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Blockchain Technology in the Food Supply Chain:
Empirical Analysis

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ABSTRACT

This paper explains the feasibility of blockchain technology in food organization. The technology of BCT helps the organizations to achieve integrity among peer-to-peer nodes, such as maintaining proof of work, reducing intermediaries, traceability, etc. It can be applied in the BCT at different levels of supply chain management processes. This empirical study was conducted with the help of the primary data. The data was collected from food industry managers who have knowledge about the BCT in the process of supply chain management. The questionnaire was prepared based on the different supply chain activities like procurement, pre-processing, logistics, warehousing, inventory management, distribution, retailing, processing, and marketing activities. Based on the literature and data analysis, the BCT had the greatest advantages including cost reduction, traceability, time-saving, immutability, authentication, and proof of work. The major weaknesses are associated with present employees having a lack of knowledge, limited scalability, complexity in usage, and high initial cost.

KEYWORDS

Blockchain Technology, Food Sector, Supply Chain Management

INTRODUCTION

India is the world's largest agricultural processor and food ingredient provider in the world. It is the fastest-growing economy among the other countries. The food items move to final consumers in three different stages like starting from farmers in the form of fresh produce, and it will be catered by the manufacturers-to-retailers, and finally reaches the end-user consumers. The goods and materials flow from one stakeholder to another are facilitated by in-house or Third-Party Logistics (3PL) service providers (Pachayappan et al., 2020). Information management is committed by all the stakeholders and their information systems are interconnected seamlessly. This kind of food chain system was enforced in most the developed countries. The food is distributed from the farmer to end-user, customers, and managing the supply chain with different stakeholders is nothing but food supply chain management (Verbeke, 2005). Supply chain management is a broad subject consist of different models.

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The supply chain management model to be adopted is based on the type of industry, management structure, materials to be handled, type of logistics involved, countries regulation, government policies etc. In layman language Supply chain management is the transfer of materials and services from producers (starting point) to the consumers (endpoint). During this transfer of materials, different intermediaries and stages like procurement, pre-processing, warehousing, staking, assortment, and inventory management, unit operations according to the type of industry, distribution, and record-keeping are performed. Which are the parts of Supply chain management (Swan., 2015). When this chain is considered for a single product at a small scale, the operations are very much manual and can be managed in a simpler manner without much involvement of technology but when it comes to managing a varied product at a large-scale level like corporate organizations level, there is a need for a continuous supply of goods and its constant management for sustainable growth.

Supply chain management is the backbone of any company, without which a company can't even operate a single unit operation. Too many intermediaries' involvement is needed for these kinds of large-scale operations. This will lead to the addition of cost, lack of transparency, loss of efficiency, and other human-related problems so there is a need for technology intervention to manage this huge chain of stakeholders for better returns of the company. In this 4th Industrial revolution technology and operations has to blend in such a way that, every action that is carried has to complete efficiently with proper proof and transparency. Too much human intervention leads to a lack of integrity, lack of proof to work, lack of authenticity, insecurity in ownership, lack of trust. Which should be supplemented through technology. At present industry is using cloud computing technology for example 78% of works are done in an organization with this technology. Which is giving the best results through its information distribution model, but hacking is one of the threats that all governments and corporates are scared of the technology development.

In the present era of the Internet, most of the communication in the industry is happening in a digital mode. This facilitates the industry to reduce their time of operations, cost of operations, and efficiency of operations and so on. Changing technology in the industry might result in a positive impact. At the same time negative impact also. Insecurity in using digital information and digital transactions, the ability of hiding information within the organization, lack of work proof are the best examples of the negative impacts created by Internet technologies and related software's in the present situation. There are several intermediaries were involved in material transfer in different stages like procurement, pre-processing, warehousing, staking, assortment, inventory management, and unit of operations based on the type of industry (Siddhartha et al.,2021). Whereas in the case of a simple chain, it is considered as a single product their can manual operations and managed in a simpler manner without much involvement of technology and middleman. However, when it comes to large-scale operators especially handling multiple products is considered a difficult task. There is a necessity to continue the good supply and constant management for sustainable growth (Beske et al., 2014).

Information and the communication technology don't remove bias in collecting and using. People running ICT are also allowed for using information in a manner that suits their individual interests. The preference of stakeholders in a multi-criteria decision, for example, it is strongly affected by the company they represent and by their involvement, NGOs will concentrate excessively on the issues to be resolved Dascano (2018). An efficient way to prevent such discrimination is by spreading data processing capacity to very huge number of people, making data manipulation challenging or even impossible. A blockchain is a database on which agents record details on how a product or service is used, transacted and consumed. The ledger is operated collectively via a peer-to-peer network usually by all interested parties Drescher (2017). The network must validate a new record before it's added to blockchain. Any modification to a recorded information will adopt a consensus decision-making process, which means that agreement should be reached between most parties involved. Additionally, altering to one record would result in altering of all records. Its therefore virtually difficult in practice to alter information stored in blockchain. Blockchain is seen as "a transparent, distributed ledger able to effectively and verifiably and permanently record transactions between two parties". Blockchain seems to be a transformative ICT can revolutionize the way technology is used in agriculture. However, agriculture is a one of the little-explored industry with the ability to revolutionize blockchain entirely Bradley (2016). There are too many intermediaries are involved in the process of a large-scale operation. These operations usually create a lot of confusion in the organization like an additional cost, lack of transparency, loss of efficiency, and other human-related problems. Therefore, there is a need for an appropriate technology intervention to address the above issues and to manage among stakeholders for the betterment of company efficiency and coordination (Pettitt, 2001).

Nowadays, the companies are required efficiently with the proper proof and transparency in their operations and to avoid much human intervention, which can overcome the lack of integrity, lack of proof to work, lack of authenticity, insecurity in ownership, and lack of trust. These problems should be sorted out through the proper system of blockchain technology (Doukidis et al., 2007). The problem is data are usually hacked by hackers which are considered as one of the greatest threats for all corporates and governments (Sengottuvel & Ganeshkumar, 2018). At the end of 2030, it is predicted that most of the organizations are planning to transform their technology into "Block Chain Technology". So, there is a necessity to study the BCT and its application which are applied to the process of Food Supply Chain Management (FSCM). The BCT is an information distribution system like a digital ledger in the field of supply chain management (Ganeshkumar et al., 2019; Rana et al., 2021). It is also considered a cryptocurrency consensus in most of the industrial people's minds (Ghezzi, 2013, Ganeshkumar et al., 2014). An effort has been made to check the practicability of BCT in the supply chain management process. This paper answers the questions of the feasibility of BCT at the present trend, and its adaptation in the field of food supply chain management (Moe, 1998; Ochoa et al., 2001). Considering these attributes of BCT, in terms of integrity, trustworthiness, authenticity, cost reduction, favouring transactions, digital ledgers are the aim of this research (Siddhartha et al., 2019).

Blockchain technology facilitates knowledge traceability within the food chain and thereby helps to increase the quality of food. It also provides a safe way to store and manage data, which enables the creation and usage of information-driven technologies for smart agriculture and agricultural insurance depend on smart indexes. It will also reduce the cost of transaction, which helps the farmers for 'market access and create new source of revenue. Notwithstanding the tremendous potential benefits, major constraints in the implementation of blockchain technology in food and agriculture remain (Paul et al., 2019). Firstly, more research is needed for motivation of the transacting parties to provide the blockchain ledger with legitimate and reliable details. In the case of small farmers this may be particularly relevant. The information produced during the agricultural process is distributed & owned by an individual farmer. The advantages for the farmers of blockchain technologies will rely on the size of field. At one side, smaller farm might easily become active in insurance industry focused at blockchain Lin & Liao, (2017). On the other hand, it may be more practical for larger farms to collect and incorporate data on-farm. Future work will therefore aim to predict which farms might benefit from the lack of solutions focused on blockchain. Second, it can be very costly to access the data added to a blockchain which will be an obstacle to the adopting this technology in the field. Setting up distributed ledger itself can be sufficient or may be inexpensive, but it may be costly to collect data required to make the ledger useful. Sampling will reduce costs, but it requires a huge data collection item. This means that for larger farms the average cost for gathering information is low than smaller farms, which increases the concern to increase income disparity. Thirdly, Blockchain does not specifically integrate easily with current legacy networks (David et al., 2019a). The technology needs to be integrated into current infrastructure and legacy structures such as business resource management, storage and distribution planning, and manufacturing execution processes has been successfully implemented. Creating infrastructure to use the blockchain technology also takes time and communication protocol capable of gluing current systems (Klötzner and Iten., 2019).

Keeping this background, in this paper researchers attempted to highlight the blockchain technology applications which are very much applicable in the Supply chain management stages.

Considering Blockchain technology as an information distribution system like digital ledger, Blockchain is still a cryptocurrency consensus in most industrial people's minds. Considering attributes of blockchain technology and suiting in Supply chain management for better results in terms of integrity, trustworthiness, authenticity, cost reduction, favouring transactions, digital ledger keeping etc. In 2030 all the organizations present in the country will transform their technology to blockchain. India being the world's largest agricultural processor and food ingredient provider should get into this safest technology as soon as possible to be a fast and effective runner in the race of globalization and this paper explains the feasibility of blockchain technology to the agriculture and food organizations based on the data collected from managers.

REVIEW OF LITERATURE

The literature review was explained the food supply chain and its agriculture products with the help of BCT. The SCM usually deals with the relationship of organization, distributors, and its final consumers. Organizations jointly working together with the suppliers for the purpose of distributing the products and services to the end consumers (Ganesh Kumar et al., 2017). When it's come to a larger firm, it usually adopts new technology in its supply chain for the purpose of more automation inflow of goods and services (Hill & Scudder, 2002). Twesige (2015) explains that the blockchain is a peer-to-peer transaction network that needs no third-party intermediaries. Different individuals involved in transaction function as nodes from a business purpose, and the mechanism is validated by cryptography. Records of these transactions over all participating entities are stored as shared and decentralized ledger. Blockchain itself may be considered meta-technology since it is the product of many other technologies like software creation, cryptographic technology, database technology, etc. being combined. Kuner et al., (2018) explain that potential advantages of greater accountability and improved monitoring are most evident in every supply chain's distribution period and the more extensive the management of supply chains, the greater the possibilities for inconsistencies in the flow of knowledge and the consistency of the supplied product. This impacts directly on customer satisfaction. None of the company wants to fail on that front in ever-increasing pressure on the market. In these conditions the block chain can be very useful. Pilkington (2017) shows that BT-supported digitalization of supply chains. Using a structure, analysis discusses differences from an alignment point of view between the company readiness and current functionalities. Furthermore, the study suggests that the use of blockchain will overcome these gaps. Zheng et al. (2018) showed the different advantages of block chain in various application areas of supply chain manufacturing and the research shows that IoT and blockchain would profoundly impact manufacturing of the next decade.

The traceability of transactions (whether it may be a product/ service or information) in the agricultural field is rapidly increased especially during the last two decades due to the pandemic disease, contaminations, toxins, etc. Genetically Modified Organisms (GMOs) and non-GMOs has reduced the consumers' confidence level about the food safety and health aspects (Bollen, 2007). It created a lot of negative impacts among the consumers' minds about the agriculture products, related to safeness, organic product and ecological diversity (David & Ravi, 2017; Opara, 2003).

Blockchain technology is otherwise called the "*Fifth Evolution of Computer*" (Thummula et al., 2019). Blockchain technology is a peer-to-peer connecting system, whereas the central authority cannot control the data flow especially a large network of independent users. Therefore, the organizations should remove the central control in their system to maintain the data integrity in their process. It specifies the computers to connect with the network across the different geographical areas and different locations (Pratheepkumar et al., 2017; Srivel et al., 2018; Paul et al., 2012; Paul et al., 2013). It creates an identity and maintains online and overcome the slow business processes like money flow and fund settlements can also be done instantly without any kind of further delay. (Deshpande, et al, 2017). So, there is a lot of opportunities to grow and develop their business with the help of blockchain technology. However, there are some practical difficulties to contend with the rapid change and uncertainty and attempted to understand the current realities, and changing drivers (David et al., 2020). However, the BCT has a lot of benefits for the Electronic (E)-SCM, there are some challenges that are prevented that need to redesign in the business processes.

Several methodologies were found that explains the business process redesign and E-business process design (Palma-Mendoza et al, 2014). The problems of food safety had directly and indirectly affected the health of the consumers and their quality of life. The global economy had a greater impact on the food safety system (David, 2020). Data is considered lifeblood for any business. Today, big data applications are used across all the industries such as retail, healthcare, financial services, government, agriculture, customer service among others (Van der Vorst, 2006; Paul., 2020a; Deepika et al. 2020). The BCT works as per the expectation of customers and provide the solution to the business problems, issues and challenges. It gives a solution to the big data needful that become a more competitive advantage (Rabah, 2018). This technology can be benefitted to the customers, manufacturers, supervisions and improvise the efficiency and effectiveness of the food supply chain management in their process as well as circulation. However, these BCT technologies are still in the infancy stage only (Arokiaraj et al., 2020; Tse et al., 2017).

The efficiency of product quality, safety management, and control system is studied only in a few research for the development and operations of the traceability system. The main interest of the traceability system is to manage the food crisis. Food companies are aimed to reduce the cost of recalls in product quantity (Dupuy et al., 2005; Panpatte & Ganeshkumar, 2021). It works on a computerized traceability system that represents an optimal way of integrating all times data with the entire SCM activities (Alfaro et al., 2004; Ravi et al., 2017). The best practices of the firm are completely integrated and highly coordinated with the supply chains that comprise feed suppliers, farmers, processing and retail activities that are agreed to use specific standards and systems (Ganeshkumar et al., 2020). Developing and implementing traceability systems is an expensive and complicated task that could lead to financial problems (David et al., 2019_b). Moreover, allocating the cost and benefits among the partners of FSC needed extra effort and cost (Bosona, et al., 2013; Paul, 2020). Fairer payment for the farmers have many issues when making it impossible for farmers to get paid for their products. Firstly, farmers take several weeks to get the complete payment to the products (Dhanavandan, 2016). To make situations worse, conventional payment systems – regularly wire transactions – frequently eat up large portion of earnings of the farmers. Blockchain-based smart contracts operate by automatically triggering payments as soon as the buyer has met a specific, previously defined condition — and without having extortionate transaction fees. This implies the farmer will potentially collect payment for the products as soon they were shipped, without taking away, large portion of their profits from them in the process.

Often, many farmers face trouble trying to sell their goods at a reasonable price on the market. The intermediaries are enjoying much of the gains right now, while performing a small amount of work in contrast. Smart contracts will eliminate such intermediaries entirely, it will enable farmers to communicate directly with distributors. Hence, they could get a fairer price to their goods. Blockchain is a new technology and has a long way to go it can develop and implement its full set of applications. It is becoming increasingly apparent, however, that there are opportunities within the agricultural sector. Present worth of global agriculture sector is more than $2.4 trillion also includes more than one billion people across the world (Lewrick and Di Giorgio., 2018; Paul., 2020).

METHODOLOGY AND RESULTS

The empirical research was conducted with the help of the primary data from the food companies' managers. The primary data was collected from different food companies across the country. A structured questionnaire was prepared that that focused on the BCT applications in the SCM. The questionnaire was drafted into the Google Form and circulated through WhatsApp, LinkedIn, and E-Mail. This sampling technique is nonrandom in nature. The information was gathered from the managers who can understand BCT and its application in the food SCM. The collected data were analyzed and interpreted with the help of descriptive statistics, Hendry Garrett ranking test and mean score with the help of Ms-Excel and SPSS (Ganeshkumar & Khan, 2021). The demographic profile of the respondent is given below in the below table.

Around 32% of data are collected from the FMCG and Paperboards and Packaging Company. The BCT had a backup control (52%) and 44% of them are adjusting according to the requirement of the business. It covers entire India by 56% and most of the company size was into medium scale organizations (48%) and 40% of them are large scale. Most of the companies were successfully running their business for more than 15 years (40%). Around 76% of the companies have adopted their software like ERP, CMR, SCM, etc. Around 36% of the company stated that they do not aware of the new BCT.

The Hendry Garett ranking test was carried out to find out the adaptation of BCT for their business process. Based on the literature review, we have identified six factors that influence the company to adopt the Blockchain technology in the food industry are trustworthiness, integrity in distribution, cost reduction, traceability, proof of work/ content/ payment, timesaving and immutability. The above table has given a detailed explanation of Garret ranking score and the average score for the adaptation of BCT.

Table 1. The BCT industry profile

Demographic Profile		% of Respondents	Demographic Profile		% of Respondents
Type of Industry	Bakery	4	Business Coverage	Particular State in India	8
	Paperboards and packaging	16		South India	8
	Retail	4		North India	4
	Cold Storage	4		Entire India	56
	Dairy	8		International	24
	Food Ingredients	8	Company Size	Small Scale	12
	FMCG	16		Medium Scale	48
	Collateral Management	4		Large Scale	40
	F&B	8	Number of years in Business	3-5 years	36
	Meat	8		5-10 years	12
	Beverage	4		10-15 years	12
	Beer Industry	4		above 15 years	40
	Food technology	4	ERP, SCM, & CMR Software	Yes	76
	Others	8		No	24
BCT Backup Control	Yes	52		Oracle	4
	No	8		JDE	12
	Maybe	40		ERP	16
BCT Business Control	Yes	40	BCT new technology	Yes	32
	No	16		No	32
	Adjustable according to need	44		Don't know	36

Source: Primary data

Table 2. Hendy garret rank result for the adaption of blockchain technology

Adaptation of BCT	Garret Score	Average Score	Rank
Integrity in Distribution	1360	54.40	2
Trust Worthiness	1337	53.48	5
Cost Reduction	1259	50.36	7
Traceability	1413	56.52	1
Proof of Work/ Content/ Payment	1356	54.24	3
Time-Saving	1345	53.80	4
Immutability	1287	51.48	6

Source: Primary data.

Based on the Hendry Garett ranking test, it is found that the traceability factor was ranked top in the Garret rank score of 1413. Integration in distribution was ranked second (Garret score = 1360), proof for their work, content, and payment were ranked third (Garret score = 1356), timesaving was ranked fourth (Garret score = 1345), trustworthiness was ranked fifth (Garret score = 1337), immutability was ranked sixth (Garret score = 1287) and the least preference was given to the cost reduction as ranked 7th with the Garret score of 1259.

Chart 2 explains the role of BCT in food supply chain management. It describes the three levels of BCT are integrity level, high communication barriers and backwards-forward linkage to its supply chain management activities relating to the logistics, warehousing, retailing, marketing activities, procurement, inventory management, and distribution as shown in Figure 2.

Figure 1. Adaption of Block Chain Technology (Source: Primary data)

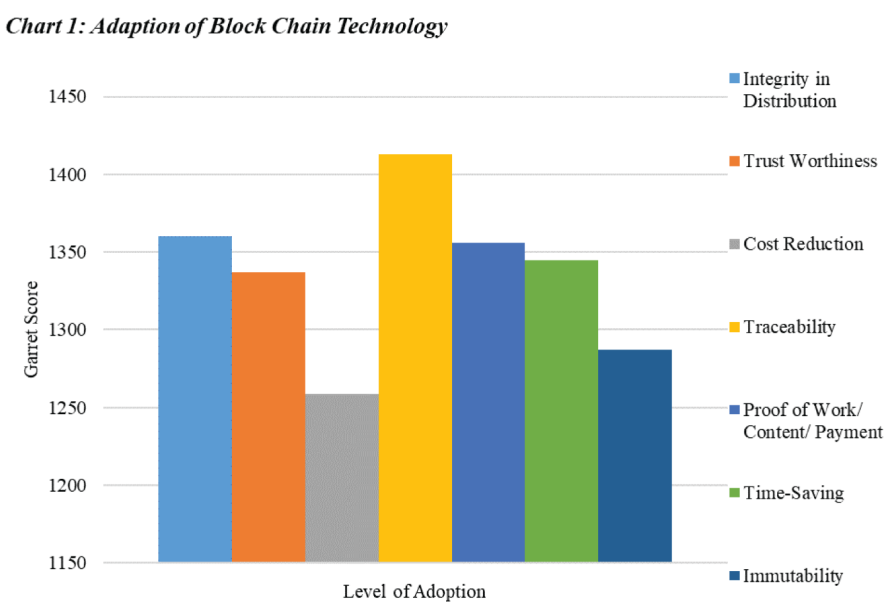
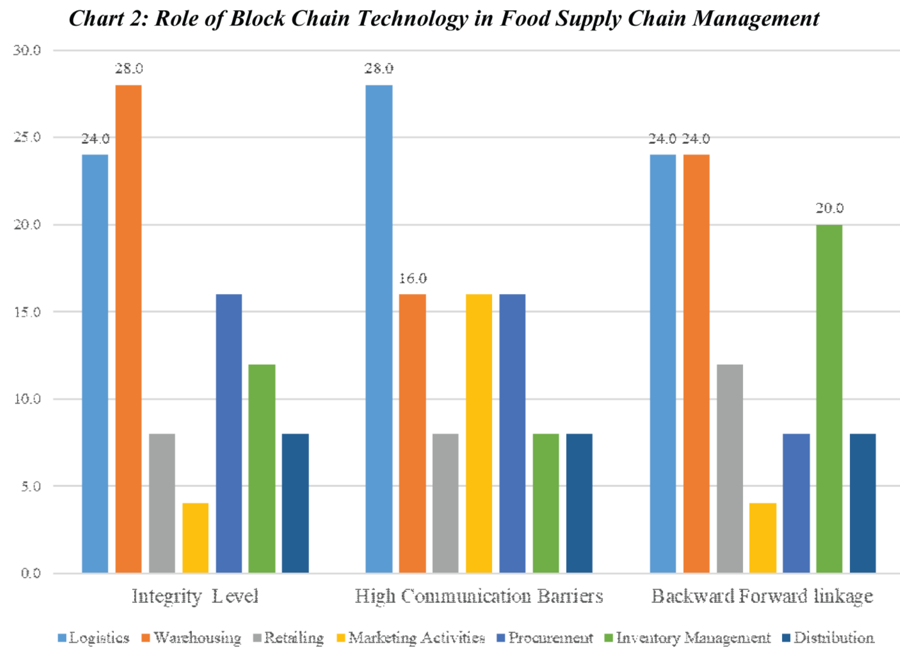


Figure 2. Role of block chain technology in food supply chain management (Source: Primary data)



It is found that warehouses (28%) and logistics (24%) had a high level of integrity and also there is a communication barrier in their logistics by 28% and warehouse (16%). In terms of backward and forward linkages, both the logistics and warehouses had a 24% and inventory management had 20% as shown in the above chart 2. Around 8% of preferences were given to retailing, distribution and inventory management across all the levels, communication, and backward & forward linkage. Whereas the least preference was marked in the marketing activities 4% in the integrity level, and also in the backward and forward linkage.

The descriptive statistics of BCT have explained in the above table. It shows the mean score for BCT for each variable. Based on that mean score, it is clearly shown that data stored in a block of BCT for future decision-making had (mean score=3.88) and efficiency of relationship and dispute management can be improved with the help of BCT (mean score=3.76). It provides a better platform for Big Data and Analytics Research (mean score=3.64). whereas it gives back control over the business had the least mean score of 1.88.

CONCLUSION AND IMPLICATION

It is concluded that the BCT is one of the most powerful tools for traceability, timesaving, immutability, authentication, cost reduction, and proof of work. It had some drawbacks with a lack of knowledge, limited scalability, complexity in usage, and high initial cost. It can be overcome by effective implementing create an awareness and training program for the employees. Blockchain technology is used in various fields across India like Agri-food supply chain management had a greater potential to transform into the next level of information distribution. Not only restricting the technology for cryptocurrency. This technological transformation helps to develop the business in a better way like proof of work traceability, transparency in communication and reducing intermediaries' costs. High integrity has to be maintained in the area of warehousing, logistics, and procurement with a proper

Table 3. Descriptive Statistics of Blockchain Technology (BCT)

Descriptive Statistics	Mean score	Std. Dev
It provides a platform for Big Data and Analytics Research	3.64	0.95
It gives back control to the business	1.88	0.97
It requires a high initial cost	3.40	0.81
It is associated with limited scalability in its operation	3.28	1.06
It helps effective communication	3.60	1.00
Technical experts are not available	3.56	1.19
BCT regulatory policies	2.24	0.72
BCT is considered vulnerable to hack the information	3.00	1.08
It is not legally accepted across the country	3.16	1.17
Influence of new technology in BCT	2.04	0.84
It can be adopted in the new business environment	3.36	1.15
It has better competitiveness to install in the Indian economic conditions	3.48	1.08
Tuning the employees towards BCT is considered a difficult task	3.08	1.28
BCT deals with both managing technical and business decision	3.28	1.20
BCT Strategies	3.36	1.03
Data stored in a block of BCT for future decision-making	3.88	1.20
The efficiency of relationship and dispute management can be improved with the help of BCT	3.76	1.26
Coordination of small stakeholders can be achieved the BCT model	3.60	1.15

Source: Primary data.

blockchain model. Businesspeople responded that BCT will be the best suit for logistics management, warehouse management, and inventory management. It reduces the job opportunities for humans is also considered as the greatest threat which is associated with technology, whereas from the business point of view; it had a good opportunity for growth and development of business.

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