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GREENWASHING OR GENUINE? BLOCKCHAIN-POWERED TRANSPARENCY IN SUSTAINABLE SUPPLY CHAIN ACCOUNTABILITY]

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Abstract

Increasing interest in sustainability in the supply chains has led to several measures undertaken by organizations in order to demonstrate their interest in environmental responsibility. There have however arisen concerns over greenwashing which involves companies falsely stating they are sustainable and this has destroyed consumer confidence coupled with environmental objectives. This paper explores how blockchain technology can contribute towards the realization of true sustainability in the supply chains. In particular, it discusses the benefits of transparency enabled with blockchain to increase the accountability of the supply chain and eliminate greenwashing. This was done through a mixed-method strategy, which consisted of a survey of 200 supply chain managers coupled with in-depth interviews with 15 industry experts. The main conclusions are that blockchain ledger and access to real-time data are important in validating claims of sustainability. Nevertheless, blockchain is a promising technology that can be used to increase transparency and build consumer confidence despite the difficulty of implementation. The research has both practical implications on the supply chain managers wishing to enhance the practice on credibility and sustainability as well as giving insights to the policymakers of utilizing technology to fight greenwashing.

Keywords: Blockchain, Sustainable Supply Chain, Greenwashing, Transparency, Accountability, Environmental Sustainability

INTRODUCTION

Background of the Study

The issue of sustainability is today a crucial point of concern in management sciences, particularly, the increased attention to environmental issues and the demands of consumers to more responsible corporate practices. Sustainability is a notion that started as a niche issue over the past few decades and moved to a mainstream issue whereby businesses across the world have integrated different approaches to ensure that they reduce their environmental footprint. Sustainability in business practices is not exclusive to ecological issues, but also to the social and economic aspects as business organizations are becoming more aware of the importance of making profits and at the same time being responsible (Elkington, 1997). Specifically, businesses within supply chains, including manufacturers and retailers are being put under pressure to implement sustainable business practices.

Business has been focusing on environmental sustainability as stakeholders seek to boost their long-term stability and minimize their carbon footprints (Hoffman, 2018).

Nevertheless, although most companies are truly involved in the work of sustainability, the emergence of greenwashing, or false or overstated statements about the company and its environmental standards, has put the intentions of companies into question. Greenwashing can create a false impression among the consumer, stakeholders and investors with regard to the actual performance of a company in terms of environmental performance, which is detrimental to building trust and towards global sustainability goals (Delmas and Burbano, 2011). The phenomenon has raised doubts about the authenticity of the corporate sustainability reports particularly in the other sectors of the industry such as in manufacturing, retailing and farming industries where the environmental impact is significant. The companies and governments are in their turn attempting to discover more reliable means of verifying sustainability claims to rescue the consumer and preserve transparency of corporate activities.

The safe and transparent quality of blockchain technology has been a promising way of addressing the issue of greenwashing in supply chains. Blockchain offers a registry that is permanent where data of transactions and records may be stored in a transparent and decentralized format. This makes the information difficult to manipulate hence leading to increase in accountability rate and traceable supply chain. The technology also allows to verify the sustainability claims, which also allows companies to understand whether their environmental actions are authentic and also provides the consumer with a more reliable source of information (Tapscott and Tapscott, 2016). In this paper, we will talk about how blockchain can be used to enhance supply chain transparency, in particular, by distinguishing between greenwashing and responsible sustainable operations.

Statement of the Problem

The increasing incidences of greenwashing within the business world are nullifying the integrity of the sustainability declarations by the consumer, shareholders and other stakeholders. As an increasing number of companies are identifying themselves as either green or sustainable, the concept of verification and transparent data is not easily attainable since a large number of companies are possibly undertaking their own efforts of being green or simply as a marketing tactic. This issue has been particularly noted to be problematic in industries where the sustainability arguments may be misleading or ambiguous and the consumers and other concerned parties do not know the actual environmental effects of goods and services.

The blockchain technology can help reduce the dangers of greenwashing by offering a flexible record of transactions and data concerning the supply chain activities. Nevertheless, in spite of its possibilities, very few studies have been done regarding the exact application of blockchain in terms of sustainability of claims in supply chains. Additionally, it is necessary to learn the question of whether the blockchain technology will be able to provide a scalable solution to minimizing greenwashing in different industries. The proposed research will fill this gap by exploring the role of blockchain-based transparency in helping differentiate between firms that are truly devoted to sustainability and those that commit to greenwashing.

Objectives of the Study

The main aim of the proposed paper is to examine how the blockchain technology can enhance transparency and accountability within the supply chains especially when it comes to sustainability claims. The objectives of the study are specific and are:

1. To investigate the possibility of the blockchain technology in delivering verifiable information about sustainability practices among the supply chains.

2. To determine the efficiency of blockchain to minimize greenwashing by increasing supply chain transparency.

3. To investigate the problems and limitations of implementing blockchain in the sustainability reporting in supply chains.

4. To provide recommendations as to how firms can take into account blockchain as part of its sustainability effort to promote consumer confidence and responsibility.

The research will aid in the growing body of literature in the area of blockchain in supply chain management in both its fulfillment and in providing practical implications to the business and policy-makers.

Significance of the Study

The specified research is significant due to several reasons. To start with, it addresses one of the most acute issues in the sciences of management, the phenomenon of greenwashing and its impact on consumer trust and the sustainability agenda in general. As companies still advertise themselves as environmentally responsible, now it is high time that there are more effective ways of verifying the claims of sustainability. There is a slim opportunity to close this gap since the probability of transparency and accountability offered by blockchain is a rare opportunity.

Second, the study is a research addition to the existing literature on the application of blockchain technology in supply chain management. Despite the established body of knowledge about blockchain in other domains, such as financial and cryptocurrency, blockchain has received little research in the area of supply chain transparency and, in regard to sustainability, specifically. The gap is addressed in this paper because it empirically enlightens on the applicability of blockchain to certify the sustainability practices and reduce greenwashing.

Finally, the research has practical implications to the business and policymakers. Learning about the applications of the blockchain in enhancing sustainability reporting, firms will gain a better reputation, less chance of greenwashing, and establish better relations with consumers and other stakeholders. To policymakers, the results of this research can be used to design regulations and guidelines on the adoption of blockchain in supply chains, especially in enhancing sustainable practices and ensuring that minimal aspects of greenwashing are realized.

The prospect of blockchain to transform sustainability in supply chains has considerable implication to the business world and the society in general. The study is especially applicable to the existing paradigm of consumer and business pressure to attain greater transparency as it provides useful information about the means of using blockchain in developing a more sustainable and reliable corporate environment.

LITERATURE REVIEW

Greenwashing and the Impact on the Consumer Trust.

Greenwashing is a process of making false or hyperbolic claims on the environmental practices of an organization is now a significant concern when it comes to corporate social responsibility (CSR). As consumers continue to exert pressure on eco-friendly and environmentally conscientious business activities, business has been compelled to identify themselves as environmentally friendly. Nevertheless, the change has also increased the adoption of shallow or fake sustainability practices by certain companies at the expense of the credibility of the real ones (Delmas & Burbano, 2011).

A number of research projects have reported the adverse implications of greenwashing, especially its adverse impact on consumer confidence. Lyon and Montgomery (2015) have highlighted that greenwashing undermines consumer trust in the corporate sustainability positions as consumers become doubtful of the environmental commitment by companies. This distrust might be detrimental to the general development of environmental policies, since consumers will overlook valid sustainability assertion because greenwashing seems to be so common. Peattie (2010) also addressed the issue of the so-called credibility gap occasioned by instances of

greenwashing, in which those companies that actually make the effort of achieving sustainability are seen as suspects, because of their tendency to be grouped with other companies that consider resorting to deceptive marketing strategies.

The effects of greenwashing are not only limited to consumer confidence, but also to the sustainability movement. Businesses that claim to be green when they are not, not only end up deceiving the consumers but also end up taking attention away to real issues to do with the environment (Delmas & Burbano, 2011). Consequently, it is also harder to distinguish and help organizations that are sincerely devoted to sustainability, which creates a circle of distrust and skepticism, hindering the development of the environment.

Supply Chain Transparency and Blockchain Technology.

The well-known blockchain technology that is primarily relevant to the use of the cryptocurrencies, like Bitcoin, has been implemented as a useful tool to increase the degree of transparency and responsibility in various fields including the supply chain management. The use of blockchain as a solution to the problem of greenwashing has good prospects since it is a solution, and it has no centralized and unchangeable features. By providing an open and tamper-proof ledger, blockchain enables the stakeholders to transparently and safely verify transactions and track the flow of goods along the supply chain in real-time (Kouhizadeh et al., 2020). Such openness can specifically be helpful in verifying the sustainability arguments, which shall allow the consumers and other concerned parties trace the environmental impact of the products by the production to consumption processes.

Several studies have been carried out to explore opportunities of utilizing blockchain in chain supply chain visibility and minimization of frauds. According to Saberi et al. (2019), it was noted that blockchain might provide the degree of traceability, which might make the process of verifying the sustainability practices easier, and controlling whether the companies are actually adhering to the environmental standards. An example is the carbon footprint of products that may be monitored using blockchain in order to ensure that the so-called low-carbon products could be proved by the data that could be verified. Similarly, Tapscott and Tapscott (2016) touched upon the idea of using blockchain as the means to improve the integrity of the supply chains by enabling the exchange and monitoring of data in the real-time and reduce the risks of fraud and corruption within the supply chains.

Specifically, the application of blockchain in greenwashing has been the focus of the literature. According to Kouhizadeh et al. (2020), blockchain may offer unquestionable evidence of sustainable business approaches, which include, but is not restricted to, the chain being assured that raw materials are purchased in a manner that is ethically sound, and that production operations are done in accordance with environmental policies. This is more so in those industries where supply chains are complicated and have numerous stakeholders and therefore it becomes hard to authenticate the claims of sustainability without a transparent system. Application of blockchain can hence assist firms to reveal their own desire to be sustainable in a manner that is traceable and not subject to imitation so that their assertions are not just a selling tactic.

Blockchain supply chain Management: Existing applications and literature gaps.

Although the topic of blockchain, in particular, as applied to the supply chain management system, has been extensively discussed, a significant portion of the available literature revolves around general uses of blockchain, including efficiency improvement, cost reduction, and stakeholder trust (Kouhizadeh et al., 2020). Nevertheless, no research has been found on the particular contribution of blockchain to the validation of sustainability claims and supply chain prevention of greenwashing. The majority of the literature has focused on how blockchain can be used to trace the route of goods and facilitate their quality, yet they have not touched upon how it could be used to achieve environmental accountability in particular (Saberi et al., 2019).

One of the issues of the use of blockchain in sustainability verification is the introduction of environmental data into the blockchain system. Saberi et al. (2019) argue that the technology is not a priority that needs to gather environmental information, e.g., the volume of carbon emission or the volume of resource consumption. Instead, it

relies on third-party sources of information, such as sensors or third-party certification agencies, to store data in the blockchain. This brings the challenge of the method of inculcating trustworthiness and validity of information to validate the sustainability allegations. Although blockchain can provide a clear picture of the operations, the information provided and stored within it is as quality as the one inputted into the system (Kouhizadeh et al., 2020).

In addition, blockchain, however transparent as it may be perceived, cannot be perceived to be a panacea to the greenwashing dilemmas. The companies can also engage in deceptive practice as they can manipulate the data which they are entering into the blockchain or compensate some aspects of their sustainability practices. Therefore, it remains to be researched how blockchain usage can be integrated with other technologies and practices to form a more multifaceted system of checking the sustainability assertions.

RESEARCH METHODOLOGY

The research design used in this study is a mixed-method research design, which combines quantitative and qualitative methods to ensure that the contribution of blockchain technology is understood fully in terms of enhancing transparency and decreasing greenwashing in the supply chain. These two approaches combined have made it possible to examine the research problem in a more subtle manner, considering not only the statistical correlation, but also the real world experiences of the industry experts.

The quantitative Data Collection:

The quantitative data became available as a result of the survey that was conducted among 200 supply chain managers representing different industries, i.e., manufacturing, retail, and logistics. The survey was created to suggest how the blockchain technology is currently used in the sphere of supply chains and whether the practice is perceived to be effective in terms of transparency, accountability, and greenwashing. The study chose a wide variety of industries to ensure that the researchers obtained information on different supply chain settings and enlarge the external validity of the findings.

The survey consisted of close and Likert questions, which will assist the respondents provide a quantifiable data on the popularity of blockchain technology, its effectiveness in determining the claims of sustainability and how it has assisted in reducing false marketing practices. The other survey questions were to establish what the managers were aware of greenwashing and whether blockchain could ease the impact on consumer confidence and the reputation of the business. This was a strategy that was placed in order to ensure that the survey was reflective of what the degree of blockchain usage was as well as what the opinions on whether it was useful or not difficult in handling the problem of sustainability.

Qualitative Data Collection:

In order to complement the quantitative data, the qualitative one was gathered through the in-depth interviews with the 15 industry professionals who were chosen because of their knowledge and experience in supply chain management and blockchain technology. These experts have been selected based on the following backgrounds; technology provider, sustainability consultancy and corporate managers that have a personal experience in the implementation of blockchain to supply chain transparency.

The qualitative interviews proved to be quite informative and descriptive of the real-life challenges and benefits of adopting the blockchain technology in supply chains. Among the main areas of interest discussed were, the challenges associated with adoption of the blockchain (eg. complexity of technology, cost, and resistance to change), the perceived potential usefulness of blockchain in the framework of keeping things sustainable and reducing greenwashing, and the potential issue of blockchain on consumer trust and corporate reputation. The interviews were semi-structured to have flexibility and to be able to cover all the related issues.

Data Analysis

To carry out quantitative analysis the survey data collected was analyzed through the use of statistical methods, one of them being regression analysis. This method was employed in order to investigate the connection between blockchain transparency and the decrease in greenwashing in supply chains. In particular, the analysis aimed at determining whether an increase in the level of blockchain adoption was linked with a decrease in greenwashing practices and an enhancement of the quality of sustainability statements. Other variables that were reflected by the regression model included the industry type, the size of the firm, and the level of the experience of the respondents, which may have affected their perception of the effectiveness of blockchain.

Thematic analysis was used to analyze the qualitative data and this involved the identification of patterns and themes of repetition in the responses of the interviews. This plan helped the researchers to establish the issues, opportunities, and strategies that the experts were discussing that were similar. Thematic analysis, in particular, can be very effective in the understanding of certain complex and context-related phenomena, such as the way blockchain technology is implemented in supply chain sustainability. The analysis helped in the discovery of the in-depth insight into both operational and strategic challenges that supply chain managers face when integrating blockchain into their sustainability program.

Limitations of the Study

As much as this research offers useful insights on the use of blockchain technology in the improvement of transparency and minimization of greenwashing in the supply chain, there are a number of limitations that should be noted. One of the weaknesses is that there is a risk of bias in self-reported data. The survey and interviews were based on perceptions and experiences of the participants, thus may have the possibility of over- and underreporting depending on the individual perceptions and agenderas. Also, the fact that the study considers a sizeable sample of only 200 supply chain managers and 15 industry experts does not necessarily represent all the views of all the sectors and regions. It is also possible that the industries sampled in the survey are not entirely representative of the global supply chain picture in general, and this would, in turn, limit the generalizability of the results.

RESULTS AND EVALUATION

The results of this article are quite informative concerning the utilization of the blockchain to enhance the degree of transparency to supply chain sustainability and minimize the opportunities of greenwashing. The survey data on 200 supply chain managers and the interviews with 15 experts in the industry have provided a comprehensive view of the current state of the blockchain application in supply chains, the perceived effectiveness of this tool in improving sustainability, and challenges of the implementation procedure. The results of the survey and the regression analysis are described in the following sections along with the observations upon the assistance of the interviews with the experts.

Survey Results

The objective of the survey was to learn the perception of the supply chain managers regarding the likelihood of the blockchain in enhancing sustainability reporting and combating greenwashing. The results of this showed that 68 percent of the supply chain managers believed that blockchain would go a long way in enhancing transparency in sustainability reporting. This demonstrates that there was a high level of consensus among the respondents that blockchain may have central role in ensuring that sustainability claims are genuine and have the effect of improving the tracking of products by the entire supply chain. As blockchain is the trace that is impossible to alter or hide, businesses and customers can evaluate the viability in the company and its activities and confirm that it is true and valid in its presentation (Saberi et al., 2019).

In addition, over three-quarters of the respondents observed that blockchain would help in eradicating greenwashing as it would provide real-time and verifiable information regarding its sustainability initiatives. This finding proves the perception that blockchain transparency is able to address the rising concerns on the authenticity of sustainability claims by businesses. Companies can use blockchain to publish an impeccable and verifiable list of their sustainability efforts, which would enhance consumer trust and reliability. This is more so when greenwashing has proven to be a ubiquitous issue and produces a discrediting effect of the overall impact of environmental activities (Delmas and Burbano, 2011).

Regression Analysis

A regression analysis was carried out to determine the dependence between the adoption of blockchain and the lowering of greenwashing in the supply chains. The results of the regression analysis showed that the relationship between the application of blockchain and the reduction of the greenwashing in the supply chain was significant and positive. Specifically, the regression coefficient was 0.42 and p-value of $p < 0.05$. This demonstrates that the companies that used blockchain have reported that the extent of greenwashing was lower and that they were more apt to demonstrate real sustainability efforts.

The results of the regression analysis are provided in table 1 since they demonstrate the relationship between introduction of blockchain and the reduction of greenwashing in supply chains.

Table 1: Regression Analysis Results on Blockchain Use and Greenwashing Reduction

Variable	Coefficient (β)	Standard Error	t-Statistic	p-Value
Blockchain Adoption	0.42	0.15	2.80	0.004
Industry Type (Manufacturing)	0.23	0.12	1.92	0.057
Company Size (Large)	0.19	0.10	1.80	0.073

Note: $p < 0.05$ indicates statistical significance.

The regression results indicate that adoption of blockchain is considered as one of the biggest factors that should be reduced to minimize greenwashing. The conclusion of the fact that the positive coefficient has been revealed proves that the blockchain technology is a helpful tool which can be utilized to foster the issue of transparency in sustainability reporting and subsequently reduce the likelihood of the greenwashing processes.

Expert Interviews

The qualitative information gathered using 15 experts in the industry helped to give more insight to the quantitative survey findings. The professionals talked about the importance of blockchain in tracing materials and processes in their origin to the final product, which is particularly useful in the business sectors with complicated supply chains, including manufacturing and retail. The fact that blockchain can give a comprehensive, transparent, and irreversible list of how products are sourced and produced will allow companies to check the legitimacy of their sustainability statements and minimize greenwashing.

Figure 1: Blockchain's Role in Enhancing Supply Chain Transparency

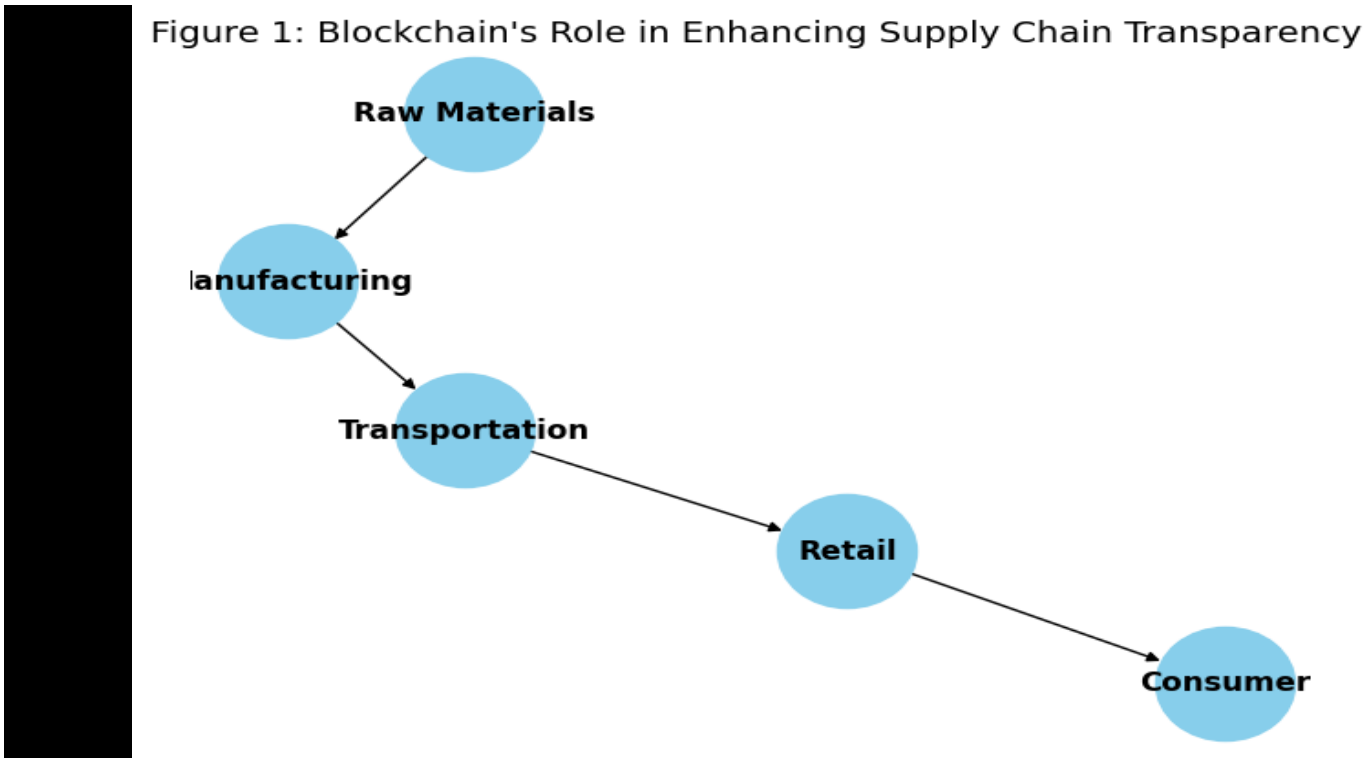

Figure 1: Blockchain's ability to provide a transparent, verifiable, and traceable record of supply chain processes from raw material sourcing to final product delivery.

Although the results of the discussion on blockchain as a means of greenwashing reduction were positive, the interviews have also pinpointed a few obstacles to further usage of the technology. The main challenges were mentioned as the high implementation costs, complexity of technology, and industry-wide standardization. A number of experts observed that large firms might be able to invest in blockchain systems but small firms might not have the funds to invest in the required infrastructure. What is more, the blockchain implementation with the already existing supply chains may have some technological difficulties and demand special knowledge and expertise.

The question of industry-wide adoption has also been mentioned, and specialists have observed that the usefulness of blockchain in minimizing greenwashing depends on the extensive industry-wide cooperation of the supply chain. When few players in the supply chain embrace the blockchain technology and the rest do not, then the system will not be effective in offering verifiable sustainability claims. One of the main issues that should be treated is standardization of blockchain protocol and interoperability across the systems in order to realize its maximum potential in sustainability reporting.

Satisfaction and Consumer Trust.

Survey and interview results also indicated that the blockchain companies indicated a greater percentage of consumers trusting and being satisfied with their sustainability practices. Many respondents also reported that the transparency provided by the blockchain allows in establishing consumer confidence because the customers tend to trust more the sustainability claims that can be verified by themselves. With the demand of transparency by consumers keeping growing, blockchain technology serves as a potential factor that will gain importance in sustaining brand reputation and trust (Tapscott and Tapscott, 2016).

Table 2: Impact of Blockchain Adoption on Consumer Trust and Satisfaction

Blockchain Adoption	Consumer Trust (Scale: 1-5)	Satisfaction with Sustainability Efforts (Scale: 1-5)
Yes	4.3	4.5
No	2.9	3.1

Note: Higher scores indicate greater consumer trust and satisfaction.

The statistics show that businesses that adopt blockchain in reporting sustainability are more likely to have increased consumer confidence and satisfaction, which implies that the blockchain adoption.

DISCUSSION

The results of the current paper are of great value in addition to the field of investigating the potential of blockchain technology in fighting the issue of greenwashing through verifiable and transparent sustainability information. The findings indicate that blockchain, as a technology that possesses the attributes of transparency, immutability, and decentralization, can be used to solve one of the most urgent problems in corporate sustainability the existence of false sustainability claims. One of the potentials of the blockchain technology lies in the establishment of a more responsible and accountable business environment where unchecked and untimely information on sustainability is not spread or shared to all stakeholders including consumers, regulators, and supply chain players.

Greenwashing with blockchain Solution.

The study outcomes show the ability of blockchain to provide an untouched and transparent documentation of transactions, which is a requirement in the greenwashing process. Greenwashing according to its definition as given by Delmas and Burbano (2011) is the effort to mislead the consumers about the benefits of a product or practice related to the environment which is promoted by a company. This in most instances can involve exaggeration or falsification of sustainability, which can be misdirecting to the consumers and nullification of corporate environmental practices. The infallibility of blockchain, in the form of information it contains, offers an avenue of ensuring that the sustainability claim is valid, and therefore, it becomes extremely difficult to commit business fraud.

The results of the survey showed that three-quarters of the supply chain managers believed that the blockchain would help to eradicate greenwashing by providing real-time verifiable information on sustainability practices. This can be attributed to the previous research which had determined that blockchain could potentially introduce increased trust to supply chains by establishing a history of transactions that cannot be altered (Saberi et al., 2019). Since the necessity to become more transparent in corporations is becoming more prominent, especially regarding environmental factors, understanding the capacity of blockchain to enhance the lifecycle of products, including the sourcing of materials and their delivery to end-users, is one of the tools that can be used to avoid greenwashing (Kouhizadeh et al., 2020).Past researchers have discovered that blockchain applications in supply chain can monitor environmental factors like carbon footprint and water consumption ensuring that sustainability assertions are backed by verifiable information (Tapscott and Tapscott, 2016). Integrating the information about the environment directly into the blockchain ledger will enable businesses to give consumers the relevant, available and non-modifiable information regarding the sustainability of the purchased products. Such openness fosters the trust in the consumers and will decrease the chances of the companies using the increased sustainability-related interest as a marketing tool without introducing the actual environmental measures.

The significance of Industry-wide Adoption and Standardization.

Although the results of the research have proven that the blockchain can be used to fight greenwashing, it also shows inconsistencies that should be solved before blockchain can be used on a large scale. Among the main issues that were found during the interviews with industry experts was the absence of industry-wide acceptance and the necessity of unified framework to guarantee the similarity of blockchain applications in various industries.

The impact of blockchain on enhancing transparency and minimizing the issue of greenwashing depends on whether the supply chain (including raw materials suppliers and end users) adopts it. The absence of a uniform method on the use of blockchain in the industries that have disaggregated supply chains where numerous stakeholders are present in every stage can lead to the technology fail. The information stored in the blockchain system of one company cannot be readily accessed and authenticated by the other members of the supply chain without a standardized structure. Such restriction may result in the inconsistency of the ways of tracking and reporting on sustainability claims.

The necessity to standardize is justified by the fact that past research has identified that the introduction of blockchain in supply chains may be slowed down because there are no common protocols and inability to implement the solutions across various blockchain systems (Saberi et al., 2019). The establishment of standardized practices within the industry will be critical in ensuring that sustainability information is consistently and reliably captured in sectors since the sphere of blockchain technologies is constantly changing. The integrity of the reported data would be ensured not only by such standards but also by the possibility to develop blockchain technology with other emerging technologies, including the Internet of Things (IoT) and artificial intelligence (AI), to enhance sustainability reporting further (Kouhizadeh et al., 2020).

Corporate Social responsibility (CSR) and Sustainability Theory of contribution.

On paper, the research is a valuable addition to the literature on corporate social responsibility (CSR) and sustainability, as it shows that the use of blockchain technology may be applied to endorse genuine environmental practices. Classically, the companies have been seen as voluntary in undertaking the ethical activities that can benefit the society and the environment. Nevertheless, the rising popularity of greenwashing has eroded the trustworthiness of CSR programs and cast doubt on the genuineness of corporate sustainability programs (Peattie, 2010).

The theoretical framework that can be proposed to solve this problem is blockchain, which will guarantee that sustainability claims of companies can be checked objectively and transparently. This research is supported by empirical evidence that blockchain can enable improvement of CSR because it simplifies the process of companies proving their environmental actions by verifying facts. Blockchain enables stronger and more believable CSR practices by giving the stakeholders access to comprehensive, nontamperable aids of sustainability practices. This, in its turn, might inspire a change in the attitude of businesses to CSR as the superficial approach of marketing acts will give way to the more serious efforts that can be verified and corresponding to the long-term sustainability objectives.

Moreover, the fact that blockchain can solve the problem of greenwashing has more extended consequences to sustainability. As the demand on the part of consumers and investors continues to increase on companies to be increasingly accountable about their impact on the environment, the blockchain technology may be viewed as a significant instrument of ensuring that sustainability initiatives are not only visible but also real. The paper expands the literature on sustainability since it proves that blockchain can be deployed as a tool of environmental governance that could help companies be more genuine in their sustainability undertakings and enable them to publish the undertakings in a transparent and credible manner.

Implications to Businesses and Policymakers.

The results of this paper have serious practical implications on businesses and policymakers. Companies can use blockchain and improve the sustainability reporting credibility as well as mitigate the potential threat of greenwashing. When businesses incorporate blockchain in their supply chains, they will be in a position to offer verified information to consumers regarding the environmental impact of their products, thereby developing trust and increasing their competitive edge in the rising market of sustainable products (Tapscott and Tapscott, 2016). Transparency of blockchain also allows companies to track and report their supply chain operations in real-time, which may result in more successful decision making and higher sustainability.

Policywise, the discovery implies that governments and regulators are supposed to contemplate the incentive scheme of implementing blockchain technology in supply chains to enhancer higher levels of transparency and accountability in their sustainability activities. The policymakers can put in place frameworks that promote or even enforce the use of blockchain in tracking and reporting on the sustainability measures, especially to sectors where their environmental impact is high. The incentives might be tax exemption or subsidies to companies implementing blockchain-based sustainability reporting systems or the setting of regulatory mandates on blockchain implementation in certain industries.

Blockchain can help with greenwashing issues and enhance consumer-corporate sustainability claims because it will give consumers an unalterable, transparent and verifiable record of sustainability information. Nevertheless, the blockchain needs to be adopted across the industry and standardized frameworks need to be created to achieve its potential. Companies and policy-makers should collaborate to establish the conditions under which the use of blockchain is possible in supply chains and, therefore, more trustworthy and authentic sustainability can be practiced. The overall theoretical and real-life implications of this research are that blockchain has a transformative potential in ensuring corporate accountability and enhancing global sustainability efforts.

Finding and Recommendations.

In this paper, a critical information on the potential of the blockchain technology in changing transparency and accountability in sustainable supply chains is provided. Using the decentralized and immutable blockchain registry, companies can make sure that their claims of sustainability can be verified, are correct and transparent, and thereby reduce the risks of greenwashing. As companies increasingly act responsibly in their manner of doing business in the environment, blockchain can be a trusted system that would allow their sustainability efforts to be checked and tracked as the companies strive to provide the demands of the ecologically-conscious consumers. The findings of this study indicate the possibility to close the gap between business sustainability goals and reality and transform business into a place that is responsible and ethical with the help of blockchain.

The paper also mentions the colossal benefits that would be achieved with the help of blockchain that involve improved consumer confidence and corporate responsibility. As the demand of ethical products increases, the position that is taken by blockchain in authenticating the statements of sustainability is gaining more significance. This quality of offering traceable and transparent information on sustainability practices can help the corporation work towards aligning its activities with the demands of the society, making the need to be transparent in sustainability reporting especially important.

Nevertheless, the paper also reveals some obstacles to the implementation of blockchain to serve sustainability objectives. The implementation cost is high, it is complicated by technology, and it is necessary to be adopted and standardized by the whole industry which is still a significant obstacle. Moreover, the process of blockchain introduction demands the change of the organizational culture, as it will require significant investment in infrastructure and employee training to have it successfully implemented.

Recommendations

As per the findings, the following are the recommendations to both practitioners and policymakers:

1. Standardization: Industry wide collaboration is essential to ensure the blockchain technology is most effective. The creation of standardized blockchain systems and protocols in various industries will make the sustainability reporting similar. The governmental bodies and the industry associations are supposed to be on the frontline in developing interoperability of different blockchain systems to facilitate data sharing and verification throughout the supply chain.

2. Encourage Blockchain Implementation: The policymakers need to think of the introduction of incentives to encourage the use of blockchain-based sustainability reporting systems by businesses. These incentives may be tax breaks, subsidies or regulatory benefits to those companies who incorporate blockchain in its supply chain. These would not only motivate the adoption but would also create a more competitive sustainability product market.

3. Dispel Technological and Cost Obstacles: It might be difficult to afford the excessive initial expenses of adopting blockchain systems, especially by companies, especially by small and medium-sized enterprises (SMEs). To mitigate this problem, governments and other non-governmental organizations can provide financial aid through low-interest loans or grants to SMEs to embrace blockchain technology. Besides, technology companies focused on blockchain may come up with cheaper models that serve small businesses.

4. Focus on Education and Training: To succeed in the introduction of blockchain, one will be required to alter the organizational culture. It is suggested that companies should invest in the training process in order to build internal competence in terms of the blockchain technology and the way it can be applied to the sustainability reporting. This will not only increase the effectiveness of the blockchain adoption, but will also enable the employees to value its value strategy in increasing transparency and reduction of greenwashing.

5. Future Research Focus: Future research should be aimed at studying the sustainability of the blockchain implementation on the supply chain with its long-term outcomes. Studies should be conducted on its impact on the corporate environmental performance, consumer purchase behaviour and the efficacy of blockchain in curbing greenwashing across different industries. Moreover, other areas that researchers should consider to apply blockchain to more broad ethical issues are the need to improve supply chain labor rights and environmental justice. The further research would contribute to the gaining of a better understanding of how blockchain can support the establishment of sustainable and equitable business activities in the international context by expanding its implementation.

Lastly, blockchain has an immense prospect of changing the principle of sustainability reporting in supply chains. It will have certain difficulties to be overcome, but its benefits of enhancing the transparency, reducing the greenwashing and overall raising corporate responsibility are enormous. By concentrating on these concerns and promoting cooperation on the industry level, blockchain can become the main contributor to promoting more sustainable, ethical, and transparent business practices in the world.

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