



Blockchain-Powered Fish Industry: Trust Perceptions of Final Consumers on Traceable Information Availability

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Abstract. Blockchain is being actively discussed for business applications to digitalise supply chains. The still nascent level of blockchain adoption creates a difficulty to see the potential value that it may add to products and final consumers. Through a quantitative method, this study explores the impact of the traceability feature of products on the trust in the seller supermarket chain from the perspective of final consumers. Data from 417 questionnaires applied to buyers of fish was used to analyse such relation. Findings reveal the interest of final consumers towards traceable products and a positive relationship between the traceable information availability and the trust towards product.

Keywords: Blockchain · Fish Industry · Final Consumers

1 Introduction

Increasing competition in the market of food retail creates pressure on retailers and decreases their ability in providing more sustainable and healthy options [1]. Today consumers are paying attention not only to the availability of a product but also to its quality, where the provenance of products' origins can impact the final consumption decision [2]. To meet the expectations and needs of final consumers, supply chain (SC) stakeholders need to work together towards a mutual goal, which creates a need for close collaboration to reach their common objective. Here, another challenge of supply chain management (SCM) arises: entities are seeking a higher dedication and openness to designate mutual dependency, as the trust level between parties impacts their willingness to collaborate with each other [3].

As technological solutions are arising, one of the most promising technologies that is being actively discussed in a business context is the blockchain technology (BCT). Blockchain can be defined as a “digital, decentralized and distributed ledger in which

transactions are logged and added in chronological order with the goal of creating permanent and tamper-proof records” [4]. When applied in the business context, BCT can reshape current processes with its native immutable nature—all transactions and information that goes through a blockchain ledger cannot be compromised, changed, or removed later due to the nature of technology, that links the blocks together in a decentralized manner [5]. Accordingly, BCT is claimed to bring provenance of products’ origins [6], ensure traceability and transparency of records [7], enable trust with final consumers, as they could easily scan and verify the product origins [8], as well as promote mutual trust between SC parties by protecting shared data [9].

Blockchain applications to SCM practices for consumer goods were studied for various categories of products, such as food and drinks [10–13], electronics [14, 15], clothing [16, 17], and others. Most of the articles in the field are conceptual model propositions and state-of-the-art, mostly focusing on the players in the SC that share information and want/need immutable information. Still poorly explored is the perspective of the final customers on the value of the traceability information and its impact on the purchase behavior of such customers, which can be potentially powered by the BCT.

Aiming at filling this gap, the purpose of this study is to explore the impact of the traceability feature of perishable products on the trust towards the product, from the perspective of final consumers. This study is based on the data collected from Portuguese consumers of fish products. Thus, the goal of this study is to reveal the potential of BCT solutions for creating value proposals by retail chains offering fish products to final consumers.

To address the purpose of this study, quantitative research was conducted and the views of final consumers on the traceability feature for fish products was investigated through an online survey. This paper contributes to the current knowledge in the area by showing that, under the scope of the analyzed sample, final consumers are interested in the traceability of products and that there is a significant and positive relationship between the availability of traceable information and the trust in the product. Such a relation may further lead to increased sales. The remaining of the paper is built as follows: a section with the review of the extant literature about BCT features and SC challenges that need to be addressed, a methodology description section, findings and data analysis, and, finally, the discussion of results and main conclusions of the study.

2 Literature Review

Supply chain players are constantly battling to understand the nature of trust and the dynamics of trust building [18]. Both the trust component of SCs and the technology component were found to have a considerable impact on collaboration between partners and operational performances of businesses. With the launching of new technologies, the trust component of SCM is also addressed. Like this, BCT is being hyped to bring to SC players “trust-free transactions” [19] by its decentralized and immutable nature.

Blockchain is a part of Distributed Ledger Technologies (DLT), that operates as an immutable ledger, keeping and recording every transaction that is instantly shared across the whole network of participants [20]. Through its decentralized nature, BCT brings transparency to the SC network, and provides reliance on products’ provenance,

decreasing at the same time the counterfeit possibilities, as products' origins can always be consulted in real-time [6]. BCT use was explored in many different fields, not only for consumer goods but also for industries such as medication distribution [21], chemical industry [22, 23], oil and gas industry [24], electricity trading [25, 26], and many others. This shows a universal ability of BCT to bring potential improvements to SCs in various fields.

However, various technical and regulatory issues still need to be addressed for BCT-based solutions to reach the maturity stage [27]. Some challenges, that were detected in previous studies include constraints like organizational readiness for change and a lack of technical knowledge [28], high cost of the technology and its complexity [29], comprehensive management procedures and adoption strategies for BCT-based networks when used by multi-actor SCs [30], and many others. Moreover, from the perspective of final consumers, providing them with a BCT-based tool to explore products' origin is not enough, as it needs to first create an environment of trust [31]. To move towards large-scale adoptions, final consumers need to first become active players of BCT-based networks [32], and for this technological awareness still needs to be raised among consumers [33].

3 Methodology

The data for this study was collected via an online questionnaire among fish consumers in Portugal. The questionnaire consisted of four broad sections: general information, fish consumption behavior, traceability of fish products, and trust towards traceable information. In the three last sections scales of 7 points were used. For consumer inclusion purposes, this questionnaire was made available in two languages: Portuguese (European) and English. Eligible respondents were considered as individuals with 18 years old or above, who had bought fish products in the previous year in Portugal. The questionnaire was built on Qualtrics online platform for surveys and pre-tested with 6 potential respondents of various age and education level groups. The feedback from the pre-test led to adjustments in terms of technical wording in the questionnaire.

The questionnaire was first made available online in May 2022 and the data collection took place between May 2022 and July 2022. The data collection used the snowball technique for spreading the questionnaire. The final data collected consisted of 417 filled-in questionnaires is important to note, that BCT was not mentioned anywhere in the questionnaire as a potential technology of choice, allowing a more unbiased consumer view on traceability importance for fish products, as BCT is just one of possible technologies that might bring traceability, but not an exclusive one.

Table 1. Study sample characteristics and frequencies.

Sample size = 417 responses		Frequency	Percentage (%)
Gender	Female	254	60,9%
	Male	161	38,6%
	Prefer not to say	2	0,5%
Age	18-19	108	25,9%
	30-39	105	25,2%
	40-49	84	20,1%
	50-59	70	16,8%
	60 and above	50	12%
Education		86	20,6%
	General secondary school	18	4,3%
	Technological specialization school	144	34,5%
	Bachelor's degree	114	27,3%
	Master's degree	55	13,3%
Doctoral degree			
Fish consumption habits	100% fresh fish		
	About 75% fresh fish and 25% frozen fish	71	17%
	About 50% fresh fish and 50% frozen fish	133	31,9%
	About 25% fresh fish and 75% frozen fish	95	22,8%
	100% frozen fish	84	20,1%
	34	8,2%	
Family size			
	1-2 persons	199	47,7%
	3-4 persons	189	45,3%
	5-6 persons	29	7%
Monthly spending on fish products	0-19.99 euros		
	20-39.99 euros	78	18,7%
	40-59.99 euros	138	33,1%
	60-79.99 euros	108	25,9%
	80-99.99 euros	45	10,8%
	100 euros and above	21	5%
	27	6,5%	

4 Findings and Data Analysis

Table 1 shows the characterization of the respondents. The sample is quite evenly spread among age groups, resulting into 51,1% of individuals between 18 and 39 and 48,9% of individuals of 40 years and above. However, in terms of the highest education level obtained, this sample can be considered as an 'educated' one, where

75,1% of respondents have at least a Bachelor's degree. This can be explained by the snowballing technique that was applied—respondents were spreading the survey among colleagues/friends/family members with similar education background.

Regarding the fish consumption habits, the sample shows a tendency towards the consumption of more fresh fish rather than frozen. However, this can also be explained by the targeted country of the data collection—the access of Portuguese consumers to fresh fish from the ocean is an important factor that influences the habits of fish products' purchasing and consumption. Nevertheless, it is important to note, that pure frozen fish consumption, despite being low (only 8,2% of respondents), still exists, therefore fish products' consumption varies across the sample, where predominantly a mix of both fresh and frozen fish products leads.

The sample shows mostly families of up to 4 persons, which is quite natural for the current demographic situation in Portugal. Regarding the proportion of money spent per month on fish products, we can see that 77,7% spend up to 60 euros per month on fish products, which is not very high, but the overall low wages in Portugal does not allow considering this value insignificant. However, when read along with the fact that the sample is of more educated persons, i.e., persons with more income, it also signifies that, overall, the weight of expenditure in fish products in the overall income among the sample is not very high.

The interest in traceable information about fish products (Q1) and the impact of traceable information availability on purchasing decision (Q2) were evaluated using a Likert-like scale, with '1 = no interest at all/negative purchasing impact' and '7 = high interest/positive purchasing impact'. As can be seen in Table 2, on average, the respondents are moderately interested in traceability information for fish products, and it potentially brings an effect of a higher purchase intention for such traceable products. Nonetheless, the standard deviation shows that there are strong discrepancies in respondents' replies.

Table 2. Means and standard deviations of items in traceability for fish products.

Item	Mean (standard deviation)
1. Interest in having information about the origin and the processing stages of fish product(s) that are bought and the path they follow until being available at the point of sales	4.96 (1.95)
2. Impact of the availability of information about the origin and processing stages of fish product(s) on the purchasing decision	5.12 (1.73)

The Trust construct that was used for this survey consisted of three items regarding consumers' towards the correctness and authenticity of potentially traceable information (adapted from [34]) (Table 3). The items about trust were measured on a 7-point Likert-like scale, with '1 = Strongly disagree' and '7 = Strongly agree'. Prior to the questions regarding trust, respondents needed to identify the retailing chain of choice, thus keeping in mind the selected supermarket chain in the questions about trust (signified as 'supermarket X'). Figure 1 shows the histograms of the three questions: (a)

Table 3. Means, standard deviations and Cronbach’s Alpha for trust construct questions.

Trust	Mean (standard deviation)	Cronbach’s Alpha
I trust that if supermarket X provides information about the fish product(s), it can be traced back to the actually captured region/fish farm	4,87 (1.60)	0,90
I trust that if supermarket X provides information about the fish product(s) processing and origin, that information will be correct	4,99 (1.47)	
I trust that if supermarket X provides information about the fish product(s), it is authentic, which means it has not been falsified in any way	4,92 (1.48)	

trust that information can be traced back to the origins of the fish product; (b) trust that information provided is correct; (c) trust that information was not falsified.

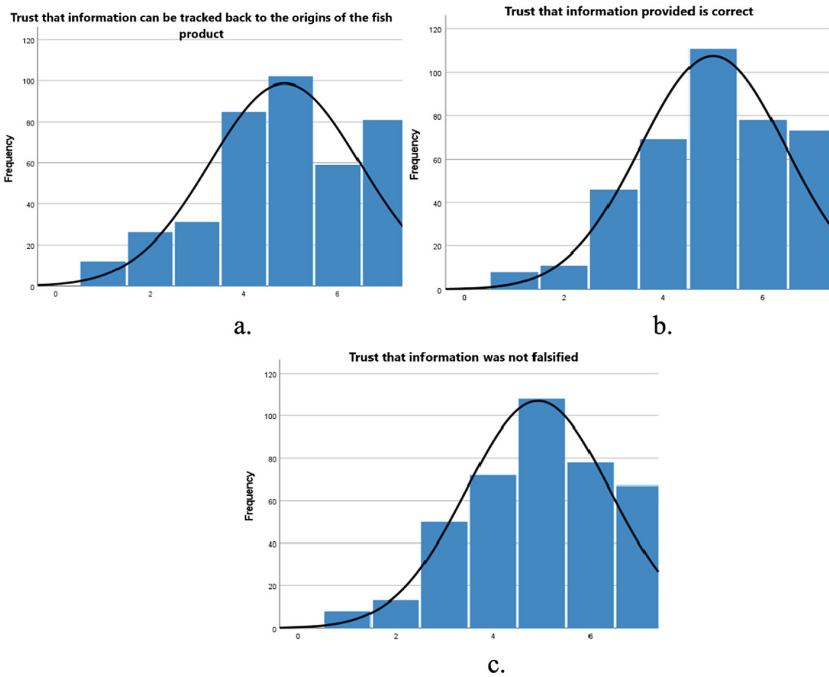


Fig. 1. Histograms of trust construct questions: (a) trust that information can be tracked back to the origins of the fish product; (b) trust that information provided is correct; (c) trust that information was not falsified.

Table 4. Regression of trust variables with the availability of traceable information as a predictor.

Trust variables	R2	F	Significance
I trust that if the supermarket X provides information about the fish product(s), it can be tracked back to the actual captured region/fish farm	0,082	35,327	< 0, 001
I trust that if the supermarket X provides information about the fish product(s) processing and origin, that information will be correct	0,067	28,311	< 0, 001
I trust that if the supermarket X provides information about the fish product(s), it is authentic, which means it has not been falsified in any way	0,086	38,152	< 0, 001

To pursue the purpose of the study and explore the impact of the traceability feature of fish products towards trust, a regression was run. Item 2 from Table 2 was used as an independent variable and each of the three trust questions from Table 3 were used as dependent variables to check if there is any significance between the variables. The results are shown in Table 4. Keeping in mind that p-value ($p < 0.05$) was considered as a significant value, we can see that there is a positive and significant relationship between the availability of traceable information about fish products and the trust towards the information provided, therefore a higher trust towards such products. The graphical representation between the purchasing decision based on the availability of traceable information and the trust relationship can be found in Fig. 2. Here, Fig. 2 shows the following relationships: (a) the availability of traceable information and the trust that information can be traced back to the origin; (b) the availability of traceable information and trust in information correctness; (c) the availability of traceable information and trust that this information was not falsified. As can be seen in Fig. 2, the tendency of the availability of traceable information is associated with higher trust in the information that was provided, therefore, under the scope of the sample used, we can conclude that the level of trust rises with the availability of traceable information provided about the selected product.

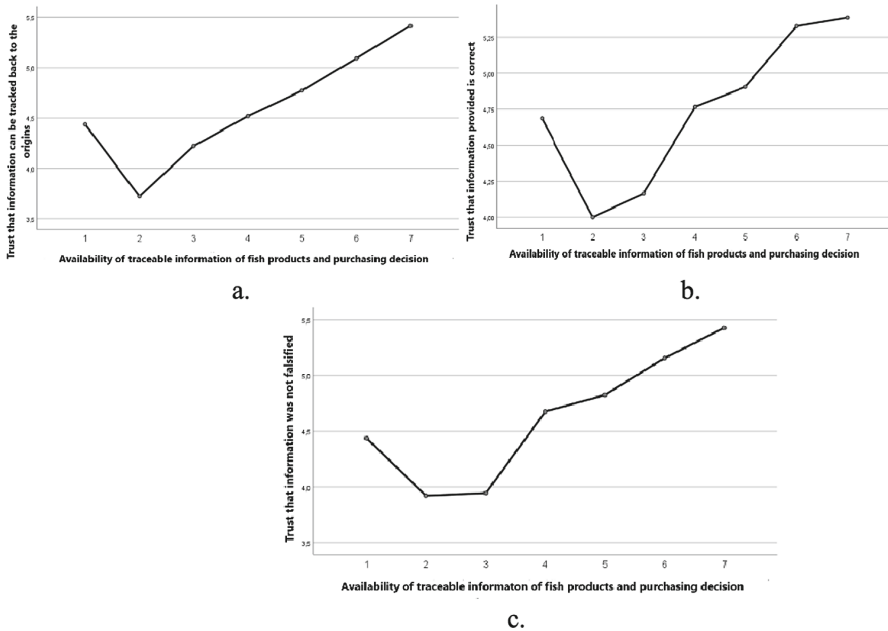


Fig. 2. Relationship between the purchasing decision based on the availability of traceable information and the trust: (a) the availability of traceable information and the trust that information can be traced back to the origin; (b) the availability of traceable information and trust into information correctness; (c) the availability of traceable information and trust that this information was not falsified

5 Discussion and Conclusions

Findings revealed real views of downstream SC players, final consumers, towards the role of traceable information about products and its potential value creation in terms of trust. At the early stages of considering the use of BCT it is crucial to see the value that this technology may bring to final consumers and understand if it is the most adequate solution.

The first important finding disclosed is the fish consumption behaviors of consumers—even in Portugal, where fresh fish is widely available, consumers still show habits of purchasing a mix of both fresh and frozen fish. This might also be explained by the type of fish that they buy, e.g. fish from the Northern seas that are not captured around Portugal might be cheaper to buy in a frozen package. [35] conducted a survey with simulations of various packages of frozen fish with BCT-based traceability option and found that only in the less familiar brand condition BCT label increases product quality perceptions to final consumers, whereas for familiar brands it does not directly influence the purchasing decision. In our study, the brand of the fish package was not mentioned, but rather respondents needed to choose one supermarket chain where they shop more often, thus here the case is more towards the trust and purchase intention for the supermarket of choice and not for a specific food brand.

Second, it is important to remember that participants of our survey were not clarified about the technology that would provide traceability information. It was done on purpose to reduce bias among those consumers that are familiar with BCT concept, for them not to be 'triggered' by the BCT application and show a higher interest in purchasing just based on the technology of choice. It was more important to understand the real value that consumers give to the traceable information—does it interest them and does it provide them added-value, if compared to those products that do not possess such option. As we saw in the previous section, the interest in traceable information for fish products is moderately high with the mean of 4,96 (SD 1.95) on the scale of 7 points maximum. This signifies that there is interest, but perhaps not all consumers realize how exactly the traceable information would be provided, thus might still be skeptical about having interest in such an option. The availability of traceable information and its consequent intention to purchase such a product shows a bit higher score with a mean of 5,12 (SD 1.73), which shows that the traceability option on a product will likely result in higher sales for supermarkets. In the case study conducted by [36], results showed that one of the main conditions for SCs to adopt BCT is related to the traceability awareness of the final consumers because the adoption is translated into higher costs for SC parties. Our study also highlights the importance to clarify how traceable information could be gained and which technologies are able to support it. We once again emphasize the fact that BCT is just a possible tool for providing traceable information, but the real importance is the value that consumers would potentially give to the traceable information provided, which was addressed in this study.

One of the key findings of this study is related to the fact that a positive and significant relationship was found between the availability of traceable information on fish products and the trust in the information provided. This means that the value that consumers give to traceability information comes out as an extra layer of trust that consumers associate with products, and consequently with the habitual supermarket chain. In Fig. 2 we can see that the high purchase intention based on the available traceable information results in higher trust towards the (1) confidence that information can be traced back; (2) correctness of provided information; and (3) reliance that the information is authentic and was not falsified. On a larger scale, [37] believes that BCT suits fisheries and the fishing industry because it motivates participating entities to demonstrate their compliance with laws and health regulations, resulting in increasing consumer demand based on trust in the product. Moreover, in our study, we assume that the trust in the information provided by the supermarket might positively affect the loyalty of consumers towards the supermarket chain, therefore brand loyalty increases. [38] believe that new technologies are reshaping not only the operational part, but also the dynamics of brand marketing, aiming at increasing brand trust and enhancing customer loyalty. Therefore, our study shows the potential that traceable information on a specific type of goods that are purchased in a habitual supermarket is adding value to final consumers and it may possibly result in increased loyalty to the supermarket chain.

This study explored the impact of the traceability feature of perishable products on the trust towards the product from the perspective of final consumers. It showed a significant and positive relationship between traceable information availability and trust towards such products. Therefore, this study provides a practical contribution for those SCs and

food retailing chains that consider BCT pilots—here they can find scientifically analyzed perspectives of final consumers towards the potential availability of transparent traceable information. One of the limitations of this study is related to the sample used for the data collection—with the snowballing technique application, respondents were spreading the survey among their convenience circle, therefore in some characteristics (e.g. education) it resulted in being non-equally spread. Nonetheless, as using the information available at the points of sales is more likely to happen in younger (and therefore more educated in the Portuguese population) and the fact that more educated respondents have the tendency to have more income available to spend on these products, the sample is likely to have more adherence to the overall profile of costumers buying fish. Moreover, as the survey touched on the topic of the supermarket that consumers choose for their habitual food shopping, it would be interesting for future studies to add a brand loyalty construct and see if the traceable information actually results in increased brand loyalty. We hope that this study will serve as an impulse for future explorations of novel technology implementation for business practices and consumer experiences.

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