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BLOCKCHAIN TECHNOLOGY IMPACT PERCEPTION IN FOOD SECTOR COMPANIES: A MULTICRITERIA ANALYSIS

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ABSTRACT

Purpose: Analysis of food company managers' perceptions of the need for a technological change and the managerial aspects considered most important.

Originality/value: The study highlighted the need to apply technology for food supply integration chain to improve internal and external processes and identified the aspects that contribute the most to business growth.

Methods: The research is exploratory with a quantitative approach. A structured questionnaire was used for data collection. To analyze possible decision making about implementing blockchain technology by supply chain managers, we adopted Analytic Hierarchy Process (AHP) – a multicriteria analysis method.

Results: It was observed that the best decision making would be an implementation of the blockchain (50.08%) or other technologies (34.94%) to achieve a better corporate performance. In addition, among the evaluated criteria, operational efficiency was considered the most important to managers, followed by technology, level of logistics service, quality, sustainability, and cost.

Conclusion: It was found that regardless of a company's size, there was a consensus among managers about the need for technological changes in their companies to keep up with market trends.

Keywords: Supply chain. Analytic Hierarchy Process. Disrupt Technology.

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1 INTRODUCTION

Blockchain technology (BT) got visibility in the global financial sector due to the Bitcoin cryptocurrency race and the structure used to make it work (Cole et al., 2019; Schmidt & Wagner, 2019). The successful use of BT in the financial sector has driven its expansion into other global market sectors. Research carried out by Bumblauskas et al. (2020), PWC (2020), Kramer, Bitsch, and Hanf (2021) reveals that blockchain has been growing in food supply chains, with a clear purpose of making the supply chain ecosystem more transparent with the provenance and traceability functions.

In the new digital era and considering the demands of a cyber society, companies are looking to redesign their business models and create collaborative networks, which implies product and process innovation. Thus, digital transformation has brought rapid and responsive changes to the market, helping companies in the process of business redesign (Warner & Wäger, 2019). The BT is a disruptive solution with an ability to help supply chain ecosystem management and in turn, contribute to building more transparent relationships between business partners as well as reducing transaction costs and increasing competitive advantage (Treiblmaier, 2018; Menon & Jain, 2021).

A premise of the Transaction Cost Theory (TCT) is the presence of uncertainty, which contributes to opportunistic behavior. According to Silva and Brito (2013), opportunistic behavior may occur due to a limited rationality of those involved in a transaction, especially in transactions involving specificity assets. Therefore, the literature has argued that when applied to commercial transactions, blockchain reduces transaction costs (Oliveira, 2022; Shoaib et al., 2020; Schmidt & Wagner, 2019). In addition, Oliveira (2022) explains that "blockchain is a multifunctional technology that, as a distributed, decentralized, immutable, and inviolable database, aims to make transactions safer and simpler by mapping them as they occur, bringing transparency to the system".

Despite its current popularity and the efforts to promote a "more democratic technology" that can be implemented in various market segments with decentralized control, BT faces restrictions on use and uncertainties in the security of transactions carried out among the members of a supply chain because the transactions are self-managed by the platform.

Uncertainties related to blockchain revolve around a lack of knowledge about the system in operation, the real cost of implementation and use, network security issues (who has access to information), and transparency issues, which, despite reducing opportunism in commercial transactions, can be sources of new strategies and profit for the parties involved in the negotiation (Schmidt & Wagner, 2019; Suhail et al., 2020; Oliveira, 2022).

To guarantee efficiency gains in supply chain ecosystem transactions in a digital age, formalizing negotiations through smart contracts is essential (Treiblmaier, 2018; Oliveira, 2022).

Smart contracts facilitate a better performance by allowing a dynamic management of terms, due to into account the adequacy of the contract over time to each condition, thus contributing positively to agile decision making.

In this context, this study aims to analyze food company managers' perceptions of the need for a technological change and the management aspects they consider most important. To this end, we adopted the Analytic Hierarchy Process (AHP) technique.

The main contribution of this study lies in its evidence of the need to apply technology in food supply chain to improve processes and identify the criteria that contribute the most to business growth.

This paper is structured in five parts: it begins with the introduction, followed by a theoretical background covering the main concepts in blockchain and its attributes, multicriteria methods for decision making with a focus on AHP, and the criteria for decision making. The third part presents the research methodology, covering the data collection instrument and analysis. Thereafter, we describe the results and discuss them, which includes the main results and need for adapting the current technology. Next, we elucidate the study contribution. We conclude the paper by presenting the references used in the study.

2 THEORETICAL BACKGROUND

2.1 Blockchain and disruptive technologies

The internet has long been considered a highly disruptive technology and has profoundly transformed the social and business environments (Treiblmaier, 2018). The internet provided new trade opportunities and contributed to linking players in a supply chain and automating production processes. For instance, new terms have come to be used and known, such as E-commerce, Business-to-Business (B2B) and Business-to-Consumer (B2C), Warehouse Management System (WMS), Transportation Management System (TMS), Enterprise Resource Planning (ERP), Electronic Data Interchange (EDI), Internet of Things (IoT), Augmented Reality, Artificial Intelligence (AI), Big Data and Business Analytics and, more recently, Blockchain and Smart Spaces (Treiblmaier, 2018*;* Warner & Wäger, 2019; Min, 2019).

Treiblmaier (2018) argues that BT promises changes similar to what the internet does, with profound transformations in commercial relations, nonetheless, he suggests a thorough investigation to add value to businesses. The technology is considered the most secure to date due to its characteristics of data immutability, distribution, and synchronization over the network, the possibility of creating smart contracts, among others, promoting transparency in transactions, and capacity to deal with potential fraud (Cole et al., 2019; Schmidt & Wagner, 2019).

Kroll’s Global Fraud and Risk Report shows that companies are concerned about the image associated with fraud, corruption, illicit activity, and money laundering, among other things, in global supply chains in particular, due to the global relationship’s complexity (Kroll, 2022). According to the report, the countries the most prone to fraud were China, India, those in the Middle East, the United States, Brazil, Australia, Switzerland, and France. This evidence leads to increased costs due to investigations, especially in global supply chains (Kroll, 2022). This implies that we can reduce costs by using appropriate technology to control and monitor relationships.

In addition, recently, it was reported many accounting scandals involving big retail sector companies, which have raised concerns for consumers (Busch, 2023). Such scandals reflect the fragility of the business world, which implies potential losses for everyone involved.

Although blockchain is not a recent concept, it is still embryonic in operations and supply chains (Cole et al., 2019). The results of a survey carried out by PricewaterhouseCooper (PwC) show that only 8% of the Brazilian companies have implemented blockchain (PwC, 2020). This result highlights that companies know the importance of adapting to the digital age and innovating in business but are unsure of the structural, managerial, and financial changes required to embrace this technology.

According to the exploratory study of Menon and Jain (2021), the blockchain concept consists in four attributes that contribute significantly to the chain’s transparency process: auditability, immutability, provenance, and traceability (Chart 1). The business transactions’ transparency and operations ensure an ethical conduct and guarantee compliance practices in organizations.

Features	Concept
Auditability	“It is the virtue of tracking historical operations on the blockchain chain, including all actors involved in those operations.” (Menon & Jain, 2021).
Immutability	“It is a property of being unchangeable or unable to be changed over time.” (Menon & Jain, 2021). Transaction immutability records on the blockchain contribute to the reliability and security of transactions.
Provenance	“It depicts the chronology and record of ownership or geographic origin of a product.” (Menon & Jain, 2021).
Traceability	Possibility of accessing information on the life cycle of products/services throughout a supply chain. This is one of the main functions of a blockchain that contributes to the transparency of transactions.

Chart 1: Attributes of a blockchain

Source: Adapted from Suhail et al. (2020); Menon and Jain (2021); Oliveira (2022)

Schmidt and Wagner (2019) argue that the main barriers to implementing BT are technological uncertainty, scalability, and development costs. An important point to consider is that BT favors a decentralization of information on transactions between all members connected (Cole et al., 2019). Thus, although this contributes to more transparent relationships among members, it also creates uncertainty about information control and information insecurity. For instance, Bumblauskas et al. (2020) cite a case of food distribution where sensors are used to track the location, time, temperature, and humidity to transmit this information to a blockchain. The information is linked to the products using a digital record to guarantee the provenance, conformity, authenticity, and quality of the food. The case demonstrates the use of BT's provenance and traceability functions in food supply chains seeking to increase food safety and reduce potential contamination scandals that damage a chain's image (Lin et al., 2020).

Previous studies on the use of blockchain have reported that the technology can provide a competitive gain to the supply chain ecosystem from the perspective of the TCT (Schmidt & Wagner, 2019; Menon & Jain, 2021; Oliveira, 2022). The application of blockchain is likely to allow a greater visibility between negotiations and operations, making transactions more efficient, increasing trust levels between parties, preventing fraud, and reducing risks (Schmidt & Wagner, 2019). The 2022 Forbes list features 50 companies that apply blockchain technology in their business activities (Forbes Money, 2022).

Schmidt and Wagner (2019) show that blockchain can reduce transaction costs and contribute to market-oriented governance structures, minimizing behavioral and environmental uncertainty and opportunistic behavior. For instance, using blockchain provides transparency about the provenance of a product, thus preventing fraud and counterfeiting; this saves costs related to controlling suppliers and monitoring product quality (Schmidt & Wagner, 2019).

Literature has shown that using BT enables a quick identification of problems, control over the manufacture of products and operating conditions, and collaboration for a better supply chain integration, and promotes communication for information dissemination and sharing, making information more accessible through proximity, frequent exchanges, and collaborative interdependencies (Tortorella et al., 2019). In addition, BT can facilitate a better integration of logistic activities and moderate the strategic relationship between a buyer and supplier (Paulraj & Chen, 2007).

Treiblmaier (2018) points out that despite a still incipient discussion and lack of research on the subject, many companies have invested heavily in blockchain in the expectation of solutions to revolutionize the supply chain. This is a concern for businesses as BT creates an uncertain environment. In addition, despite the various advantages that BT can offer companies, there are general questions about its sustainability and impact on the environment, the regulation of operations, and security of the blockchain ecosystem. There are also specific questions about the operability of blockchain platforms that Lin et al. (2020) address, such as the transaction throughput, which can vary with the blockchain platform, smart contract language, database status, and access control, among others.

Suhail et al. (2020) discuss technical and non-technical issues in blockchain application. They show that the technology meets the main challenges of supply chain data management and security; however, the use of the technology requires a further analysis of other factors. Studies also examine the barriers and challenges in implementing blockchain, including the digital transformation, education, regulation, quality of information, sustainability, and security uncertainties (Schmidt & Wagner, 2019; Suhail et al., 2020).

Thus, blockchain implementation requires caution and a thorough analysis of its impact on businesses considering the technical and technological capabilities as well as material, human, and financial resources to reduce investment risks.

2.2 Multicriteria decision making methods

In a dynamic business environment, decision making is essential to help leaders apply methods and models to adopt alternatives with the lowest possible risk to the company's business. Many decision-making methods exist, including the Analytic Hierarchy Process (AHP). Reis, Ladeira, and Fernandes (2013) discuss methods like the Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Elimination et Choix Traduisant la Realité (ELECTRE), Benefits, Opportunities, Costs, and Risks (BOCR), and Technique of Preference by Similarity to the Ideal Solution (TOPSIS).

In their book "Models, Methods, Concepts & Applications of the Analytic Hierarchy Process," Thomas Saaty and Luis Vargas clarify that the AHP is a basic structure to be used for decision making considering the rational and intuitive aspects of individual perspective for selecting alternatives based on the evaluated criteria (Saaty & Vargas, 2001).

In general, the AHP application initially involves determining hierarchies and defining priorities, followed by analyzing the logical consistency (Nascimento et al., 2019). Saaty and Vargas (2001) explain the simplest structure for decision making, consisting of three levels: 1) definition of the objective; 2) determination of the criteria, and 3) proposing alternatives to be evaluated Figure 1.

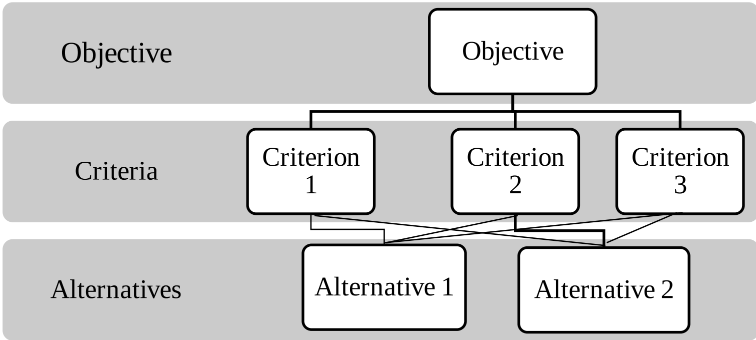


Figure 1: AHP method structure example
Source: Adapted from Saaty and Vargas (2001)

Chart 2 shows the fundamental scale of intensity of importance recommended by Saaty and Vargas (2001).

Intensity of importance*	Definition*	Explanation*	Intensity of reciprocal importance
1	Equal importance	Two activities contribute equally to the objective	1
2	Weak		1/2
3	Moderate importance	Experience and judgment slightly favor one activity over another	1/3
4	Moderate plus		1/4
5	Strong importance	Experience and judgment strongly favor one activity over another	1/5
6	Strong plus		1/6
7	Very Strong or demonstrated importance	An activity is favored very strongly over another; its dominance demonstrated in practice	1/7
8	Very, very Strong		1/8
9	Extreme importance	The evidence favoring one activity over another is of the highest possible order of affirmation	1/9

*Text taken from the book: Saaty and Vargas (2001)

Chart 2: Intensity of importance scale proposed by Saaty and Vargas

Source: Adapted from Saaty and Vargas (2001), and Wegner et al. (2020)

A decision matrix A is used to calculate the evaluation weights, which is the basis for generating the paired comparison matrix A and calculating the maximum eigenvectors and eigenvalues (λ_{max}).

$$\mathbf{A} = \begin{vmatrix} 1 & A_1 & A_n \\ 1/_{A1} & 1 & A_{2n} \\ 1/_{An} & 1/_{A2n} & 1 \end{vmatrix}$$

Calculating the maximum eigenvalue is essential for analyzing the Consistency Index (CI) of the evaluation weights, Equation 1.

$$CI = \frac{\lambda max - n}{(n - 1)} \qquad \text{Eq. (1)}$$

According to Briozo and Musetti (2015), it is important to calculate the Consistency Ratio (CR) in addition to the CI, given the random error related to the order of the matrix, based on the Random Consistency Index – RI (Table 1), Equation 2.

$$CR = \frac{CI}{RI} \qquad \text{Eq. (2)}$$

Table 1: Random Consistency Index

N	1	2	3	4	5	6	7	8	9
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45

Source: Adapted from Saaty and Vargas (2001)

Saaty and Vargas (2001) recommend that the CI remain less than 0.10; otherwise, it is up to the decision maker to study and revise the weights of the judgments in relation to the criteria evaluated. Thus, if the weights are inconsistent, they can be adjusted by applying Equation 3.

$$p' = 1 + \left(\frac{p}{10}\right) \qquad \text{Eq. (3)}$$

Where, p' = adjusted weight; p = actual weight

2.3 Technological change assessment criteria

A systematic review of the Web of Science sources related to “Analytic Hierarchy Process” and “Blockchain” yielded 51 works, of which, approximately 76.5% were scientific articles and 49% were published in 2022, with most studies carried out in China and India, Table 2.

Table 2: Ten applications of AHP for decision making involving BT

Title	Authors	Journal	Year	Total/ citations	Average / year
A sustainable production capability evaluation mechanism based on blockchain, LSTM, analytic hierarchy process for supply chain network	Li, Zhi; Guo, Hanyang; Barenji, Ali Vatankhah; Wang, W. M.; Guan, Yijiang; Huang, George Q.	International Journal of Production Research	2020	40	10
A multi-criteria evaluation model based on hesitant fuzzy sets for blockchain technology in supply chain management	Colaka, Murat; Kaya, Ihsan; Ozkan, Betul; Budakc, Aysenur; Karasan, Ali	Journal of Intelligent & Fuzzy Systems	2020	31	7,75
Analyzing blockchain adoption barriers in manufacturing supply chains by the neutrosophic analytic hierarchy process	Vafadarnikjoo, Amin; Ahmadi, Hadi Badri; Liou, James J. H.; Botelho, Tiago; Chalvatzis, Konstantinos	Annals of Operations Research	2021	30	10
An integrated framework to prioritize blockchain-based supply chain success factors	Shoaib, Muhammad; Lim, Ming K.; Wang, Chao	Industrial Management & Data Systems	2020	30	7,5
Managing disruptions and risks amidst COVID-19 outbreaks: role of blockchain technology in developing resilient food supply chains	Sharma, Manu; Joshi, Sudhanshu; Luthra, Sunil; Kumar, Anil	Operations Management Research	2022	23	7,67
Towards blockchain-enabled security technique for industrial internet of things based decentralized applications	Sodhro, Ali Hassan; Pirbhulal, Sandeep; Muzammal, Muhammad; Luo Zongwei	Journal of Grid Computing	2020	23	5,75
Technology assessment: enabling blockchain in hospitality and tourism sectors	Sharma, Mahak; Sehrawat, Rajat; Daim, Tugrul; Shaygan, Amir	Technological Forecasting and Social Change	2020	21	5,25
Administrative reforms in the fourth industrial revolution: the case of blockchain use	Myeong, Seunghwan; Jung, Yuseok	Sustainability	2019	12	2,4
Blockchain, an enabling technology for transparent and accountable decentralized public participatory GIS	Farnaghi, Mahdi; Mansourian, Ali	Cities	2020	11	2,75
A conceptual framework for blockchain-based sustainable supply chain and evaluating implementation barriers: A case of the tea supply chain	Mangla, Sachin Kumar; Kazancoglu, Yigit; Yildizbasi, Abdullah; Ozturk, Cihat; Calik, Ahmet	Business Strategy and the Environment	2022	10	5

Source: Web of Science

Li et al. (2020) used the AHP theory to evaluate corporate production capacity, incorporating three main technologies (internet of things, machine learning, and blockchain) based on the criteria of human resources (social criteria), production (material and environmental aspects), product quality, and logistic operations (logistic costs and transportation efficiency). Shoaib, Lim, and Wang (2020) employed AHP to investigate the success factors of blockchain-based supply chains and obtained the following factors: accessibility of supply chain, data management, costs, supply chain management integration, sustainability, efficiency, and customer satisfaction among others.

The literature review presented various broad as well as specific models and criteria for evaluating the application of blockchain in supply chains along with different proposals (Li et al., 2020; Vafadarnikjoo et al., 2021; Sharma et al., 2022). In this study, to assess a company's perception of the need for technological changes, we decided to carry out an initial survey with the broadest criteria (Chart 3) and three possible scenarios: 1) maintain the current scenario; 2) implement BT, and 3) implement other technologies.

Criteria	Description	Source
Technology	Refers to implementing existing technologies to increase the productivity of the business.	(Li et al., 2020) (Mahak Sharma et al., 2021) (Vafadarnikjoo et al., 2021)
Quality	Involves standardizing the company processes and products to meet market demands (customer satisfaction).	(Shoaib et al., 2020) (Li et al., 2020)
Sustainability	Relates to business practices aimed at balancing three pillars: social, economic, and environmental	(Shoaib et al., 2020) (Li et al., 2020)
Logistic service level	Refers to managing the quality of the logistics flow.	(Shoaib et al., 2020) (Li et al., 2020)
Costs	It refers to cost management and a company's ability to use resources rationally.	(Shoaib et al., 2020) (Mahak Sharma et al., 2021)
Operational efficiency	It refers to a company's ability to remain competitive by using its resources in line with its strategies and offering the best product at the lowest and most sustainable price to the market.	(Shoaib et al., 2020) (Mahak Sharma et al., 2021)

Chart 3: Evaluation criteria employed

Source: Authors (2022)

3 METHODOLOGY

To meet the research objective, an exploratory study with a quantitative approach was carried out, using a structured questionnaire to gather data by means of interviews conducted remotely, as described below. The research involved three food companies located in the state of São Paulo.

3.1 Data collection instrument (DCI)

For data collection, a structured script divided into two parts was used. Initially, it contained 15 close-ended questions on the characteristics of the volunteers and organization, followed by five close-ended questions presented in comparison blocks to assess the criteria for deciding to implement BT, as shown in Chart 4.

1) Which of the criteria listed below is more important than the others? To apply the importance weight, use the Saaty scale shown below.

Criteria	Saaty importance scale																	Criteria
Technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Quality
Technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainability
Technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Logistic service level
Technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Costs
Technology	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operational efficiency
Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Sustainability
Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Logistic service level
Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Costs
Quality	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operational efficiency
Sustainability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Logistic service level
Sustainability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Costs
Sustainability	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operational efficiency
Logistic service level	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Costs
Logistic service level	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operational efficiency
Costs	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Operational efficiency

Chart 4: Example of the close-ended questionnaire

Source: Authors (2022)

The Research Ethics Committee approved the research project (Consubstantiated No. 5.558.128). The DCI was tested and validated prior to its application by a practicing blockchain specialist with a recognized knowhow in innovation to guarantee the effectiveness of the research. The research volunteers were commercial, logistics, or supply professionals with experience in food processing companies that either use BT or plan or do not plan to implement BT.

Interviews were carried out remotely using the Google Meets platform on a date previously scheduled with the research volunteers. The participants were informed of the objective, ethical research procedure, and DCI. Pádua (2019), warned that the interview is widely used for data collection and allows the data collected to be analyzed both quantitatively and qualitatively.

3.2 Data analysis applied to decision making

The profiles of the survey participants and organization were created and measured by tabulating data from close-ended questions using MS Excel® for a descriptive exploration and univariate data analysis.

The AHP was used to analyze the possible decision-making process regarding the implementation of BT by supply chain managers. Six comparison criteria were considered, namely technology, quality, sustainability, logistic service level, cost, and operational efficiency, along with three possible alternatives: maintaining the current scenario, implementing BT, and implementing other technologies, Figure 2.

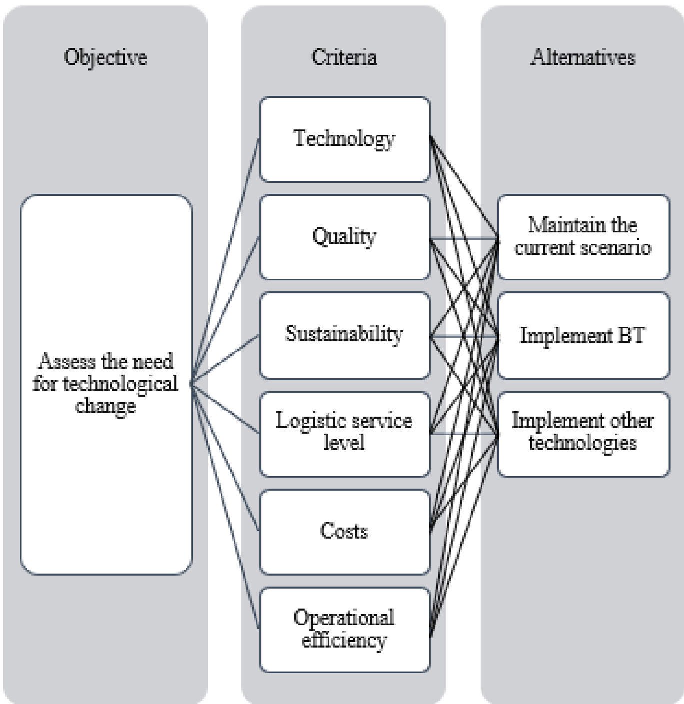


Figure 2: Multicriteria analysis framework
Source: Authors (2022)

The volunteers were provided the Saaty importance scale presented in Chart 2 in the literature review, with values from 1 implying being of no importance to 9 implying being extremely important in relation to another criterion assessed. To avoid interpretation problems, the volunteers were explained the application of the scale and its measures. They then judged the criteria and alternatives using paired comparisons.

The judgments were tabulated in MS Excel spreadsheets and Equation 4 below was used to calculate the weights, as recommended by Araujo et al. (2022).

$$p = \frac{mm + mg + mn}{3} \qquad \text{Eq. (4)}$$

where, p = weight; mm = maximum value assigned; mg = geometric mean, and mn = minimum value assigned.

We used the SuperDecisions v. 2.10 (2019) software to analyze data. Moreover, CI < 0.10 was used to check for inconsistencies between judgments (Saaty & Vargas, 2001). The model used showed no inconsistencies between the criteria evaluated; however, there were inconsistencies between the judgments when comparing the alternatives "Implement Blockchain versus Implement other technologies" for most of the criteria, except for the cost criterion. Equation 5 below was adopted to correct the inconsistencies found, Table 3 (Araujo et al., 2022).

$$p' = 1 + \left(\frac{p}{10}\right) \qquad \text{Eq. (5)}$$

Table 3: CI before and after adjustment

Criteria	Implementing blockchain versus implementing other technologies	
	CI before adjustment	**CI after adjustment**
Technology	0.10749	0.0005
Quality	0.10749	0.0005
Sustainability	0.10749	0.0061
Logistic service level	0.1598	0.0090
Operational efficiency	0.10749	0.00615

Source: Results of data analysis

4 RESULTS AND DISCUSSION

4.1 Description of results

Male participants accounted for 67% of the total survey participants. All the survey participants were between 20 and 30 years old, with a background in administration, logistics, and other areas. Only 33% of the volunteers answered that they had between 05 and 10 years of experience in the company, the rest, between two and five years.

Sixty-seven percent of the companies are food retailers or wholesalers, with the remaining 33% being secondary suppliers. All have been in the market for more than 15 years. Regarding the type of product, all the companies sell fresh products, whereas only 33% sell semi-processed, chilled or frozen, and processed products.

The study had participation from large, small, and micro enterprises located in the state of São Paulo.

4.2 Need for technological change

The participants' assessment of the necessity for technological changes in their company revealed that the best decision would be to implement blockchain (50.08%) or other technologies (34.94%), with a view to achieving a better corporate performance (Table 4). In this sense, the worst scenario would be maintaining the current situation, without technological changes or innovation in management and operational processes.

To ensure transparency in commercial relations in global supply chains, a flow of traceable information, and secure environment, applying up-to-date technologies like blockchain is necessary; however, companies in developing economies face particular difficulties in adapting to disruptive technologies and maintaining productivity (Vafadarnikjoo et al., 2021).

Table 4: Priority matrix of criteria and alternatives

		Weights	Rank
Criteria	Technology	0.22730	2
	Quality	0.14044	4
	Sustainability	0.09546	5
	Logistic service level	0.19572	3
	Costs	0.06552	6
	Operational efficiency	0.27556	1
Alternatives	1. Maintaining the current scenario	0.14972	3
	2. Implementing blockchain	0.50084	1
	3. Implementing other technologies	0.34944	2

Source: Results of data analysis, adapted from SuperDecisions (2019)

Among the criteria evaluated, operational efficiency was perceived to be the most important by managers of the participating companies, followed by technology, logistic service level, quality, sustainability, and costs. The survey results corroborate those of Shoaib et al. (2020).

The cyber society is constantly and dynamically changing, forcing a break from traditions and shaping human relationships. One of the big challenges the digital age poses to companies is to keep up with these changes and quickly meet new needs, which requires a greater capacity for innovation and process agility. Nevertheless, considering the global supply chain complexity and impacts of digital transformation, using big data to explore behavioral patterns that better define market value and help control and monitor activities is practical for companies. Warner and Wäger (2019) present the digital transformation of a company from the perspective of a strategic renewal, taking into account the renewal of the business model, collaborative approach, and culture. The authors emphasize that "digital transforming capabilities consist of micro foundations relating to (1) navigating innovation ecosystems, (2) redesigning internal structures, and (3) improving digital maturity."

The contribution of the Internet to corporate business can be inferred to be of fundamental importance. The timeline of technological advances and their impact on the business environment mentioned in the literature review indicate the profound changes made to supply chains by applying ERP, WMS, TMS, EDI, and QR Code, among others (Treiblmaier, 2018; Warner & Wäger, 2019; Min, 2019). In addition, a "supply chain 4.0" thinking has advanced in digital business perspectives, enabling a range of alternatives for companies in terms of process automation, cost reduction, productivity gains, new channels for marketing products, shortening the supply chain, and a better control and monitoring of production and operations.

4.3 Sensitivity analysis

To assess the robustness of the AHP, we carried out a sensitivity analysis (Chart 5). Four experiments were considered, and the criteria were assigned the following weights obtained from the results for the respective criterion: 0.25, 0.50, 0.75.

The experiment results showed that the model is consistent. The indication that scenario 2 (implement blockchain) was the best decision was maintained, followed by those for scenario 3 (implement other technologies) and scenario 1 (maintain the current scenario).

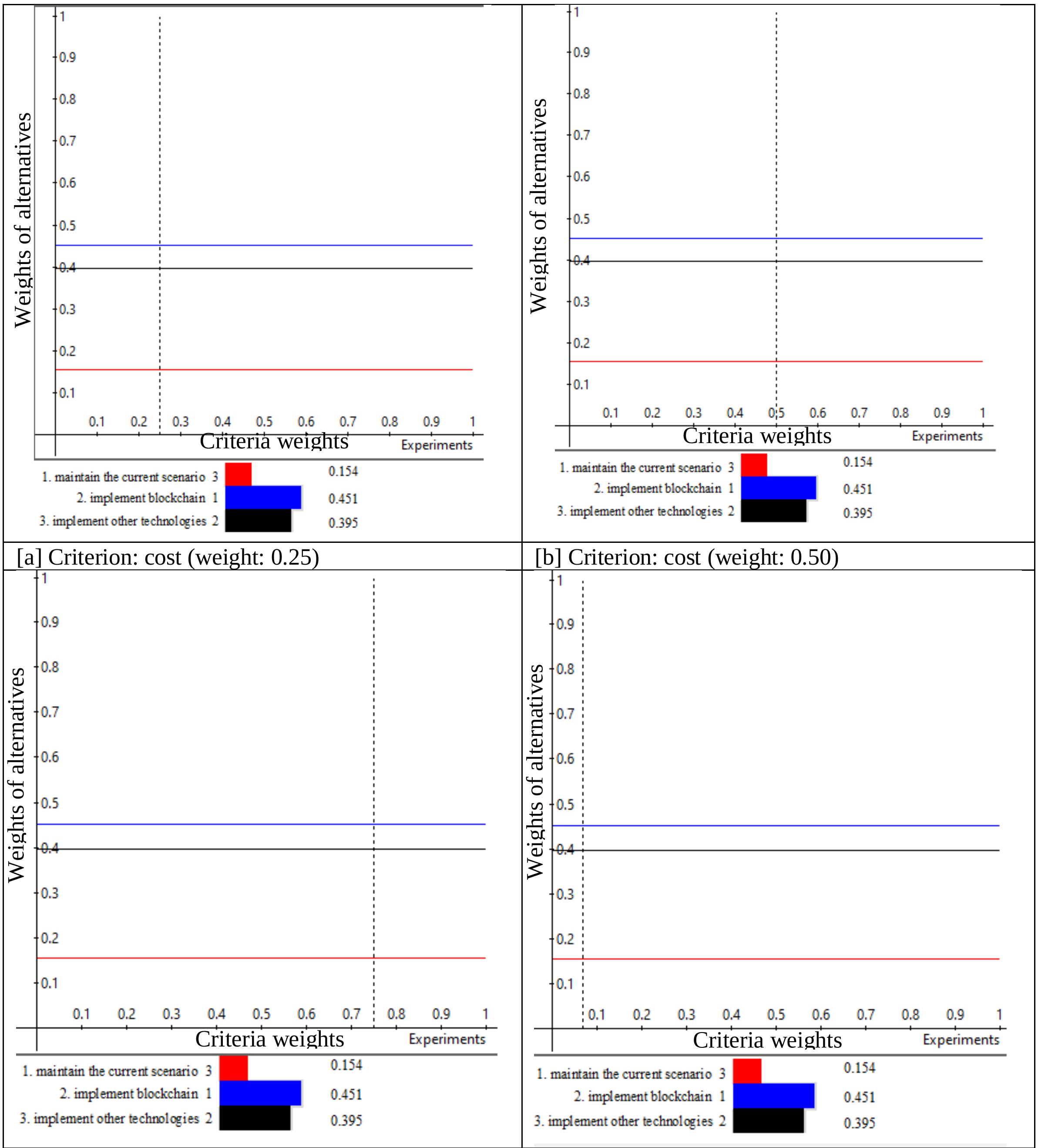
Criteria	Experiment 1 (0.25)	Experiment 2 (0.50)	Experiment 3 (0.75)	Experiment 4 (weight calculated: 0.065)
Technology	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1
Quality	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1
Sustainability	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1
Logistic service level	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1
Costs	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1
Operational efficiency	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1	scenario 2, 3, 1

Chart 5: Sensitivity analysis considering experimental values for weights 0.25, 0.5, 0.75 and weight calculated during the study 0.065.

Source: Authors (2022)

To illustrate the experiment results, we use the "cost" criterion, Figure 3. No change was noticed in the prioritization of the decision-making scenarios. Transparency in relationships in and processes of the supply chain ecosystem, promoting credibility, and reducing transaction costs are some of the benefits that companies envision and are moving toward in the advancement of blockchain applications in several market segments.

Adapting to the current scenario is no longer a matter of survival in the global market. Companies that want to be competitive must constantly innovate and reinvent themselves.



[a] Criterion: cost (weight: 0.25) | [b] Criterion: cost (weight: 0.50)
[c] Criterion: cost (weight: 0.75) | [d] Criterion: cost (weight calculated: 0.065)

Figure 3: Sensitivity analysis for the criterion: cost
Source: Adapted from SuperDecision (2019)

The BT promises a revolution in commercial transactions and is already showing marked disruptions in negotiations between companies through smart contracts, contributing to various market segments as presented in the list published by Forbes (Forbes Money, 2022). Regarding blockchain attributes, participants evaluated traceability to be the most important, followed by auditability, immutability, and lastly, provenance. Participants pointed out that blockchain can add value by reducing costs and improving quality, service, response times, and innovation.

5 CONCLUSION

The AHP analysis highlighted that regardless of the size of a company, there was a consensus among managers on the need for technological changes in their companies to keep up with market trends. Operational efficiency was found to be the most important criterion for the participating companies, followed by technology, logistic service level, quality, sustainability, and cost.

Moreover, the method applied proved to be consistent in selecting the best scenario for decision-making. In this regard, considering the criteria evaluated, the study indicated BT implementation as the first alternative. The second was other technologies that can meet the company’s needs.

It is therefore suggested that companies carry out a diagnosis of their business to decide on the technological change that needs applying. This study verifies the various benefits that BT can provide to supply chains, whether through a cost or value strategy, especially when companies seek a competitive advantage. Nonetheless, it was clear that blockchain faces restrictions despite its benefits, owing to an uncertain environment and the decentralized manner of information management by the network. Furthermore, there are legal and regulatory issues surrounding transactions. However, it seems unlikely that these factors will hinder the progress of the blockchain ecosystem and its use.

In this context, the gains in operational efficiency from the use of technology for supply chain integration seem to outweigh the risks, and in general, the technology contributes to the competitive advantage of the supply chain. Thus, the main contribution of this study lies in the evidence that companies need to adapt to the era of innovation and digitalization in a strategic way and in the presentation of a consolidated theory for evaluating the criteria that help in decision making.

For future research, we suggest an empirical investigation of the strategic factors in the application of blockchain and the perspective of the impacts of this technology on food supply chain, considering competitive advantage in the digital age.

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