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Blockchain Technology for Manufacturing Sector

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Abstract

With technology advancing rapidly, organizations must continuously develop to remain competitive. They invest in technologies such as blockchain, artificial intelligence, machine learning, and cloud computing. This study focuses on the challenges of implementing blockchain technology in the manufacturing sector. Data was collected through structured interviews with production and design managers, as well as employees of organizations using new technologies. The snowball sampling method was employed, and analysis was conducted using thelarge group decision method. The findings will have significant implications forleveraging blockchain in manufacturing. The study focuses on exploring factorsrelated to opportunities and challenges within the technology organisation's environment, addressing existing research gaps. The findings are constrained by thescope of the data series, presenting longitudinal facts. To tackle the prospects and complications highlighted in the study, organizations should make use of this technology to enhance their manufacturing processes.

Keywords: Blockchain technology, Industry 4.0, Decision Making Model

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1. Introduction

Organisations need to constantly remain competitive in an ever-evolving business environment. Indeed, organisations depend on new technology to enhance, build and update their development of organisations [1] [2]. With continuous development in technology, organisations can improve productivity and contribute to the realisation of organisational goals [3] [4]. A recent study conducted by Mishra and Venkatesan (2021) mentions that by the year 2030, organisations will be significantly influenced by emerging technologies, and this will influence, to a large extent, the digitalization of the manufacturing process in the organisation [5].

In the same vein, the adoption of emerging technologies would become more relevant; hence, it has become very crucial for manufacturing organisations to bridge the technology gap and gain the necessary technology to adapt and perform in the changing business environment [6] [7].

Hence, the intervention of these technologies would become more relevant for the organisation, and these interventions would also act as a competitive advantage and promote innovation in the manufacturing process of the organisation [8] [9].

Further, to leverage the emerging technologies, organisations need to invest time and money in upgrading

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the manufacturing process to leverage these technologies in man ufacturing [10] [11].

Based on the above discussion, the purpose of the study is twofold. Firstly, it reports the role of blockchain technology in manufacturing. In doing this, it contributes to the literature by providing qualitative evidence from, the perspective of production manag ers specific to the manufacturing companies operating in India.

Additionally, studies on blockchain technology in manufacturing are premeditated from the perceptive of manufacturing and operation management; however, it is important to understand the role of production managers in implementing blockchain technology in the manufacturing industry.

Secondly, the study applies the Large Group Decision Making (LGDM) model, as proposed, to analyse data and derive insights; this method collects data from a large number of participants from several professionals and suggests the best feasible alter- natives for technology implementation. This study uses data collected from professionals in the manufacturing industry (production managers, and purchase managers) to understand the challenges of adopting blockchain-based manufacturing processes in the organisation.

2. Literature Survey

2.1 Blockchain and Manufacturing Sector

Blockchain technology transfers records faster with the use of a ledger system. This ensures transparency for various stakeholders. Transaction records applied in this technology are encoded in different blocks and executed through two keys i.e., public key and personal key [12] [13].

Blockchain technology presents a unique identifier for every part; for example, in the food industry, blockchain can provide expiration dates, storage temperatures, and delivery information. Blockchain in manufacturing provides layers of accountability and transparency, it is clear that blockchain technology has practicable purposes in the manufacturing domain. However, research on the utility of blockchain technology in manufacturing requires more research. To be specific, to recognize the benefits of blockchain for manufacturing from investment and return of this technology [14] [15].

Recent research show that implementation of blockchain is slow, on the whole. Stud ies on this technology have gained focus from practitioners, academics and researchers. Various research exhibit that Blockchain adoption is growing in various functions such as supply chain, manufacturing and finance [16] [17].

Organisations need to consider three elements while implementing blockchain: technological,organisational and environmentsnowal. These three elements are derived from the technology-organisation-environment framework proposed in the study.

Technological elements related to blockchain implementation are perceived bene- fits, complexity, compatibility, information security, coding, maturity, relative ad- vantage and architecture [18].

Organisational elements encompass organizational readiness, administration support, organisation size, business mannequin readiness, innovativeness, incentives to take part and knowledge of blockchain [19].

Environmental factors influencing the adoption of blockchain science are the market and industry and the regulatory environment [20].

Moreover, the country-by-country adoption of blockchain technology suggests thatthe implementation is low in developing nations. Reasons for low adoption are organi- sational and technological readiness and lack of blockchain awareness [21] [22].

The above discussion suggests that three elements are influencing the adoption of blockchain technological they are technological, organisational and environmental. Furthermore, the above discussion additionally indicates blockchain technology is in itsnascent stage and therefore, understanding from the Indian manufacturing organisations would enrich the literature. This is the novelty of the study to examine the use of blockchain in India's manufacturing sector [23] [24].

2.2 Factors Related to Blockchain

There are many technologies to understand the organisation’s needs, however, block- chain technology can add value to the development of the organisation.

However, a key challenge for an organisation to adopt blockchain is the acceptance ofthis technology. Acceptance of this technology is based on the compatibility of this tech nology with the organisation in the current business environment of the industry [25].

Considering the “Technology” and “Business environment” factors, the framework pro-posed by would add value to the present study in understanding the adoption of block-chain technology in the manufacturing sector. The framework in the context of technology-organisation-environment (TOE) considers the following factors

Factors related to technology are: (1) Perceived benefit of blockchain technology; (2) complexity in blockchain technology (3) Compatibility of blockchain technology; and(4) data security of blockchain technology [26]. The organisational factors related to the adoption of blockchain include (1) organisational readiness; (2) organisation size; and (3) technology readiness [27] [28] [29].

From the perspective of environmental factors, there are two factors namely (1) industry and (2) regulatory environment.

Table 1. Profile of the Respondents

Parameters	Details	Purchase Group (N=9)	Production Manager Group (N=82)	Management Group (N= 38)	Total
Gender	Male	37	81	7	125
	Female	33	12	45	90
	Total	70	93	52	215
Age	25 years	8	16	8	32
	25- 35 Years	11	14	8	33
	35-45 years	18	22	6	46
	45-55 years	22	35	17	74
	Above 55 years	11	6	13	30
	Total	70	93	52	215
Education	College (Certification /Diploma)	17	8	9	34
	Undergraduate	32	52	17	101
	Post-Graduation	21	33	26	80
	Total	70	93	52	215
Experience	Less than Two years	3	12	3	18
	3-5 years	5	15	5	25
	5-8 years	12	21	16	49
	9-15 years	22	24	11	57
	15 years and above	28	21	17	66
	Total	70	93	52	215

3. Research Methods

This section details the methodology used to conduct the research with specific reference to (1) procedures and sample, (2) research instrument, and (3) selection of the data analysis tool.

3.1 Procedure and Sample

The manufacturing region is a vital contributor to the Indian economic system and the international market with an annual turnover of greater than USD 21.1 billion[30], which include exports to extra than 10 distinguished clusters of manufacturing. The information for the study was collected from manufacturing companies operating in foundry and machining. The study specifically approached the manufacturing units operating in the Belagavi and Bangalore clusters in Karnataka, India.

Further, the study selected manufacturing units that are working on blockchain technology. Hence, the snowball sampling method was adopted; Snowball sampling is a non-probability sampling technique used in social research where existing study subjects recruit future subjects from among their acquaintances. Thus, the data was collected through an interview with the experts working on blockchain technology in the above-mentioned manufacturing units operating in Belagavi and Bangalore clusters. The details with regard to the respondents are presented in Table I.

3.2 Research Instrument

The review of literature covers a study on a range of elements related to the adoption of TOE framework. The study identified the factors that influence blockchain science adoption in the organisation. These elements are in Table II.

3.3 Data Analysis tool

The study adopts a Large Group decision-making tool. This method uses the data collected from respondents and then analyzes as steps proposed in the model[31].

Table 2. Constructs Related to the Study

		Code	
Technology	Perceived benefit	TE 1	Tornatzky and Fleischer ,1990;Himani and Venkatesan, 2021
	Complexity in blockchain technology in the organisation	TE 2	Tornatzky and Fleischer ,1990;Himani and Venkatesan, 2021
Organisational	Organisational readiness	OR 1	Tornatzky and Fleischer, 1990;Himani and Venkatesan, 2021
	Organisation size	OR 2	Tornatzky and Fleischer, 1990;Himani and Venkatesan, 2021
Environmental	Industry	EN 1	Tornatzky and Fleischer ,1990;Himani and Venkatesan, 2021
	Regulatory environment	EN 2	Tornatzky and Fleischer ,1990;Himani and Venkatesan, 2021

4. Results

4.1 Percentage distribution

LGDM method was applied to collect data for the study. This is the first step for evaluating the parameters of the study. The respondents were from three groups to provide their feedback. The results are as under*;* Our findings are relevant to research objectives in appreciation in the manufacturingsector. The discussion area highlights results associated with technical, organisational, and environmental elements relevant to the manufacturing sector. The technical factors impacting blockchain implementation are rated as follows.

Table 3. The Variance for group evaluations

Adoption	Purchase Group (N=95)	Production Manager Group (N=82)	Management Group (N= 38)
TE 1	0.65	0.83	0.52
TE 2	0.24	0.21	0.24
OR 1	0.26	0.25	0.16
OR 2	1.41	1.36	1.00
EN 1	0.65	0.83	0.52
EN 2	0.24	0.21	0.24

Table 4. GroupWise consensus analysis

Adoption	Purchase Group (N=95)	Production Manager Group (N=82)	Management Group (N= 38)
TE 1	0.60	0.54	0.64
TE 2	0.76	0.77	0.76
OR 1	0.73	0.75	0.73
OR 2	0.48	0.43	0.62
EN 1	0.74	0.75	0.80
EN 2	0.41	0.42	0.50

Table 5. Objective Weights for the study

Adoption	Purchase Group (N=95)	Production Manager Group (N=82)	ManagementGroup (N= 38)
TE 1	0.34	0.31	0.36
TE 2	0.33	0.34	0.33
OR 1	0.33	0.34	0.33
OR 2	0.31	0.28	0.41
EN 1	0.32	0.33	0.35
EN 2	0.31	0.32	0.38

Table 6. Objective Weights for the study

Adoption	Purchase Group(N=95)	Production Manager Group (N=82)	Management Group (N= 38)
TE 1	0.33	0.32	0.35
TE 2	0.33	0.34	0.33
OR 1	0.33	0.34	0.33
OR 2	0.32	0.31	0.37
EN 1	0.33	0.33	0.34
EN 2	0.32	0.32	0.36

Table 7. Collective percentage distribution

Adoption	Not at all Good	Slightly Good	Good	Fairly Good	Very Good
TE 1	0.02	0.14	0.48	0.29	0.07
TE 2	0.63	0.37	0.00	0.00	0.00
OR 1	0.11	0.71	0.18	0.00	0.00
OR 2	0.02	0.10	0.08	0.42	0.38
EN 1	0.00	0.23	0.73	0.03	0.00
EN 2	0.07	0.04	0.22	0.35	0.32
EN 1	0.00	0.23	0.73	0.03	0.00

Table 8. Dominance Matrix

	TE 1	TE2	OC 1	OC 2	EC 1	EC 2	EC3
TE 1	0.50	0.96	0.65	0.32	0.50	0.96	0.86
TE 2	0.04	0.50	0.04	0.05	0.04	0.50	0.21
OR 1	0.14	0.79	0.19	0.11	0.14	0.79	0.50
OR 2	0.75	0.97	0.86	0.56	0.75	0.97	0.92
EN 1	0.35	0.96	0.50	0.20	0.35	0.96	0.81
EN 2	0.68	0.95	0.80	0.50	0.68	0.95	0.89

Table 9. Ranks obtained from analysis

Adoption	phi^+(A_j)	phi^-(A_j)	Relative Dominance Value	Ranks
Interoperability issues	0.012	0.051	-0.039	1
Organisational Structure and Culture	0.013	0.042	-0.028	2
Complexity of blockchain technology	0.015	0.029	-0.014	3
Lack of awareness and understanding of Block-chain Technology	0.018	0.023	-0.005	4
E-Waste Management	0.018	0.022	-0.004	5
Energy Consumption	0.029	0.015	0.014	6
Regulatory and Legal	0.029	0.015	0.014	7

Security and blockchain:

Data security is a challenge for this technology as blockchain transactions are avail-able to all members. In relation to the manufacturing sector, security and privacy are essential factors as the data may contain important information related to manufacturingdesigns and processes.

Another security factor related to blockchain and manufacturing arises from the blockchain's peer-to-peer network structure. Systematic interconnections such as DoS, ARP, spoofing, jamming, and channel interference should therefore be considered for blockchain applications in organisation.

Awareness of Blockchain technology:

The main difference between blockchain and other technology is the unique structure. In this technology, information is stored in blocks that contain different sets of information. As blocks fill up, they are added to the existing chain. Blockchain supports manufacturing processes in matters of product, design, supply chain management, quality assurance, and overall efficiency management.

Additionally, the system can be set up to provide automated quality checks that generate actions for manufacturing decision-making.

Implementing Blockchain technology:

This is a breakthrough technology, but a major challenge of blockchain is scalability regarding its ability to manage applicants simultaneously.

Another point that complicates blockchain adoption in financial institutions to offersecure payment gateways and other services at an affordable price compared to the costs associated with blockchain.

Employee Skills and Blockchain Technology:

Adopting blockchain requires a range of skills, including knowledge in app development, security, engineering, and other related fields. As companies begin to explore and invest in blockchain, the demand for personnel with proficient knowledge of these technology components and skills is needed by the organisation. The organisational factors are ranked as follows.

Size of the organisation

Responses from respondents in the manufacturing sector indicate that acceptance of this technology is based on factors such as cost, availability of expertise, and executives' willingness to implement this technology.

Technological readiness

New facets of blockchain can make enterprise processes efficient, secure and trans-parent. According to the study results, the availability of expert personnel and management support. These factors influence the implementation of this technology in the manufacturing sector. In the case of environmental factors

Industry structure

Blockchain technology is becoming increasingly available across industries as it helps organize data. By creating a common digital ledger for a business, blockchain makes key information easily accessible and allows employees to monitor the inner workings of the business.

Blockchain has the potential to revolutionize the way manufacturers design, develop,manufacture and scale their products. Moreover, it rewrites the way companies interact with their ability to foster trust among competitors despite the need to work together within a shared ecosystem.

5. Discussion

Research discussions on change in technology in manufacturing required the devel- opment of blockchain technology for the manufacturing process in the organisation. The main contribution of this study is to understand the development of blockchain technology for manufacturing companies. Our findings will be useful to practitioners, policymakers, academics and consultants.

The study contributes to academic research by identifying factors influencing block- chain technology in manufacturing. Our findings support the manufacturing sector in understanding the factors they should consider when implementing blockchain technology. This study uses the LGDM method for data collection and analysis because it provides better results compared to other decision models.

The study fills research gaps by identifying factors related to blockchain implementation by understanding the perspective of the technology-organisation-environment framework [31]. Furthermore, these findings bridge the gap in blockchain technology research for the manufacturing sector. Findings suggest that blockchain technology skills would add value to an organisa tion by aligning roles and meeting the expectations of the manufacturing sector.

Thus, in the current context, our findings suggest that data security and coding developments for blockchain would add value to the manufacturing sector[32] [34] [35][36]. Furthermore, the size of the organisation is another important factor that affects the domain of block- chain technology. Finally, the structure of the industry also influences decision-making in this context of the study.

Practical contribution

The findings will have significant managerial implications for practitioners when implementing blockchain technology in the manufacturing sector [33]. The findings pro- vide practical implications regarding organisational size and the adoption of blockchain technology. Two significant factors influence adoption, namely the cost and complexity of implementing blockchain. Second, organisational readiness is required by manufacturing companies while implementing blockchain technology. Third, organisations report that they need more information about the key skills needed to fill the skills gaps needed to adopt Blockchain technology.

6. Conclusion and Future Directions

The study is of practical importance. To begin with, finding out about the low levelof awareness of blockchain. Moreover, the positive effect of the support and readiness of the organisation's top management on the implementation of blockchain technologyrecommends that arming managers with the required knowledge and skills is crucial for the adoption of these technologies.

This study also assessed opinions regarding organisational factors, barriers and possible uses of blockchain technology. Based on empirical analysis, a model or frame- work can be created based on these factors. Researchers can try to evaluate the key factors that lead to the implementation of blockchain technology, for example, an organisation's technological readiness, innovation, firm size, leadership and top management support sentiment expressed on social media during the pandemic, which can be crucial for decision-makers, researchers, and organizations to better understand public opinion.

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