IMPLEMENTING BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT

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ABSTRACT

This paper is aimed at studying the factors influencing the implementation of blockchain in supply chain management to solve the current issues faced in the supply chain ecosystem. Supply chains are part and parcel of every business and have multiple inefficiencies in the system. Some of these inefficiencies can be managed by usage of blockchain Platform .Technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation are critically evaluated for adoption of blockchain in supply chain. A pilot study is conducted in form survey for analysis of these factors. Hypotheses are derived for these factors for quantitative research. Subsequently these hypotheses are examined with the help of ADANCO2.3 for structural equation modelling. As an outcome, it is evident that Innovation and Extrinsic factors are significantly impacting the adoption of blockchain in supply chain management.

KEYWORDS

Blockchain technology, Supply chain management, Technology, smart contract, Intracompany synergies, Intercompany collaboration; Extrinsic Factors, Innovation.

1. INTRODUCTION

In today’s world, Supply Chain management has grown into an intricate network of suppliers and partners. It faces a myriad of challenges such as fraudulent transactions, non-traceability of genuine products, counterfeit products, unethical practices of using child labour and many others, resulting in a lack of transparency and trust issues amongst stakeholders. In this paper, blockchain technology is analysed to manage the current issues of Supply chain management. This paper is concluded by laying out research framework for studying the adoption of blockchain technology in Supply chain environment. Based on the literature survey, research problem and question are derived. Based on the research question, the research objective is framed to provide the direction for the studies.

1.1. Research Problem and Question

Below research question is framed based on the research problem at hand:

a) What variables influence the usage of blockchain technology in supply chain management?

The logical reduction of the research question is the research objective, which is to examine this field in more depth.

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1.2. Research Objectives

Research objective is logically deduced from the research question to study the aspects of blockchain adoption in supply chain.

a) To examine the reasons which affect blockchain technology adoption in supply chain ecosystem

Due to time constraints, factors impacting the adoption of blockchain technology in supply chain management are studied in pilot studies. For Pilot studies, assessment of the outcomes are carried out in a time-bound way following the required research practices involving multiple steps from problem identification to the providing recommendation based on data analysis.

2. LITERATURE REVIEW

As part of literature review last 5 years (2018-2022) research papers, journals, industry reports are studied with regards to adoption of blockchain in supply chain management to arrive at the variables of conceptual framework.

2.1. Blockchain Technology

In 2008, Santoshi Nakamoto (pseudonym) wrote a white paper describing Bitcoin and blockchain technology. Blockchain technology can be applied in multiple industries such as supply chain, manufacturing, and finance (for example, Bitcoin is a use case of blockchain technology in finance). Blockchain is a distributed database system that is secured cryptographically and uses a consensus mechanism to store transactions in blocks. Each block in the chain is attached to an earlier block via the hash function, resulting in blockchain's key features of transparency, traceability, immutability, timestamping, and decentralisation [1][2]. The traceability and transparency features of blockchain can contribute to addressing many of the issues of the traditional supply chain [3].

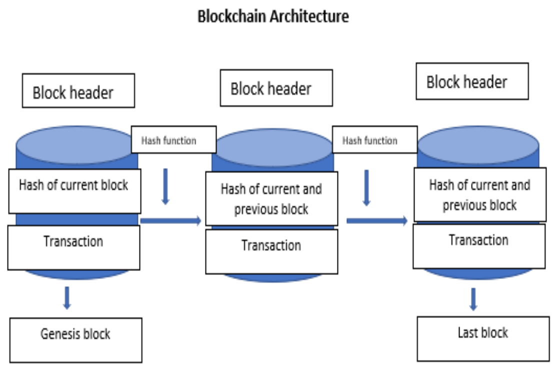

Figure 1. Framework of blockchain architecture (Giri & Manohar, 2021, p. 3)

2.2. Role of blockchain technology in the supply chain

Traditional SCM starts from the raw material supplier to the manufacturer, distributors, wholesalers, retailers and, finally, to the end user, in a linear manner. In contrast, the blockchain-enabled supply chain employs three additional entities which are not part of the traditional supply chain. These entities include registrars, certifiers, and standards organisations, each of which ensures the blockchain-based platform is building the elements of trust and transparency through the use of smart contracts [4] . In the blockchain-based supply chain model, change of ownership can be executed through a smart contract without any manual intervention. Blockchain-based records can be updated by certifiers and registrars once the change of ownership is completed. In this manner, all the records can be tracked from the time of origination to the end of the delivery chain without the chance of anything getting tampered [5][4].

Figure 2. Supply chain transformation through blockchain technology

2.3. Blockchain technology adoption in supply chain

This section is organised into five themes: technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation, which are used for investigating the barriers and challenges to the adoption of blockchain technology [6] [7] [8] [4].

2.3.1. Technology

Technology is constantly evolving in this era and, in decades past, enterprise resource planning, SCM and customer relationship management (CRM) packages were in great demand to address supply chain business problems. Radio-frequency identification (RFID) is considered a cutting-edge technology to address some of the tracking and tracing issues of the supply chain [4]. Technology constructs are focused mainly on security and privacy, technology scalability, technology resilience, design architecture and technology maturity as primary areas in studying the applicability of blockchain in SCM. Information generation, handling and usage need to be secured and protected [4, 7, 9-11]. Security and privacy of data offer a competitive advantage to businesses in the supply chain [12]. Blockchain has features of encryption and hashing mechanisms to protect the data from tampering [2].

2.3.2. Intracompany Synergies

Intracompany synergy elements are internal to the organisation. An organisation's culture, leadership, knowledge and capability, cost of ownership and enterprise strategies are considered internal to the organisation. Top management support is considered as a positive influencing factor demonstrating the plan of small and medium businesses to implement blockchain [10] whereas a lack of support and commitment from management is one of the barriers to the adoption of this technology[4]. Organisations planning to implement blockchain technology need to invest in building required knowledge and capabilities in this area. Being as blockchain is a niche technology, organisations are apprehensive about its overall return on investment. Whilst organisations continue to use legacy technology due to the lack of tools and their hesitation to convert to newer systems, this, consequently, acts as barrier for blockchain technology adoption.

2.3.3. Intercompany Collaboration

Intercompany collaboration refers to coordinating with multiple supply chain partners outside the organisation. Under intercompany collaboration, the elemental attributes of sustainability, traceability, transparency, collaboration, and interoperability are important. The lack of customer awareness and the challenge of incorporating sustainable practices of blockchain technology between different supply chain partners create barriers to the adoption of the technology. Information security and data sharing policies of different organisations are not coherent, adding to further complexity for blockchain adoption [4]. To establish a common culture of transparency and trust amongst different supply chain partners that are geographically dispersed across the world takes much time and effort. It is one of the key challenges to be addressed. The absence of common technical standards amongst intercompany collaboration of stakeholders results in a lack of collaboration and coordination amongst industry players[13] .Collaboration is one of the six themes presented as well [14] and it is a critical success factor for implementation of blockchain in production and operation management. This can be addressed through the roles of registrars and certifiers in the blockchain. The goal of blockchain application is to attain leaner processes resulting in reduced paperwork, improved information sharing and automated processes overall between various stakeholders in different supply chain businesses, such as maritime industries [8].

2.3.4. Extrinsic Factors

The category of extrinsic factors is comprised of extrinsic stakeholders, governments, industries, and institutions that have an impact on blockchain implementation in the supply chain [4]. Governmental policies, decision rights, extrinsic stakeholder involvement, governance of traceability efforts, social challenges, customer influence, market demand, the environment, supply chain practices, global standards, legislations, and regulations are the subconstructs of extrinsic factors[5-11,13-16]. Blockchain adoption is impacted due to non-availability of uniform international standards and a lack of clarity amongst different nation states on the policies and standards of blockchain. Governments across the world are divided in their intention to allow blockchain technology in multiple sectors. This needs to be addressed soon to reach some consensus about this technology.

2.3.5. Innovation

Blockchain technology is currently undergoing tremendous innovation. Innovation in blockchain solutions, along with smart contracts, internet of things (IoT) adoption, big data implementation, artificial intelligence (AI) and machine learning can result in tremendous potential for digital disruption. In blockchain-enabled supply chain practices, a smart contract ensures the automatic change of ownership of a product once the product moves across various supply chain actors such as manufacturer to distributor and helps in easier tracking and trust-building amongst stakeholders [3] [4].

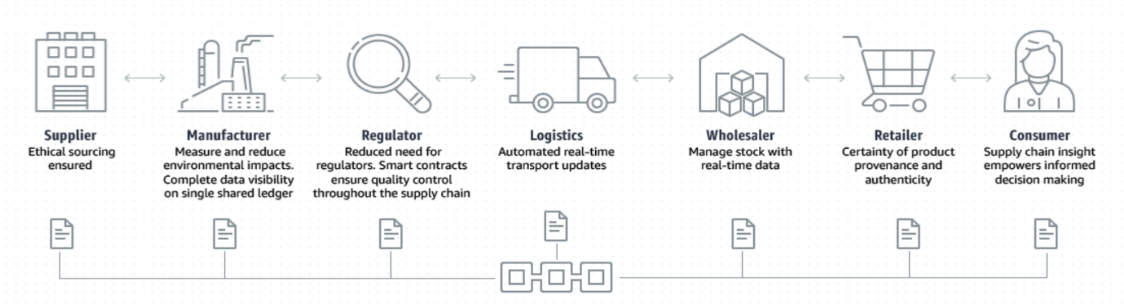

Figure 3. Blockchain for Supply Chain (AWS Amazon,2022)

The development of blockchain comprised of smart contracts and IoT technologies is the real innovation needed for Supply chain management.

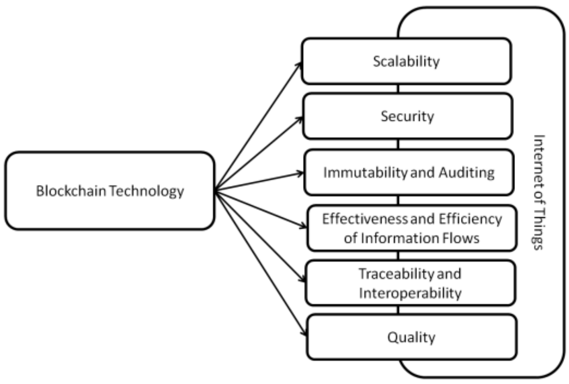

Figure 4. Blockchain and IoT (Rejeb et al., 2019, p. 8)

Characteristics of blockchain technology along with IoT enables scalability, security, immutability, and auditability of the system. Effectiveness and efficiency of information systems, traceability, interoperability, and overall quality of information is maintained by the application of blockchain technology. Algorithms such as proof-of-stake and proof-of-work add to the data security in the blockchain[19] .Organisations in the supply chain are experimenting with various blockchain design choices, such as public and private blockchains, permissioned and permissionless blockchain technologies, distributed ledger technology (DLT), and other blockchain-based platforms and solutions, and are selecting the design choices based on their requirements to ensure acceptance of blockchain along the supply chain [2,6,10,19-21].

3. RESEARCH FRAMEWORK

It is evident that acceptance and applicability of blockchain in the supply chain sector are currently in a nascent phase and need to be researched further to address supply chain issues. Logistics and supply chain businesses are facing multiple challenges in adoption and implementation of blockchain technology. Below is the proposed framework for blockchain adoption and implementation in Supply chain management

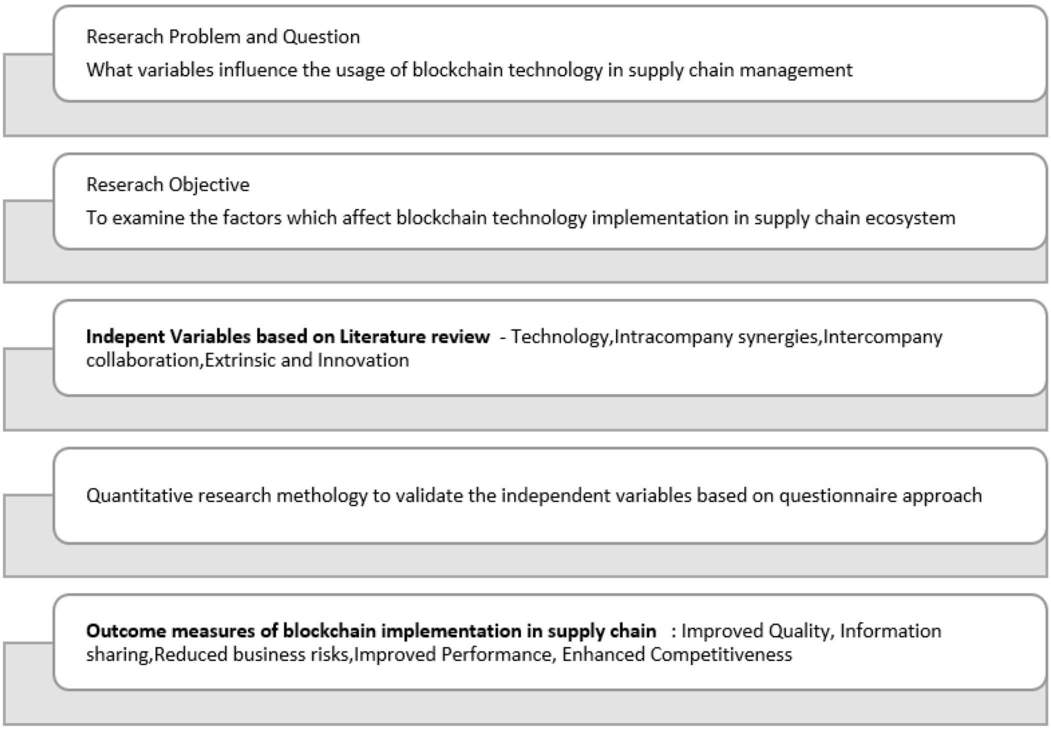

Figure 5. Research Framework for Blockchain Implementation in Supply chain management

Based on the five independent variables of research framework below hypotheses have been formulated for quantitative research

H1: Technology is significantly impacting the adoption of blockchain in supply chain management

H2: Intracompany synergies is significantly impacting the adoption of blockchain in supply chain management

H3: Intercompany Collaboration is significantly impacting the adoption of blockchain in supply chain management

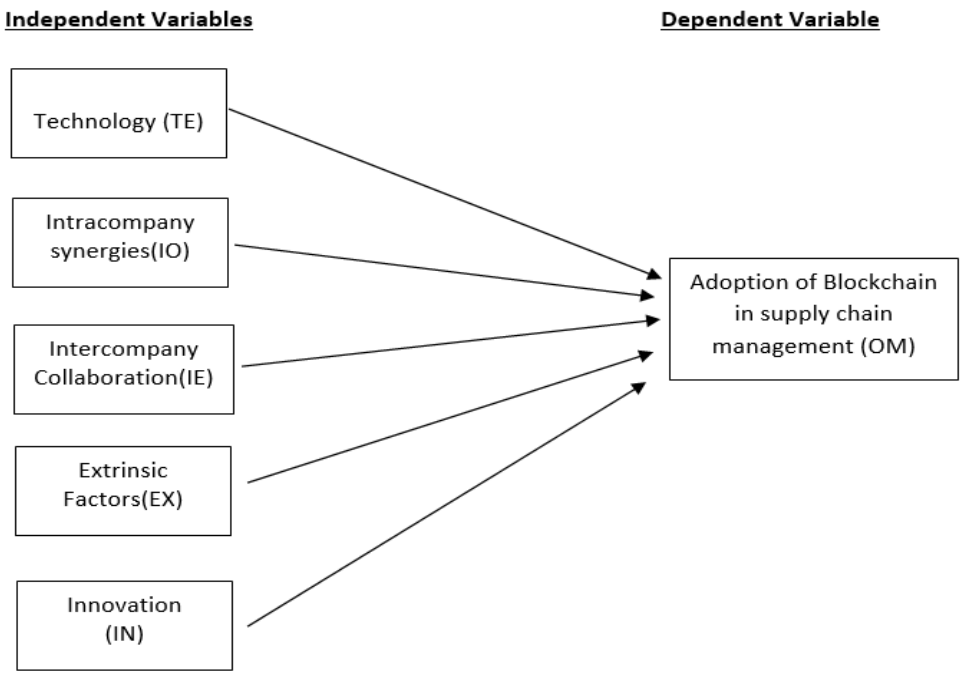

Figure 6. Conceptual model for blockchain adoption in supply chain management

H4: Extrinsic Factors is significantly impacting the adoption of blockchain in supply chain management

H5: Innovation is significantly impacting the adoption of blockchain in supply chain management

The factors influencing adoption of blockchain in the supply chain are categorised under the constructs of technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation. The supply chain and operations can be transformed by usage of blockchain technology [1] because it enhances the safety and security of a product. The outcome measure for blockchain technology results in improvement of overall quality of the supply chain ecosystem by using smart contracts [22]. Blockchain system usage ensures better information sharing by bringing intracompany synergies [23]. Blockchain technology also results in improving interorganisational information sharing amongst supply chain stakeholders [24]. A blockchain-based system helps in reducing business risk and illegal counterfeiting through a risk management structure between supply chain partners [25]. The adoption of blockchain technology in the supply chain ecosystem improves the overall performance of the SCM, owing to intermediaries being removed, and results in addressing sustainable SCM practices. Innovation in the application of blockchain technology for SCM enhances competitiveness by improving operational performance. Innovations such as application of blockchain with IoT results in enhancing the integrity of the supply chain businesses [18].

The challenges in adoption of blockchain in SCM are attributed to organisations lacking interoperability and technological standards for its implementation [5]. For widespread adoption of blockchain in the supply chain, there is heavy dependence on intercompany collaboration amongst various stakeholders across the ecosystem, which is a challenge faced by supply chain partners. Scalability of blockchain technology to meet the growing demands is a barrier to be addressed in the adoption of blockchain technology [20]. Issues of higher costs, technological complexity, and the lack of skills and capabilities are inhibitors for the adoption of blockchain technology [10] .Leadership support and organisational culture as part of intracompany synergies are required and act an enabler for the adoption of blockchain in SCM.

4. RESEARCH METHODOLOGY AND APPROACH

There are mainly 3 types of research methods: Mono, mixed and multi. For this studies, mono method was used due to time limitation. Mono method uses a single method for data collection and analysis. For example: either Quantitative method or Qualitative method for data collection and analysis. For current studies, mono method is used in form of quantitative method. Online survey questionnaire is used due to limitation of overall time.

Deductive approach is used as part of the current study to arrive at the hypothesis based on literature review. These hypotheses are tested through data collection and quantitative analysis to validate them

5. SOURCES OF DATA

While carrying out the Pilot study, multiple sources of data were considered. The Literature review was based on secondary data, and it was followed by using primary data for preparing the questionnaire.

5.1. Secondary Data

As part of literature survey, secondary research was carried out with the help of various databases search such as google scholar, ProQuest, EBSCO and other online databases, journals, and articles. Secondary data has helped in ensuring the limitations and scope for future research is taken by for further studies by researcher. After thorough analysis of these articles, gap variables were identified from scope of future research. There were more than 185 gap variables discovered as part of secondary research. The frequency distribution for these gap variables were ensured, so that these gap variables can be bucketed into 5 major variables - Technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation - for taking it ahead as independent variables.

5.2. Primary Data

Based on conceptual framework and hypotheses derived from secondary data, questionnaire is used as an instrument for primary data collection. In this pilot studies – google form survey was used for reaching out to the respondent. Initially questionnaire in form of word document was created to get the endorsement from ethical committee. After the required ethical standards are met, google form was created for capturing the response from the users and assurance was provided to the respondents to the safety and security of their data.

6. DATA ANALYSIS

The google form questionnaire was rolled out for 4 weeks' time to get maximum responses as part of this assignment. There were 85 responses received as part of this pilot exercise. The data received was cleaned up and coded so that it can be analysed with the help of ADANCO2.3 for structural equation modelling. The hypothesis was formulated and analysed as part of this exercise. The results of the Adanco2.3 was analysed, and the output is received in form of different tables. Various tables of construct reliability, convergent validity, loading-based validity, discriminant validity, inter-construct correlations, indicator multicollinearity, direct effects, indirect effects, total effects, t-values for various constructs and so on were analysed and compared to the threshold values generated. A figure is generated having relationship with dependent variables – Outcomes and measure with satisfactory R^2 values for the same.

Construct reliability is meant for measuring consistency of any construct within research. Construct reliability can be measured through values of ρA , ρc and Cronbach's values. As part of analysis, ADANCO 2.3 provide the values for the model for these parameters. Values of Cronbach alpha (α) is fine for Intercompany collaboration, Extrinsic factors, and Innovation. For Technology and Intracompany synergies, value is relatively on lower side

Table 1. Construct Reliability

Construct	**Dijkstra-Henseler's rho (ρ_A)**	**Joreskog's rho (ρ_C)**	**Cronbach's alpha(α)**
Technology (TE)	.5283	.7237	.4554
Intracompany Synergies (IO)	.6249	.7782	.5847
Intercompany Collaboration (IE)	.8162	.8691	.8117
Extrinsic factors(EX)	.7739	.8009	.6983
Innovation (IV)	.8344	.8800	.8275

TE: Technology; IO :Intracompany synergies; IE: Intercompany collaboration; EX: Extrinsic factors; IV: Innovation

Convergent validity is the extent to which a measure correlates positively with alternative measures of the same construct. Convergent validity refers to the degree to which two theoretically related construct measurements are really related [45]. The average variance generated from the model is used to assess its convergent validity (AVE). Average variance extracted is used to compare the degree of variance explained by an unobserved construct to the variance attributed to random measurement error (AVE). A construct with an AVE value larger than 0.5 explains a considerable portion of the variance in the model. For all the constructs AVE value is more than .5 except technology and extrinsic factors.

Table 2. Convergent validity

Construct	Average Variance extracted(AVE)
Technology (TE)	.4781
Intracompany Synergies (IO)	.5435
Intercompany Collaboration (IE)	.5710
Extrinsic factors (EX)	.4701
Innovation (IV)	.5968

The discriminant validity of the construct is confirmed when it has the largest absolute value in each column and row which is at the major diagonal. Since the diagonal values of Average variance extracted are bigger than the non-diagonal squared correlation values of their respective rows and columns, the model has discriminant validity. Each Construct is distinct and significantly different from each other

Table 3. Discriminant validity : Fornell-larcker Criterion

Construct	TE	IO	IE	EX	IV
Technology (TE)	**.4781**	.1657	.4482	.3466	.3169
Intracompany Synergies (IO)		**.5435**	.2400	.2838	.3003
Intercompany Collaboration (IE)			**.5710**	.3795	.4421
Extrinsic factors (EX)				**.4701**	.2463
Innovation (IV)					**.5968**

In the structural model, R^2 provides the explanatory power of the model. For dependent variable – Blockchain adoption in supply chain (OM) has R(Square) value of .646 which is good value for Pilot study as there are limited number of respondents.

Table 4. Structural Model

R-Squared		
Construct	Coefficient of determination(R^2)	Adjusted(R^2)
Blockchain Adoption (OM)	.6461	.6174

OM: Blockchain Adoption

7. DATA INTERPRETATION

Based on Direct effect inference table analysis (ADANCO 2.3):

- Innovation (IV) is significantly impacting the blockchain adoption (OM) in supply chain management since P value (2 sided) < .01 and t-value (3.374) > 2.59
- Extrinsic factor (EX) is significantly impacting the blockchain adoption (OM) in supply chain management since P value (2 sided) <.01 and t- value (2.9)>2.59 meaning that external (EX) factors such as government policies, customer, global markets have role to play for the adoption of blockchain in supply chain management
- Intercompany collaboration (IE) is not significantly impacting the blockchain adoption (OM) in supply chain management since P value (2 sided) >.01 and t-value (1.5) < 2.59
- Intracompany synergies (IO) is not significantly impacting the blockchain adoption (OM) in supply chain management since P value (2 sided) >.01 and t-value (1.1) < 2.59
- Technology (TE) is not significantly impacting the blockchain adoption (OM) in supply chain management since P value (2 sided) >.01 and t- value (.3562) <2.59

Direct Effects Inference

Effect	Original coefficient	Standard bootstrap results					Percentile bootstrap quantiles			
		Mean value	Standard error	t-value	p-value (2-sided)	p-value (1-sided)	0.5%	2.5%	97.5%	99.5%
IV -> OM	0.3115	0.2960	0.0923	3.3740	0.0007	0.0004	0.0435	0.1107	0.4750	0.5412
EX -> OM	0.2601	0.2803	0.0887	2.9331	0.0034	0.0017	0.0113	0.0806	0.4351	0.4787
IE -> OM	0.2576	0.2751	0.1700	1.5150	0.1298	0.0649	-0.1047	-0.0244	0.6131	0.7025
IO -> OM	0.1074	0.0950	0.0975	1.1016	0.2707	0.1353	-0.1341	-0.0830	0.2958	0.3608
TE -> OM	0.0458	0.0357	0.1285	0.3562	0.7217	0.3608	-0.2847	-0.2105	0.2866	0.3644

Figure 7. Based on ADANCO2.3 analysis - Direct Effect Inference

8. CONTRIBUTION TO PRACTICE

The conceptual framework for adoption of blockchain in SCM include the five constructs of technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation. The outcome measures for these constructs include improved quality, information sharing, reduced business risk, improved performance, and enhanced competitiveness. These enable organisations and stakeholders to solve the existing problems of the supply chain, such as lack of trust, counterfeit products, and malpractices in the supply chain business, resulting in the establishment of sustainability practices in the value chain and supply chain 2.0.

9. CONCLUSION AND RECOMMENDATIONS

In this paper, we propose a conceptual framework for the adoption of blockchain in supply chain management based on the constructs of technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation. Based on these constructs five hypotheses are formulated with respect to the significance of them in adoption of blockchain in supply chain management. A pilot study was conducted through online distribution of questionnaire to 345 individuals for duration for one month. 85 responses were received. These were analysed using ADANCO2.3 (PLS-SEM) tool after data cleaning. Based on the response analysis, it is evident that Blockchain is still in the early phase of adoption in supply chain management. Innovation is significantly impacting adoption of blockchain in supply chain ecosystem. Smart contract, IOT, AI, Cloud Computing are some of the recent innovations which has the potential to impact supply chain. Extrinsic factors are also significantly impacting the adoption of blockchain. Some of these external factors are government policies, overall global markets, governance framework and customer demands. This conceptual framework based on the blockchain system can result in establishing SCM 2.0 practices. Since blockchain technology adoption is still in a nascent stage of application in the supply chain ecosystem, it has a vast future potential for researchers and industry practitioners.

10. LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

Most of the respondents of this survey were from Asia pacific region, hence the result cannot be generalized across geographics .As part of the scope of future research, these constructs of the conceptual framework - technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation must be empirically evaluated for specific geography or country to give accurate results. In this research there were no qualitative techniques such as focused group discussions with industry experts were used. Interviews and focused group discussed should be explored as a scope of future research along with this conceptual framework. Due to limited timelines – no moderation or mediation variables were considered during the analysis. The effect of theories such as TAM, UTAUT, TOE on the conceptual framework variables - technology, intracompany synergies, intercompany collaboration, extrinsic factors, and innovation – should be evaluated as future scope of research.

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