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Assessment of the Blockchain Capabilities to Combat the Global Trade in "Falsified" and "Illegal" Fish Products

[1]O. Korneyko and [2]A. Podvolotskaya
[1]Department of Economics,
Vladivostok State University of Economics and Service, Vladivostok, Russia
[2]Innovative Technology Center, Far Eastern Federal University,
Sukhanova Street 8, Vladivostok, Russia

Abstract: Since, wild fisheries continue to be depleted throughout the world and illegal and falsified products are included in the supply chain, there is a need for innovative technological solutions to ensure global food security. We conducted a multidisciplinary review of information technologies and general academic literature and found that Blockchain Technology (BCT) is an effective mechanism to limit the access of illegal and falsified fish products to commodity markets as an additional solution that improves the exchange of information and data collection. The results of the research established that this technology of the new generation is still at the stage of maturation and its introduction is fraught with many problems that cannot be ignored. However, the features and prospects of BCT, considered in the practical part of the work as well as the existence of successful cases in the analyzed area, confirmed the need of the blockchain for the supply ecosystem and the industry's interest in investing in new digital technologies based on distributed registers and their integration into the business processes of the world market participants.

Key words: Falsified fish, fishery products, illegal fishery products, supply chain, blockchain, illegal, unreported and unregulated fishing

INTRODUCTION

Fisheries activities also known as pisciculture and fish farming (production and aquaculture) and fish processing are a significant producer of vital food products, currently providing 17% of the world's protein intake (Korneiko and Dubovik, 2017).

As the global population grows exponentially, the demand for fish products reaches the highest level in the entire history. The capacity of this market exceeds the total capacity of the markets for rubber, bananas and coffee (Korneiko and Lee, 2017). In addition, the rapid expansion of developing countries gradually leads to an increase in the incomes of the population with simultaneous penetration of some elements of Western culture, even into traditional Asian societies including an indicative cult of consumerism. There is an increase in demand for high quality products and consumption of dainties made of valuable fish species, shrimp, crabs and caviar. In 2014, the total volume of fish production in the world amounted to 167.2 mln. ton and the demand for it shows no signs of slowing down (FAO., 2016). The Food and Agriculture Organization (FAO) of the United Nations expects that by the year 2030 additional 27 mln. ton of products will be required to maintain the current level of fish consumption per capita (20 kg/year). Under these circumstances, the provision of high-quality, stable, uninterrupted and sufficient supply of fish products is an important condition for global food security.

However, the global fishery products trade faces challenges of penetration of "falsified", "illegal" and "substandard" products in the entire global supply chain. This occurs on vessels engaged in IUU fishing (IUU stands for Illegal, Unreported and Unregulated fishing) at fish processing enterprises that purchase unaccounted raw materials on the shelves of retail stores selling falsified products in informal markets. The impact of these goods is enormous as they not only have a significant negative effect on the safety of consumption but also lead to an excessive exploitation of aquatic biological resources causing the reduction of their reserves and environmental problems. The hidden economy leads to currency leakage abroad, tax evasion and customs control which significantly hinders the financing of the fishing industry, hinders economic growth and seriously threatens to ensure fair and safe access to the world's most popular food product-fish (Korneiko and Dubovik, 2017).

Corresponding Author: O. Korneyko, Department of Economics, Vladivostok State University of Economics and Service, Vladivostok, Russia

Even with the expansion of research, the strengthening of outreach, sanitary and epidemiological surveillance with related regulatory and enforcement measures, the real extent and impact of this global problem is still underrepresented as incidents go unnoticed, persist in non-public reports of national governments due to political or commercial problems. The key risk factors for the trade in "falsified", "illegal" and "substandard" fish products are inherently difficult to measure, taking into account its multisubject nature, politicization of the issue, disagreement on the terminology, complexity and interdependence of all participants in the producer-processor-supplier-consumer chain and also the continuous evolution of the supply chain including its globalization.

The fight against the global trade in "falsified" and "illegal" fish products creates the need for innovative technological solutions for supply chain management. One of these solutions may be a blockchain industry that has grown over the past few years from a small but bold idea to the volume of billions of dollars. This technology not only changed the economic environment but also defined new approaches to business management.

MATERIALS AND METHODS

The purpose of the study: This study is devoted to the study of BCT and a review of its application possibilities to ensure the integrity of the global supply chain of fish products by combating "falsified" and "illegal" goods. We are conducting this review in order to better understand how the blockchain technologies can act as a unifying structure for various international stakeholders to solve the multi-year problem of the fish market that requires innovative solutions. The information base of the study was the official reports of FAO UN, Rospotrebnadzor (Federal Service on Surveillance for Consumer Rights Protection and Human Well-being), World Wildlife Fund, Federal Agency for Fisheries of the Russian Federation; scientific and technical materials published by the Institute of Electrical and Electronics Engineers ("IEEE"); expert assessments and calculations of Russian and Foreign scientists published in the scientific literature (publishers Taylor and Francis, Elsevier and others).

Literature review: Value chains have become the dominant element of the world economy, attracting the attention of politicians, practitioners and researchers. It is noted that break through innovations affect the development of new paradigms, principles and models in Supply Chain Management (SCM). In accordance with research, Internet of Things (IoT), cyberphysical systems and intelligent related products contribute to the development of digital Supply Chains (SC) and intelligent operations (Fazili *et al*., 2017; Liao *et al*., 2017; Tran-Dang, *et al*., 2017; Minner *et al*., 2017; Ivanov *et al*., 2018).

Multidisciplinary reviews of information technology, informatics and general academic literature are also popular in the scientific literature with the aim of identifying advanced "digital" solutions for combating counterfeit goods in specific markets (Mackey and Nayyar, 2017; Juan *et al*., 2018). However, there is a lack of research on this problem in the context of fish products, caused by the limited capacity of existing databases and the disinterest of fishery companies and even the governments of some countries in such studies for political and commercial reasons. As far as we know, this is the first study that assesses the opportunities of blockchain usage in the fight against the global trade in "falsified" and "illegal" fish products.

RESULTS AND DISCUSSION

To clarify the terminological issue, let us clarify the definitions of the categories used in the research (Table 1). It should be noted that the focus of this study is placed on falsified and illegal fish products.

Fundamentally, the blockchain is a secure distributed digital register (that is shared by several users/locations simultaneously and not stored in one place), consisting of "blocks" of continuous transaction information. Blockchain technology has been the subject of wide attention, investment and industry fuss, given its potential for sharing, synchronizing and better protecting information and transaction data (via. cryptography and "miners" that checks and aggregates transaction data blocks without the need for a central authority) through peer-to-peer, distributed and decentralized database structure (Norton, 2016; Marr, 2016). Our point of view follows the scientists who believe that the blockchain revolution includes 3 stages: blockchain 1.0 (digital currency Bitcoin), 2.0 (smart contracts) and 3.0 (applications of the nonfinancial sector that can cover and completely change all spheres of society-blockchain of everything) (Swan, 2015). Primarily the blockchain technology influenced financial institutions. The main factor of this influence was the the creation of crypto currency as well as the opportunities that its usage discloses. Blockchain technology rapidly changed the

Table 1: Categories and definitions

Term/Definition	Examples
Substandard fish products	
Fish products produced by registered producers on a legal basis but not meeting the quality requirements established by national standards. Low-quality goods are usually the result of poor manufacturing, storage or transportation	In recent years, there has been an objective increase in the scale of the immediate danger to the consumer's life and health, related to the availability of poor quality fish products on the Russian market. Some experts attribute this to counter-sentences introduced by the Russian authorities. They "bared" the market and it began to be filled with products of questionable quality. Only in 2017, out of 73,000 samples of fish and products from aquatic biological resources, investigated by Rospotrebnadzor, 6% of the samples didn't meet the sanitary and epidemiological requirements (Anonymous, 2018a, b)
Falsified (counterfeit) fish products	
Deliberately altered, counterfeit products. Incomplete and unreliable information is given about their hidden properties and quality. This production may include incorrect information about the country of origin of the goods, the quantity and composition of the ingredients. It can be imported accompanied by forged certificates, incorrectly labeled, does not correspond to intellectual rights for registered trademarks	In the Russian fish market falsification concentrates in the most profitable segments: red and black caviar, fish fillets, chilled fish. For example, for the manufacture of flying fish caviar, violators use dyed herring and capelin caviar and in the category "chilled fish" they sell defrostered fish. In the absence of an official statistical source, it is difficult to assess the extent of falsification of fish products in Russia (according to Rospotrebnadzor the level is about 6-8%) (Portal of the All-Russian Association of Fisheries Enterprises, Entrepreneurs and Exporters
Illegal (unreported) fish products	
Produced as a result of IUU (Illegal, Unreported and Unregulated) fishing which includes poaching, illegal extraction of aquatic biological resources, catch in prohibited areas, for deadlines and/or using prohibited fishing gear, catch above established quotas. Such production is manufactured but it is not registered in the system of full traceability supply chain of products ("from boat to throat")	According to the UN FAO data, IUU fishing accounts for up to 26 mln.ton of fish caught annually from $10-23 billion (FAO., 2016). According to the WWF in the last 10 years catch of crab in the Russian waters of the Asia-Pacific Region, due to illegal fishing, was 2-4 times four times higher than the permitted quota (WWF., 2015). The spread of illegal, unreported and unregulated (IUU) fishing has a negative impact on marine ecosystems, excessive industrial pressure on aquatic biological resources and a reduction and deterioration in the quality of their habitats

financial and banking instruments that for many years remained unchanged. Now a days, many representatives of the financial and banking sectors are trying to use the blockchain technology as they provide a great competitive advantage (Fanning and Centers, 2016).

In addition to the financial sector, the blockchain is steadily finding support in the world scientific and business communities. This is confirmed by a huge number of the blockchain-based start-ups in completely different directions. There are various crowdfunding services (Kickstarter, Indiegogo), voting systems, bitcoin-totes (Fairlay, Predictious), file service systems (IPFS), asset sharing services (LaZooz), file storage systems (Storj), social networks (Gems, Twister) and many other noteworthy applications (Anonymous, 2017a, b). Legal documents, medical records, shipping documents and copyright records or their unique identifiers can be generated and processed with the usage of blockchain technology. Marco and Lakhani (2017) note that contracts, transactions and records of these data are not keeping up with the transformation of the world economy, comparing the blockchain with "a rush-hour gridlock trapping a Formula 1 racecar". An open, distributed register can effectively conduct transactions between two parties, by passing traditional intermediaries (lawyers, brokers and bankers).

In the context of "falsified" and "illegal" fish products, the blockchain can be used to: tracing the raw materials and finished products from the fishing companies to the end customer in an unchanged and integrated electronic database created by the virtue of the electronic register. Ensuring transparency in identifying unreported products in the supply chain, due to the ability of all participants to verify the reliability of the data. Integration into the "Internet of Things" and better detection and authentication of unaccounted fish products. Increasing the exchange of information between unrelated databases and various participants in the supply chain.

This can potentially transform the supply chain of fish products in the global market into a more reliable, accountable and transparent data architecture that can cross several entities and jurisdictions.

Intel is already using the Sawtooth lake platform based on open source block technology which was developed for the seafood supplies. Due to this technology buyers can track the entire process of delivering goods. Sensors of the Internet of Things (IoT) help to track the recorded delivery data in the blockchain. These sensors also contain information about the owner of the property, its dislocation in real time and also the environment in which the products are stored (temperature, humidity).

IBM and Wal-Mart are researching how to increase food (SC) Safety Control using blockchain technology. In practice, new cloud-based analytics platforms such as supply on industry 4.0 sensor clouds make it possible to control the SC in real time and plan and adjust processes using up-to-date information. By simply clicking on a container type, the graphs indicate whether there has been a violation of the defined temperature or humidity limits along the time axis (Ivanov *et al*., 2018).

The distributed ledger technologies can help to outcompete falsified and unreported fish products from the local market if, for example, they integrate data-fusion and QR-code systems, combine them with blockchain technology and introduce them into the state electronic system for controlling production flow (in Russia this is the "Mercury" system). At the same time, each product should be assigned a unique code containing information about the production: from the moment of catch to the sale. Thus, the buyer will be able to access this information using the mobile phone application.

Also, the technology block will help automatically identify anomalies in the production and consumption processes. For example, the importer of frozen fillets will know that the raw fish is saturated with water and chemicals to significantly increase its weight and fish cakes on the counter in the supermarket will show that illegal raw materials of IUU fishing is used. Producers of crab sticks will no longer be able to add to the product prohibited in many countries Pangasius, caught in the Mekong which is the most polluted river of the planet. All parties including the monitoring bodies will have the access to these data. Automation will reduce the number of documents and will give more time for adding-value activities.

Problems: The possibility of using blockchain technology to ensure the integrity of the global supply chain of fish products by combating "falsified" and "illegal" goods is associated with numerous problems that can lead to delayed misleading results for the following reasons:

Heterogeneity of participation in global value chains: The OECD and World Bank report indicates that low-income developing countries are under represented in global value chains, although, their integration has expanded significantly over the past two decades: from $259 billion in 1995 (or 6% of the total of $4, 6 trillion) to about $1.5 trillion in 2011 (or 11% of the total of $14 trillion) ((OECD) World Bank Group in 2015).

The same is applied to Small and Medium-sized Enterprises (SMEs) in the fishing industry. Mainly they work in the informal economy. Their participation in the SC is a difficult task, so, the narrow adoption of a new platform by market agents can cause questions about the quality of the data (e.g., no data, the data is inaccurate) in an electronic database based on an electronic book.

High cost of implementation: The blockchain by itself is technically easy to apply. But as any new technology it should support the possibility of integration with exterior applications. For example, in case of integration with the internet of things, the purchase of RFID tags, sensors and IoT devices is necessary. It should be understood that IoT is not just a gadget. To manage devices and connect them to the blockchain applications, a special IT platform is needed. Amazon, Cisco, GE, IBM, Oracle, Salesforce and Microsoft are technology giants with their own IoT platforms. Software developers and cloud service providers will use these platforms to create industry-specific applications (Heiskanen, 2017). In addition, the use of new technologies will require the participants to automate the internal processes of production. Specialists will have to learn new information systems and subtleties of work with the distributed registry which will also lead to material and time costs. Therefore, in spite of the promising economy which the transition to the blockchain can provide, the initial costs of implementing the technology are very large and cannot be ignored.

The risk of vulnerabilities in the software. Theoretically, a blockchain network can suffer from an attack if sufficient computing power is used. In addition, modern software is quite complex and integrated which makes it more problematic to detect its vulnerabilities. Finally, the reliability of system depends on the professionals who develop it which are not immune from errors. When implemented, this risk can create a channel for fraud and lead to the theft of user data or assets.

Uncertainty of legal status in many countries. In 2013, bitcoin transactions in Russia were deemed unreliable and illegal. The state explained this by the fact that bitcoin is not provided with real value and the price for it is formed speculatively (Anonymous, 2017a, b). Recently, the government bodies of the Russian Federation have been paying close attention to the blockchain technology and the possibility of its application for the benefit of society. The advantage of the blockchain registry over existing systems is obvious but the legal aspect of the use of technology is still a matter of debate. The implementation of the blockchain registry will become possible only after all legislative issues are resolved.

Taking into consideration the above mentioned problems and the fact that the blockchain platform is first to be created on local markets and then implemented into an integrated network, covering an increasing number of participants in the global fish trade, we estimated the applicability of technology on the Russian market (Table 2).

To assess the level of IT infrastructure maturity, Microsoft's methodology was used. It identifies 4 levels of maturity from the basic level when the company has a

Table 2: Assessment of the limits of applicability of BCT on the Russian fish products market

Criteria	Values	Assessment	Values	Assessment	Values	Assessment
Is the company registered in the "Mercury" system?	Yes	+	No	-		
Type of company by assets	Large	+	Medium	+	Small	-
Type of company by type of ownership	Private	?	State	?	Joint-stock	?
The level of maturity of the IT system	Dynamic	+	Rationalized	+	Basic/Standard	-
IoT maturity level	High	+	Medium	+/-	Low/None	-

+ Positive influence; - Negative influence; +/- may be assessed both as positive and negative; ? Neutral

large number of non-automated processes and there is no well-thought-out information structure to dynamic level, when the processes are fully automated, there is a high level of security and a single information space for the work of all employees from different branches and investments into information technologies are characterized by efficiency and quick return (Increase the efficiency of the company's IT infrastructure. Retrieved from https://www.intuit.ru/studies/courses/1164/260/lecture/6648).

Table 2 shows the small enterprises as well as companies with a low level of the IT infrastructure maturity that are not registered in the state supply chain traceability systems are beyond the limits of the blockchain technology applicability. For many developing countries, real problems in food safety and illegal, unreported and unregulated fisheries are placed on a different front. Their legislation does not comply with market standards. Only a few countries in Africa conduct food product testing and certification at their borders; their testing laboratories are not always accredited with ISO 17025; they lack the financial capacity to purchase logistical support to control the quality of fish and fish products and to prevent, deter and eliminate IUU fishing; there is no regional reference laboratory, etc (Anonymous, 2017a, b). Obviously, for these countries not digital technologies are currently relevant but traditional forms of opposing counterfeiting (for example, product serialization, the use of authentication for packaging, visual inspection solutions and laboratory diagnostic technologies) (Anonymous, 2015, 2018a, b; Beyens *et al*., 2018).

CONCLUSION

The global trade in fishery products faces the challenges of "falsified" and "illegal" products penetration in the entire global supply chain. Consumers and marine ecosystems are affected by the deterioration of health, finance and security. As criminals become more sophisticated and supply chains more complex and diverse, new technologies for preventing, responding and eliminating falsified and illegal products must undergo a continuous process of development and implementation. Blockchain stands out as a potential revolutionary technology to better ensure the modernization and digitization of the fish supply chain which will be more reliable, accountable, transparent and protected from counterfeit. The main idea is to develop a new architecture in which all market participants will work with a joint set of data. Our research shows that blockchain technologies do not function in isolation, they use reinforcing digital technologies (for example, Mobile Technologies). Therefore, the evolution of design and conceptualization of anti-counterfeit solutions will go hand in hand with elements such as advanced Tracking and Tracing (T&T) technologies, big data analytics, Industry 4.0, additive manufacturing (3D printing), etc.

Currently, many forms of anti-counterfeit blockchain technologies cannot be implemented or scaled due to inherent limitations such as the heterogeneity of participation in global value chains, the high cost of implementation, the risk of software vulnerabilities and uncertain legal status in many countries.

Nevertheless, resisting the penetration of blockchain is senseless and risky. In order to ensure global food security including eco-supplies of wild fisheries, the world community will sooner or later have to accept the new technological solutions discussed in this study. The question is: "Sooner or later?".

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