other (please briefly describe):

_____

14. What are the most significant barriers to your organization's use of Blockchain technology? (Please select all that apply)

- ☐ Blockchain technology is still in its infancy
- ☐ A lack of knowledge of what Blockchain can and can't achieve
- ☐ Not enough specialists who know how to use Blockchain technology
- ☐ Lack of industry standards
- ☐ Regulatory restrictions
- ☐ Concerns about privacy and security
- ☐ Limited market for available Blockchain solutions
- ☐ Don't know
- ☐ Others (please briefly describe):

_____

SECTION C: Knowledge, Implementation, Benefits, and Drawbacks of Food Safety Pre-warning System which uses data mining algorithms and Internet of Things technology

To what extent:	Extremely Poor	Bad	Average	Good	Excellent
15. Have you attended a seminar on better knowledge of Pre-Warning Systems					
16. Do you have knowledge and skills regarding Pre-Warning Systems					

17. Do you implement Pre-Warning Systems correctly					
18. Is the company controlled through Pre-Warning Systems					

To what extent has your company:	Extremely Poor	Bad	Average	Good	Excellent
19. Implemented Pre-Warning Systems					
20. Established a dedicated group to support Pre-Warning Systems					
21. Developed a budget for its Pre-Warning efforts					

22. What various advantages do you intend to receive from Pre-Warning Systems for your organization/industry? (Please select all that apply)

- Increased business productivity
- Identifying innovative methods for partners to automate business operations
- Improved transaction transparency and integrity
- Improved transaction speed
- The potential of Pre-warning Systems to eliminate points of failure in corporate networks provides better data safety.
- Reduced transaction cost
- Improved working relationships with collaborators
- Facilitating the development of innovative business concepts
- Time savings
- Risks are minimized

- Don't know
- Other (please briefly describe):

  _____

23. What are the most significant barriers to your organization's use of Pre-warning Systems? (Please select all that apply)

- Pre-warning Systems are still in their infancy
- A lack of knowledge of what Pre-warning Systems can and can't achieve
- Not enough specialists who know how to use Pre-warning Systems
- Lack of industry standards
- Regulatory restrictions
- Concerns about privacy and security
- Limited market for available Pre-Warning System solutions
- Don't know
- Others (please briefly describe):

  _____