



Traceability Technology Using Blockchain: An Overview of Food Industries in the State of São Paulo, Brazil

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Abstract: the scarcity of studies on the adoption of Blockchain technology in the food supply chain, especially regarding the potential and risks involved, motivated the need to investigate how the food sector in Brazil uses this technology. The study evaluated, through structured research, whether companies operating in the segment make use of this technology for food tracking. Thus, it aimed to investigate the adoption of Blockchain technology in large food companies in food tracking, adopting as a sample the 100 largest companies in the sector in the state of São Paulo. The study shows that some companies were found that make use of this technology, and the impacts of its use on food traceability were demonstrated. Traceability with Blockchain technology, when adopted, has brought gains for companies in terms of phytosanitary issues and, consequently, awareness for sustainable behavioral choices.

Key words: Food Supply Chain, Logistics, Brazilian Food Industry.

1 Introduction

Logistics has a strong presence in any business segment. Logistic activities are essential to promote the flow of goods, raw materials, and semi-finished products, reconciling the commercial relations of purchase and sale.

Transport is the physical movement or flow of products along distribution channels, using their modes to link production and storage units to points of purchase or consumption. Thus, transport is considered in the economy activity of great value and a driver of economic development in any area.

The National Association of Cargo Transport & Logistics (NTC&Logística) points out that in 2020 there were 14,150 records of occurrences of cargo theft on Brazilian highways. This scenario points to a loss of 1.2 billion reais. Also, according to the study carried out by NTC&Logística, the most targeted items in 2020 were food products,



fuels, pharmaceuticals, and textiles. Also included in the list are cigarettes, electronics, beverages, and pesticides.

Such theft favors the supply of illicit trades, prominent unethical production practices, and fragile supply chains. The food industry faces problems due to volatile consumer demands, increasing competition, product recalls, and theft during transport to the destination. Another factor affecting the food industry is strong criticism due to unfair labor practices and the use of products that do not conform to the standards set by regulatory agencies, mainly because of opaque supply chains [1].

Given these facts, the tracking system appears as an essential instrument to support business logistics and management of origin and destination. Recently, the implementation of traceability in the supply chain has emerged as a possible countermeasure, which can help solve these problems [2], [3]. Thus, according to the United Nations Global Compact and Business for Social Responsibility (2014), traceability is "the ability to identify and trace the history, distribution, location, and application of products, parts, and materials, to ensure the reliability of sustainability claims. In human rights, labor (including health and safety), environment and anti-corruption".

Supply chain traceability is based on the integrity and transparency of the saved and shared data. In addition, traceability is a way of preventing the entry of food without quality or safety, reducing the volume of product returns, establishing responsibilities, and simplifying the location of problems, such as identifying places/steps that are out of the ordinary. [4].

One of the ways to control this tracking is through Blockchain technology, creating an information trail, and ensuring data security and immutability [1], [5]. Blockchain-based traceability enables secure information sharing and facilitates product quality monitoring/control, operation monitoring/control, real-time data acquisition, transparency, and visibility across the entire supply chain. [6], [7].

Blockchain can be described as "a shared and immutable ledger that facilitates the process of recording transactions and tracking assets in a business network" [8]. An asset can be tangible (a house, a car, money, land) or intangible (intellectual property, patents, copyright, trademark). Virtually anything of value can be tracked and traded on a Blockchain network, reducing risks and cutting costs for everyone involved. That is, this technology is essential to avoid cargo losses and consequently increase profit.

This tool is innovative since it operates from a decentralized network, with its data immutability feature. Thus, Blockchain implementation is a suitable solution to provide better visibility with information sharing, building and elevating technology-based trust among supply chain stakeholders.

The technology that guides Blockchain has been gaining more and more space in the logistics systems of industries, which have presented a technical architecture of a



Blockchain-based logistics monitoring system for tracking orders in a given supply chain, which supports a shared and immutable record. of all transactions [9].

Blockchain technology can solve these information exchange and payload theft problems by offering a shared/common version of the truth. This would facilitate information sharing between partners and resolve any disputes faster with low chargeback [10]. In this sense, Blockchain can facilitate the effective sharing of resources in the food industry and, ultimately, improve the overall performance of the supply chain, as well as the creation of a chronological chain of records of all transactions in encrypted and immutable blocks, to facilitate material traceability [11].

Thinking about all the issues and challenges with the traceability of the supply chain, the present work sought to identify the companies in the food industry that make use of Blockchain technology for food tracking. This work is organized into 04 sections, with the conceptual approach of the topics analyzed in section 1, the explanation of the method of analysis in section 2, the exposure of the research results in section 3, and the demonstration of the conclusive observations of the research in section 4.

2. Methodology

According to data from the Brazilian Food Industry Association-ABIA, the number of industries in the food sector in 2020 corresponded to 37,200 companies. In the state of São Paulo this number reaches more than 10 thousand. In the present study, the largest 100 companies in the food sector were selected (according to data from ECONODATA®) and, from this universe, the 50 that most profited in 2020 were selected according to Table 1.

Table 1- Food industries in the state of São Paulo.

Food Industry (name)	City
DSM Produtos Nutricionais Brasil	Itapira
Pepsico Do Brasil Industria E Comercio	São Bernardo
Camil Alimentos	São Paulo
Padma Industria De Alimentos	São Paulo
Tereos Amido E Adoçantes Brasil	São Paulo
Nestle Brasil	São Paulo
Bagley Do Brasil Alimentos	São Paulo
Mars Brasil - <i>Masterfoods</i> Brasil Alimentos	São Paulo
Moinho São Jorge - Moinho São Jorge	Palmital
Minerva Dawn Farms Industria E Comercio De Proteínas	São Paulo
<i>Trouw Nutrition</i> Brasil Nutrição Animal	Moji Mirim
Kellogg's - Kellogg Brasil	Campinas
<i>Ingredion</i> Brasil Ingredientes Industriais	Santo André
Pandurata Alimentos	Barretos
I.B.A.C. Industria Brasileira De Alimentos E Chocolates	Mirassol
Probiótica Laboratórios	São Paulo
Kerry Do Brasil	Guarulhos
Harald S/A. - Harald Industria E Comercio De Alimentos	Itapevi
Santa Helena Industria De Alimentos	Matão
J Macedo Alimentos	Campinas
Ab Brasil Industria E Comercio De Alimentos	Santana De Parnaíba
Sancor Do Brasil Produtos Alimenticios	Ribeirão Preto
Anglo - Anglo Alimentos	Sao Paulo
De Heus - De Heus Industria E Comercio De Nutricao Animal	Ibiúna
Nestle Sudeste Alimentos E Bebidas	Pederneiras
Ocim S A Produtos Alimenticios	Barueri
Lider Alimentos - Lider Alimentos Do Brasil S.A	
Em Recuperação Judicial	São Paulo
<i>Gl Foods Worldwide</i>	Rio Claro
Dohler America Latina	São Paulo
Brasilia Alimentos - Brasilia Alimentos	São Paulo
Via Nectare - Via Nectare Tecnologia Em Bebidas E	
Alimentos	São Paulo
<i>Yessinergy</i> Do Brasil Agroindustrial	Jundiaí
Nestle Waters Brasil - Bebidas E Alimentos	Limeira
Marilan - Marilan Alimentos	São Paulo
Companhia Do Leite - Companhia Paulistana De Alimentos	Marília
Correcta Industria e Comércio	Sao Paulo
Rousselot Gelatinas Do Brasil	Sao Paulo
Stella D'oro - Stella D'oro Alimentos	Amparo
Alibra - Alibra Ingredientes	Itapólis
Richard Saigh Indústria E comércio	Campinas
Frigorifico Ceratti - Cidade Do Sol Alimentos	Jundiaí
Castelo - Castelo Alimentos	Santo Anastacio
Potensial - Potensial Nutrição E Saúde Animal	Sao Paulo
Moinho Paulista	Campinas
<i>Affinity Petcare</i> - Mogiana Alimentos	Osasco
Poli-Nutri Alimentos	Sao Paulo
Arantes Alimentos - Arantes Alimentos Ltda	
Em Recuperação Judicial	Guaira
Só Fruta Alimentos	Pedreora
<i>Biospringer</i> Do Brasil	Valinhos
<i>Hero Brazil</i>	Itatiba
N = 50	

Once the food industries were defined and surveyed, the next step was to know which of them used Blockchain technology to track their food. To find out how the companies handled the initial to the destination of their food, the companies were contacted via available communication channels, where they were asked what types of technology they used for screening.

To identify whether the technology used in the screening (if it was Blockchain) had an impact on the ranking of companies, Chi-square tests were carried out with a significance level of 0.05 using the IBM SPSS Statistics 20 software to compare the two variables: technologies used X position.

The main limitations of the research are the items related to the region, which focused only on cities in the state of São Paulo, in the industrial segment, which analyzed only the food industry and only those that use tracking methods in their products.

3. Results

From a universe of 50 companies, 43 returned, clarifying how their screening method works (86%). Of the respondent industries, 10 (23.26%) use Blockchain technology to track their food products (Table 2).

Table 2 shows that all companies use at least two technological instruments for tracking food. Although some still use GPS, the trend is to migrate to Blockchain and Telemetry, considering that GPS technology, together with hardware, software, support, and the very knowledge about the technologies, will become obsolete, and to minimize these effects it has been proposed the implementation of a strategy aimed at developing new technologies to help in the traceability process.

Table 2: Main technologies used for the transport/tracking of food products.

Food Industry	Tracking Technology
DSM Produtos Nutricionais Brasil	GPS- Blockchain - Telemetry
Pepsico Do Brasil Industria E Comercio	GPS- Blockchain - Telemetry
Nestle Brasil	Blockchain- Telemetry
<i>Kellogg's - Kellogg</i> Brasil	GPS- Blockchain- Telemetry
Minerva Dawn Farms Industria E Comercio De Proteínas	GPS- Blockchain
Camil Alimentos	GPS- Blockchain
Probiótica Laboratórios	Blockchain - Telemetry
Nestle Sudeste Alimentos E Bebidas	Blockchain - Telemetry
Kerry Do Brasil	GPS - Blockchain
Trouw Nutrition Brasil Nutrição Animal	GPS – Blockchain - Telemetry

When comparing technologies x ranking/production, there are no significant results between these variables, $p < 0.05$, see Table 3. This fact can be explained due to the

differences in the supply chains of different sectors since they differ in many aspects of their characteristics and functioning. It is essential to investigate Blockchain operations, considering their applications and supply chain requirements [12].

Table 3: Chi-square test for comparisons of technology use and billing

Food Industry	Tracking Technology	Revenues (BR\$)	χ^2
DSM P	GPS- Blockchain- Telemetry	235X10 ¹¹	0.060
PEPSICO	Blockchain- Telemetry	198X10 ¹¹	0.056
PEPSICO PEPSICO	GPS- Blockchain-	168X10 ¹¹	0.068
KELLOGG'S	GPS- Blockchain- Telemetry	179X10 ¹¹	0.078
KELLOGG BRASIL	Blockchain- Telemetry	128X10 ¹¹	0.069
MINERVA	GPS- Blockchain-	136X10 ¹¹	0.076
CAMIL	GPS- Blockchain-	149X10 ¹¹	0.096
PROBIOTICA	Blockchain- Telemetry	56X10 ¹¹	0.064
NESTLE SUDESTE	GPS- Blockchain-	187X10 ¹¹	0.710
KERRY DO BRASIL	GPS- Blockchain- Telemetry	157X10 ¹¹	0.683

The ten largest food industries that use Blockchain technology in the state of São Paulo, represent a movement of 12 billion in the food export and import sector. However, only 2 of these 10 are national, as the others are multinational, reinforcing the understanding that the Blockchain tracker is still new to national food companies.

It is worth noting that the use of Blockchain technology by the food sector, especially Brazilian industries, since we are large food exporters, would help to enhance the main argument used by countries to use phytosanitary and technical measures with protectionist and trade limitation purposes, on public health issues, such as the safety of imported food. However, identifying the use of these measures for such purposes is not easy since "the argument of protection of human, animal and plant health gives legitimacy to protection measures to defend the interests of domestic markets" [14].

It is noteworthy that these companies in the state of São Paulo, follow standards in the aspects of phytosanitary, and the bodies responsible for this regulation of the control of sanitary and phytosanitary barriers are ANVISA (National Agency of Sanitary Surveillance) and the Ministry of Agriculture, Livestock and Supply (MAPA), both responsible for creating norms, regulations, providing support for all activities in the area and, also, in the execution of sanitary control and inspection activities in ports, airports, and borders that transport agricultural and food products. And agricultural. Thus, identifying/tracking these foods and products from this area is a great option to ensure that quality foods are used or that they reach the final consumer.

The Blockchain identifier/tracker that private food industries use can determine the type and extent of access an individual partner has to the private Blockchain network. Thus,



this technology can help define network rules and partner interaction policies, culminating in better interactivity, preventing fraudulent transactions. The private key is always confidential and known only to its owner [1]. Through this functionality, it is easy to comply with data protection regulations, maintain data privacy, track product history, identify the origin of the defect and have better control over the data attached to the Blockchain [13].

4. Conclusion

Blockchain is a well-distributed notebook that works without a central authority and allows you to create a decentralized, immutable ledger of verifiable and traceable transactions. Due to these unique characteristics, it has been explored for several applications, mainly in the food sector. Due to the applicability of Blockchain technology, it is evident that it can be implemented in several sectors, especially in the supply chain sector, since companies need to meet new and necessary demands, such as the origin of production and proof of sustainability, each increasingly demanded by consumers.

The main result is a survey of the main industries in the food sector in the state of São Paulo that use this Blockchain technology in the food supply chain and how it affects the position of these industries in the production ranking using Blockchain-based traceability framework.

As for the issues that guide the sanitary or phytosanitary barriers, as protection mechanisms that act to control the entry of products of agricultural and agro-industrial origin into the country, through the inspection of the health of these products, the role that Blockchain technology can play is well known. Bring thus avoiding waste and food quality.

In this sense, the application of Blockchain technology is promising for traceability/control of the production chain. The study showed that the implementation of Blockchain technology is viable for traceability and can impact the profits of the sector involved and offer transparency in transactions in the food supply chain.

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