Blockchain Adoption Factors, Enablers and Barriers in Fisheries Supply Chain: Preliminary Findings from a Systematic Literature Review

Colin Callinan, Amaya Vega, Trevor Clohessy, Graham Heaslip
Galway Mayo Institute of Technology, Galway, Ireland

Correspondence: colin.callinan@research.gmit.ie

Abstract

Technological adoption has become a key goal of digital transformation within firms, affecting many facets of an organisation, such as attaining competitive advantage, increased revenue, reduction of operational costs, and improving operational efficiency. Blockchain as a decentralised peer-to-peer technology appears uniquely suited to being deployed within complex food supply chains such as the fisheries industry, which is the focus of this study. In this context, blockchain technology can be used for a variety of purposes, such as providence authentication, handling and storage, transparency, counterfeit prevention, food forensics, and enhanced supply chain resilience. The purpose of this study is to synthesise existing research on the interrelationship between blockchain technology and the factors that determine adoption, as well as identifying the enablers and barriers. This preliminary work identified key themes emerging from the blockchain literature, suggesting that adoption factors are wide ranging, encompassing aspects including organisational readiness, security, complexity, partnerships, competition, governmental influence, and transparency. The thematic analysis of enablers and barriers to blockchain adoption identified the broad theme of resources as the key enabler and integration as the key barrier. These preliminary findings add to the growing body of research, including increased understanding of the current state of academic research in the areas of blockchain adoption factors, blockchain adoption in supply chains, blockchain adoption in the fisheries industry, and the enablers and barriers to adoption. This study is the initial step in a large-scale study with the next phase comprising case studies of specific fishery supply chain stakeholders.

Keywords: *Blockchain – Distributed Ledger Technology – Supply Chain – Fisheries.*

JEL Classifications: *L14, L21, L22, L23, L24, L66, L91, O33, Q22.*

1. Introduction

Blockchain has been gaining a lot of attention in recent years by both academics and practitioners spanning multiple industries [1]. Gartner predicts that blockchain will generate $3.1 trillion in new business value by 2030 with wider-scale adoption coming on stream in 2023 [2]. Further data claim that blockchain spending will reach $17.4 billion in 2024 [3]. This signifies increased interest in the realm of distributed ledger technology. Blockchain as a decentralised peer-to-peer platform appears uniquely suited to adoption within complex food supply chains. In contrast to other industries, food production operates in more vulnerable value chains that require increased attention to handling and storage. In addition, transport and temperature can affect food quality and freshness [4]. In the fisheries industry, blockchain technology can be used to record the readings of specialised IoT devices like intelligent sensors. Blockchain can store values from the point of capture all the way to the shipment delivered to the end customer. In this scenario, readings from sensors represent data about the status of the condition of the product (temperature) being transported. The blockchain can be used for the purpose of transportation, handling and storage, tamper-proof checks, and product history among others [5].

In the remainder of this article, we review the extant literature on blockchain adoption, supply chains, and fisheries. Although recent academic literature has begun to address blockchain adoption along supply chains in greater numbers, there still exists a paucity of research examining blockchain adoption in fisheries supply chain. To address this, we conducted a systematic literature review of recent literature examining blockchain adoption in supply chains. Various theories have been forwarded in the past to elucidate the factors that drive information technology adoption [6]. We chose to utilise the technology, organisation, and environment (TOE) model first developed in 1990 by [7]. It pinpoints three distinct areas of an organisation's context that affect the process of adoption and implementation of a technological innovation: the technological context, the organisational context, and the environmental context [8]. This framework is extremely well suited to an industry that is characterised by its complexity at the organisational level. Ireland's fisheries industry is distinguished by its diversity of vessel types and fishing techniques. Further complexity is added through market segmentation, firm-level organisational structures, types of aquaculture production, and geographic locations [9]. This process enabled the identification of a number of adoption factors, enablers, and barriers to blockchain adoption. We believe the identification of these factors adds to the existing body of knowledge in the blockchain adoption sphere. These factors can be further used to identify enablers and barriers, specifically within the fisheries industry.

2. Literature Review

A systematic literature review was chosen as the most appropriate approach for this review. Emanating primarily from the sphere of medical research, this method is considered as 'a way to synthesize research findings in a systematic, transparent, and reproducible way and have been referred to as the gold standard among reviews' [10, p. 334]. The goal of this systematic review was to gather and analyse a large selection of sources in order to examine a comprehensive range of blockchain literature spanning supply chains, fisheries, and adoption. There exists a number of explanatory articles that offer a range of guidelines and approaches regarding the authoring of a systematic literature review [10]–[17]. As the focus of the review was primarily the determination of the factors that enable the adoption of blockchain in the fisheries industry through the lens of the TOE model, the following keywords and strings were selected: blockchain *and* adoption AND fisheries, blockchain AND adoption AND TOE, blockchain AND supply chain AND adoption. The next stage involved the literature search. Given the multidisciplinary nature of the topics under examination, the keywords were entered into renowned academic databases such as Web of Science, Scopus, PubMed, Business Source Complete, Jstor, and ProQuest. The databases were searched for citations while limiting the search of the keywords to titles and abstracts only. Where there was any ambiguity pertaining to the article's title, the abstract was examined to determine the relevance of the study. The resulting articles that were considered appropriate for inclusion were imported into the Mendeley reference management software package. The next stage concerned analysing the titles and abstracts against pre-determined inclusion and exclusion criteria. The inclusion criteria were determined as empirical, theoretical, and grey literature in a desire to be thorough. In an effort to be inclusive and garner an expansive result, concluding sections of articles were reviewed when the abstract lacked the information required [15, pp. 105–6]. Exclusion criteria were determined as duplicate citations, studies unrelated to the research question, i.e. occurrences of articles where the keywords appeared in the title but were not the focus of the article. Snowballing was then performed to elicit further references. This resulted in the retrieval of 272 articles. Of these 272 articles, 40 focused specifically on fisheries supply chains.

3. Blockchain and Supply Chains

A supply chain can be defined as a complex adaptive system network that traverses multiple stages, relationships, geographical locations, various financial systems, and multiple entities encapsulated by differing time-based pressures depending on the type of product and market [18], [19]. Supply chains are typified by the inclusion of multiple partners. These may include but are not limited to manufacturing factories, distribution centres, suppliers, couriers, and ancillary logistic services [20]. As such, supply chains are increasingly becoming more complex. A number of factors have contributed to this: the search for sustainability, increasing globalisation, trade liberalisation, reduction in trade costs, and the application of new technologies. In addition, the management of supply chain networks is a crucial factor in preserving organisational competitiveness [18], [21]. Blockchain's role within supply chain has gained increasing attention from researchers and practitioners in recent times. A number of purported benefits have been listed, including smart contracts, product traceability, enforcement tracking, stock control, transaction and settlement, and information immutability [6]. Extant literature has identified a number of areas and applications within supply chain and supply chain management. Table 1 collates prior research and identifies the area of supply chain that will be affected by blockchain and its application to this area.

Table 1. Supply Chain Area and Blockchain Application

Supply Chain Area and Blockchain Application		
Operations	Recording, tracking, and sharing information with greater speed and precision	[20], [22]
	Reduced paperwork and cost reduction	[20], [23], [24]
	Information management – immutability, error reduction, and increased trust	[18], [25]–[29]
Supply Chain Management	Governance structure	[1]
	Visibility, optimisation, and demand forecasting	[26], [30]
	Disintermediation – cost savings and efficiency	[25], [28], [31]
	Collaboration	[24], [32]
	Automation – smart contracts	[22], [24]
Auditing	Transparency	[23], [29]
	Traceability	[22]–[24], [30]
Activity Control	Increased trust and efficiency	[18]
Fraud Detection	Cost savings	[33]
	Asset ownership	[29]
	Information asymmetry	[26], [34]
Competitiveness	(Lack of) Transparency	[18]
Logistics	Customer value	[31]

4. Blockchain Fisheries Adoption

The pace of technological innovation and change has necessitated the speedy adoption of information communication technologies as a crucial goal for firms. The fisheries industry can be characterised by its complexity,

primarily because of the number of products, processes, individuals, and organisations that constitutes its make-up [35]. For example, Ireland's fishing fleet is segmented around five key areas: refrigerated seawater pelagic segment, e.g. herring and mackerel, beam trawler segment, e.g. sole and plaice, polyvalent segment, e.g. whitefish and molluscs, specific segment, e.g. bivalve molluscs and aquaculture species, and aquaculture segment, e.g. collection of spat from wild mussel stocks for aquaculture installations [9, p. 408]. Irish aquaculture production is dominated by salmon farms. Additionally, fish processing comprises 160 companies, with 85 of these enjoying a revenue of more than €1 million [36]. The industry is primarily made-up of whitefish, pelagic, and shellfish operators, with whitefish, shellfish, and smoked salmon processors dominating [37, p. 119]. This complexity has been driven by the globalisation, distribution, and consumption patterns of food production [35], [38]. To address supply chain complexity, a number of solutions have been proposed, e.g. vigilant information systems and blockchain [5], [39]. Various theories have been forwarded in the past to elucidate the factors that drive information technology adoption. Many of these examine the motivation behind user behaviour like the technology acceptance model (TAM), the task-technology fit (TTF) theory, the diffusion of innovation (DOI) theory, the theory of reasoned action (TRA), the theory of planned behaviour (TPB), the unified theory of acceptance and use of technology (UTUAT), and social cognitive theory (SCT) [6]. Other theories espoused include the perceived e-readiness model and assimilation theory [40]. The TOE model was first developed in 1990 by [7]. It pinpoints three distinct areas of an organisation's context that affects the process of adoption and implementation of a technological innovation: the technological context, organisational context, and environmental context [8]. The technological context refers to both the internal and the external technologies pertinent to the firm. From a more granular perspective, the technological context incorporates factors such as complexity, relative advantage, privacy, security, and compatibility. These factors have been shown previously to effect existing or potential information technology adoptions [8], [40], [41]. An abstract view of the organisational context describes the firm by examining its scope, size, and managerial structure. More specific considerations include top management support, prior IT experience, innovativeness, information intensity, and organisational readiness [8], [40], [42]. The environmental context refers to the wider area in which a company operates its business, i.e. the industry, its competitors, and relationships with the government, including regulations [8], [40]. This research will incorporate an adapted framework proposed by [40], which incorporates the individual and task-related contexts in addition to the technology, organisational and environmental. The individual context considers social influence and hedonistic drives incorporating expectations, how privacy is perceived, as well as trust and non-utilitarian motives. The task-related context refers to the task and technology characteristics that have to be matched to allow a task-technology fit leading to positive performance and IT utilisation [40]. The TOE framework has been used

extensively both across a wide variety of industries and in a number of different contexts [43]–[49]. Table 2 presents an overview of the articles reviewed that address blockchain adoption. It does so by delineating the TOE factors that drove adoption. Table 3 presents an overview of the articles reviewed that consider the individual and task-related factors that drive adoption. Table 4 lists the enablers and barriers identified.

Table 2. Summary of Blockchain Adoption Factors

Technological Factors		Organisational Factors		Environmental Factors	
Security	14	Organisational Readiness	13	Policy and Regulations	14
Complexity	9	Top Management Support	12	Competitive Pressure	10
Privacy	7	Technological Readiness	7	Collaboration Efforts	4
Integration	4	Innovativeness	4	Government Support	4
Technology Costs	4	Business Model Readiness	2	Transparency	4
Relative Advantage	4	Facilitating Conditions	1	Market Dynamics	3
Compatibility	3	Information Intensity	1		
Technological Immaturity	2				
Scalability	2				
Interoperability	2				
Perceived Benefits	2				
Disintermediation	2				
Traceability	2				

Table 3. Summary of Individual and Task Adoption Factors

Individual Factors		Task-Related Factors	
Trust	8	Task-Technology Fit	5
Expectations	3	Performance	2
Privacy	1	Complexity	1
Social Influence	1	Standards	1
		Usability	1
		Legal	1

Table 4. Enablers and Barriers to Blockchain Adoption

Enablers		Barriers	
Collaboration	6	Policy and Regulations	11
Management Support	5	Cost	10
Government Regulations	5	Lack of expertise	7
Organisational Infrastructure	4	Interoperability	7
Training and Education	4	Stakeholders	6
Perceived Benefits	4	Organisational Culture	6
Technological Infrastructure	3	Scalability	6

Support	3	Legal Concerns	6
Integration	3	Complexity	5
Partnerships	3	Market Barriers	4
Complexity Reduction	3	Awareness	4
Financial Resources	2	Privacy Issues	3
Job Opportunities	1	Security	3
		Uncertainty	2
		Infrastructure	2
		Hype	2

5. Thematic Analysis

Thematic analysis has become a widely used method for analysing qualitative data. This type of analysis can be performed within numerous ontological frameworks, which is in turn linked to the epistemological approaches to data [50]. There are two key approaches to thematic analysis in qualitative research. The first is the deductive approach, which utilises existing theories to build themes, then uses them as a guide in the coding process. This approach is rooted in the scientific method as the process moves from theory to hypothesis to hypothesis testing. The second approach is the inductive approach, which attempts to build themes through the examination of available information. The process followed begins with coding the contents of the data examined and then developing and completing themes during and after the coding process [50], [51]. This study employed a mixed approach to examine the literature. Firstly, the deductive approach was employed by using the TOE framework to build initial themes related to blockchain adoption that were then used to guide the coding process. Following that stage, the process moved onto utilising the Leximancer tool https://www.leximancer.com/. Leximancer is a text analytics tool frequently used by researchers to analyse the contents of textual documents to display the extracted data visually.

5.1. Blockchain Adoption Factors

Top management support emerged as the key outcome of the thematic analysis of the blockchain adoption factors. The theme of support can be broadly broken down into two broad concepts of top management support and organisational readiness. In this scenario, top management is a broad concept encompassing CEO level to senior management. This is context specific to the organisation. The second theme identified by thematic analysis is that of security. This theme can be broken into the key concepts of complexity, privacy, and transparency. The next theme to emerge is that of partners. In this context, the concepts related to partners include vision, cultural differences, financial factors, and policies. Complexity is the next key theme to emerge. This includes concepts such as technological novelty, security, technological immaturity, complexity perception, disintermediation, and compatibility. Government is the next theme to emerge. This incorporates government support, policy, and regulations. The theme of competitors refers primarily to the environmental adoption factor and the

pressure exerted on organisations to adopt blockchain. Finally, the theme of transparency refers to concepts such as the enhancement of transparency through blockchain adoption, traceability, immutability, sustainable practices, and data disclosure for clients

5.1.1 Enablers

The outcome of the analysis of the data collated regarding the enablers to blockchain adoption identified six key themes.

Resources − The most heavily weighted theme to arise is resources. This is a broad theme that threw up a number of concepts encompassing availability of resources, technological and organisational infrastructure, network and human support, training and education, research funding, financial resources, and commitment to technological infrastructure and innovativeness.

Government − This theme was narrower and more focused on concepts around collaboration between government and industry, development of government guidelines, policy and frameworks, and regulations. The remaining themes emerged with lower weighting but still threw up some interesting data.

Support − The support theme contains the concepts of degree of managerial support, vendor support, and human support.

Visibility − The visibility theme refers to the concepts of transparency, tracking, improved communication, cargo visibility, and documentation transparency.

Business − The business theme refers to concepts such as choice of business partner as an adoption enabler, simplification of business processes, transaction cost reduction, knowledge sharing, and new business models.

Management − Finally, the management theme encompasses the concepts of management involvement in platform selection and the hiring of consultants.

5.1.2 Barriers

The thematic analysis of the barriers to blockchain adoption produced some very interesting results. In contrast to the enablers, where six key themes emerged, double the number of themes were produced for barriers.

Integration − Integration was the central theme to emerge in barriers to adoption. It is inextricably linked to a number of other barriers and encompasses concepts like acceptance by partners, uncertainty about benefits, costs and return on investment, scalability, existing infrastructure, standards, and lack of knowledge.

Regulatory − The regulatory theme encompassed the concepts of regulatory clarity and uncertainty pertaining to regulatory developments.

Costs − The costs' theme refers to general costs, high sustainability costs, and implementation costs.

Stakeholder − The stakeholder theme contains concepts such as industry resistance, increased coordination demand, collaboration hesitation, external stakeholder involvement, and collaboration differences with partners.

Legal − The legal theme was conceptualised by issues like future legal implications and long-term uncertainty around legal developments.

Complexity − The complexity theme considers concepts like technological complexity, decreased operational efficiency, increased coordination demand, and required openness.

Scalability − The scalability theme incorporates concepts such as wasted resources, and intra-organisational implementation costs.

Uncertainty − Uncertainty as a theme contained broad concepts relating to legal, technological, and regulatory developments, as well as collaboration uncertainty.

Interoperability − The interoperability theme refers to the concepts of interoperability across jurisdictions and a reluctance to change current systems.

Technology − The technology theme incorporates concepts such as unfamiliarity and unclear benefits, lack of knowledge, and technology risks.

Infrastructure − The infrastructure theme contains the concepts of existing technological infrastructure and needed infrastructure.

Expertise − The expertise theme refers to concepts such as existing knowledge and expertise.
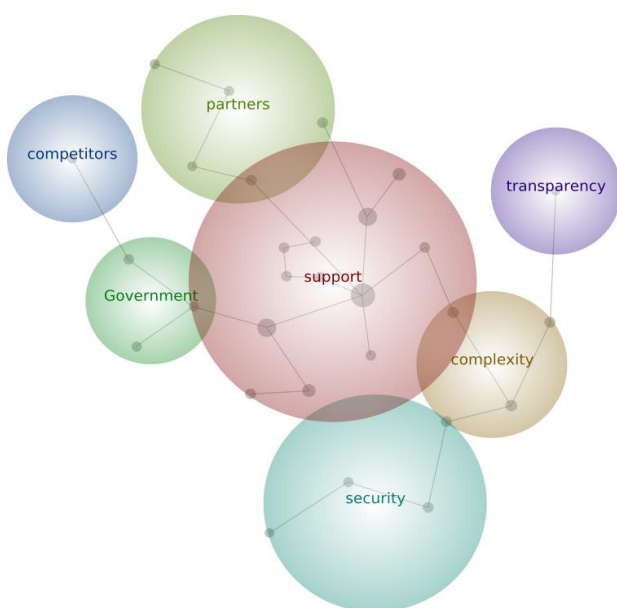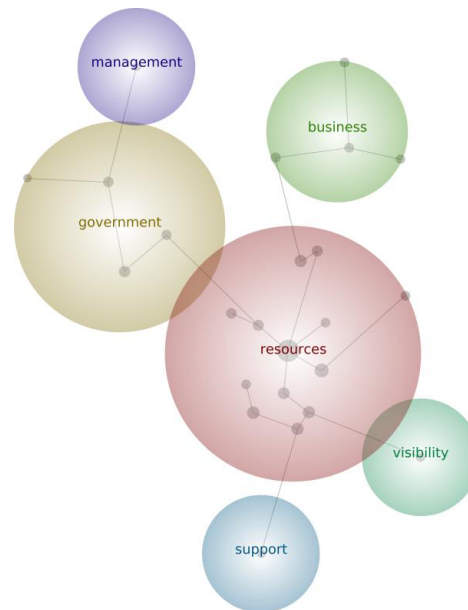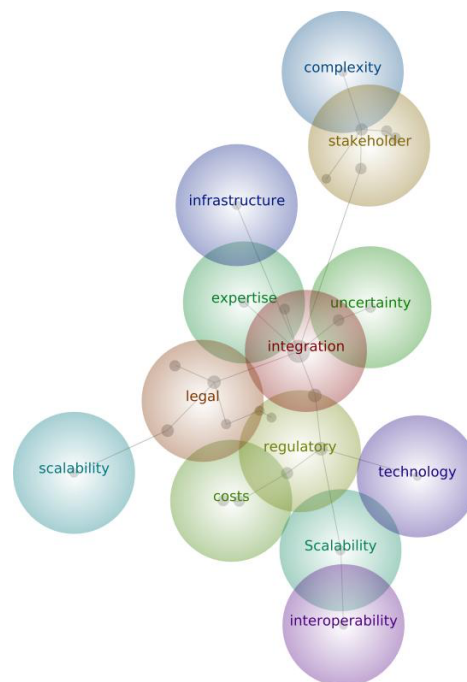

Figure 2: Enablers

Figure 3: Barriers

6. Conclusion

Interest in blockchain utility in supply chain is garnering increasing interest. However, blockchain adoption in fisheries supply chain is a somewhat neglected sphere of research. To address this gap, this research presents the preliminary findings from ongoing research into blockchain adoption along fisheries supply chain. Through the performance of a structured literature review, we have identified key supply chain areas that are primed for the application of blockchain. A number of adoption factors have been identified and

Figure 1: Blockchain Adoption Factors

thematically analysed. Furthermore, enablers and barriers to blockchain adoption have been pinpointed and thematically analysed. The next step for this research is to empirically examine the enablers, barriers, and adoption factors through a series of interviews and focus groups. It is hoped that this will elicit further insight into these issues.

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