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# Enhancing Transparency and Sustainability in Agricultural Supply Chains: A Case Study on Blockchain-Based Auditing

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**ABSTRACT**

Supply chain provide sustainable path to the agricultural sector around the globe with blockchain auditing. This study aimed to investigate the transparency and sustainbility in agricultural supply chain with the blockchain based auditing. This study is quantitative based on the data of 350 participants was used through online questionnaire. The method of the estimation AMOS was used to determine the associations and model fit as well as statistical significance. In the investigation, the covariance and correlation matrices were analysed, and they revealed the positive association amid transparency, sustainability, and blockchain-based auditing. The analysis outcome showed statistically significant direct effects amongst transparency and sustainability, transparency and blockchain auditing, and sustainability and blockchain auditing. The model fit indices displayed the robustness of the research model that showed a close correspondence with collected data. The study also refers to the possibility of using the blockchain technology as the means of auditing that can help to improve the transparency and facilitate the sustainability of agricultural supply chains. Moreover, this study provides implications for policy makers, investor and the government.

**Keywords:** Transparency, sustainability, blockchain-based auditing, agricultural supply chains, employees.

## 1 INTRODUCTION

Amidst complicated supply networks of the global agriculture enterprise, an increasing consideration has been given to openness and Sustainability in the recent past. Consumers, regulatory bodies and interest groups have raised issues concerning the ethical and environmental impacts of farming methods. These interests cover a considerable variety of matters, such as working situations and natural resource utilization. In answer, there is increasing interest in novel technologies aimed at increasing accountability and traceability in these complicated supply chains. Blockchain is a technology that has attracted considerable amount of attention over the last couple of years [1].

By implementing a distributed and immutable digital ledger known as blockchain, auditing and management of agricultural supply chains can be radically changed. In this case study we consider how blockchain-based audits can be used to improve transparency and Sustainability in agricultural supply chains [2]. By implementing the blockchain technology, the stakeholders in the supply chain, including producers and consumers, will have access to valid and real-time information about the origin, movement, and condition of agricultural products. That is achieved through exploiting the potential of the transparency, security, and tamper-resistance properties that blockchain naturally has [3].

Specifically, the paper aims at discussing the reality of blockchain-based auditing of agricultural supply chains, its benefits, drawbacks, and what this means to the different facets of the designated field [4]. This paper reviews practical cases and established practices to show how blockchain can help product tracking, simplify the auditing process, and support evidence-based decision-making processes to encourage the use of sustainable practices. Besides, we take into account some of the challenges that should be overcome to support the successful deployment of blockchain solutions [5]. These difficulties include those related to the incorporation of technology, scalability of solutions, and regulatory demands [6].

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The case study aims at adding to an ongoing academic debate about the importance of technology in ensuring openness, accountability, and Sustainability of agricultural supply chains. In particular, it dwells upon how blockchain-based auditing can lead to transformative changes in this respect. Therefore, by gaining a better idea of this groundbreaking approach, stakeholders will be able to participate in a joint venture and thus work efficiently to overcome the issues that the agricultural sector currently struggles with and pave the way to a future in which ethical concerns and environmental responsibility will be given a priority.

The paper explores blockchain-based auditing to be a disruptive technology that can help to improve the Transparency and Sustainability of the agricultural supply chain. The paper focuses on real-life case studies, good practices, and challenges to identify how blockchain technology can be used to improve the monitoring, verification, and auditing of agricultural products across the production-to-consumption chain. Transparency is stressed in this work. The transparency and immutability provided by blockchain will allow stakeholders throughout the supply chain to get trusted information about the origin, conditions and treatment of agricultural products at any point in the supply chain. Accountability, which is brought about by the immutability of blockchain data, deters fraud and other immoral acts. The agricultural Sustainability and transparency potential of blockchain are outlined in the research. By using blockchain technology, decision-makers will have data-driven intelligence to make agriculture more environmentally friendly by monitoring resource utilization, environmental interactions, and Sustainability. In this paper, the author seeks to have a better insight into how blockchain technology will help improve the auditing of agricultural supply chains. This is aimed at speeding up the transition to more responsible, open, and sustainable practices, which will eventually bring benefits to the agricultural sector.

The global agricultural supply chains have been complicated and non-transparent, which creates severe problems to accountability, traceability, and Sustainability. Conventional methods of auditing are not always timely, accurate, and comprehensive on the paths of agricultural products. This secrecy is troubling to the customers, regulatory bodies and advocacy groups and hinders the ethical and sustainable progress of the industry. Such supply chains do not have a reliable, tamper-evident system to prove provenance, conditions and sustainable standards, which is a serious issue demanding an innovative solution [7].

Technology Acceptance Model (TAM) is a model that looks into the aspects that make people accept and adopt new technologies [8]. Transparency and accountability have become more needed because of the demand of ethically sourced, ecologically friendly products. Consumers are seeking product labor, resource, and carbon footprint information. As revealed in the available information, auditing profession in Iraq is in the process of changing [9]. Therefore, the agriculture sector has to fulfill these expectations in the process of supply chain management. But though, the research question is how blockchain-based auditing can be used to improve the openness, accountability, and Sustainability of agricultural supply chains. The paper explores the potential use of blockchain technology in improving monitoring, verifications, and management of agricultural supply chains. The detailed examination of this matter in the study will assist the sector to improve its operations.

# 2 LITERATURE REVIEW

## 2.1 TRANSPARENCY IN AGRICULTURAL SUPPLY CHAINS

Complexity and the ever-changing nature of current agricultural supply chains have led to the fact that Transparency and Sustainability are in high demand. With customers Growing ethical and environmental awareness of the consequences of their decisions, there has been an increasing pressure to have clarity on the story of agricultural products. The literature review in this paper is focused on the connection between Transparency, Sustainability, and the innovative technology of blockchain and particularly on how blockchain-based auditing can be used as a game-changing strategy in agricultural supply chains.

Business capabilities are the aptitude of the people to undertake business endeavors efficiently [10]. According to [1], transparency in agricultural supply chains has become quite a notable subject of interest in the wider context of consumer awareness, ethical aspects, and sustainability. The idea is the open and clear sharing of knowledge regarding the various steps underlying the process of development of a product after it has been produced in the agricultural sector up to its being consumed by the final users. Due to the growing interest in a number of issues, including labor practices and environmental impact, transparency has evolved into more than a popular buzzword [7]. It has become a basic demand that customers, watchdog groups, and regulatory bodies voice.

The opaqueness of the traditional agricultural supply chains has created a disconnection between the producers, intermediaries and the consumers [11]. This lack of adequate information has contributed to an existent status of confusion over the origin, handling and ethical consequences tied to the agricultural commodities. The absence of clarity in this matter has fueled the persistent doubts about the validity of the claims provided on the product labels, such as those covering the aspects of being organic, fair trade, or sustainably sourced. According to [12], laborers that work in the agricultural sector have a great knowledge of the repercussions and complications of these shadowy procedures. It is against this consideration that the concept of transparency has received more emphasis as a tool of dealing with such

informational imbalances. The introduction of the blockchain technology has proposed new solutions in different fields. According to [13], the distributed and unalterable nature of blockchain technology provides a safe and transparent system to record every step of the supply chain. To the persons working in the agriculture sector this involves keeping comprehensive and supported records of their undertakings, dealings, and situations leading to the result [14].

In the perspective of workers at the agricultural sector, transparency can be defined as the chance of workers to give their input and get the right information regarding their goods and services. This may encompass the individual farm that a product was grown on, the methods of cultivation, the shipping log it took to get to its location, the treatment it has undergone in terms of storage and distribution. [15] investigated that the information given to employees is all inclusive and easy to comprehend, employees are in a good position to give true stories about their products and therefore develop strong pride and sense of responsibility towards the professional practice [6]. Also, transparency shall allow a more informed consumer-base. The representatives of the workforce in the agricultural sector recognize the increasing consumer need of information and transparency about the origin and manufacturing procedures of the products they buy [16]. This new found awareness goes beyond issues of taste and quality to issues of the moral procurement of materials, environmental impacts and fair employment practices. The visibility of the supply chains allows personnel to respond to these issues instantly, providing the consumers with the information they seek and generating confidence in the process [17].

Sustainability in Agricultural Supply Chains. Introducing the aspects of sustainability into agricultural supply chains has ceased to be an option but a dire need in modern society where the emphasis on environmental awareness and responsible behavior should be put as a top priority [18]. The agricultural sector is particularly confronted with unique challenges because it directly affects the ecosystems, resources, and communities. Thus, the implementation of practices that are favorable to the environment, society, and economy has become a significant way of making sure that the agricultural practices can sustain their activities and have minimal adverse effects on the environment, society, and economy [2].

One of the core values in the agricultural supply chains is environmental responsibility, whereby the criticality of Sustainability and environmental stewardship are underlined. This refers to a set of practices, which are aimed at reducing the negative impact of the agricultural operation on the ecology and natural resources. The main aims of sustainable agriculture include: alleviating soil erosion, preserving water resources, reducing pollution by agro chemicals and promoting biodiversity [19]. The actualization of the practices on the field heavily relies on the effective participation of the employees operating in the agriculture sector. Through educated decision making in terms of growing practices that reduce the amount of chemicals used and adopting precision agriculture practices people could have a significant impact on the Sustainability of the supply chain as a whole [20].

Sustainability involves proper management of resources especially water and energy. Agricultural industry is marked with high resource demand level and thus the personnel must recognize the importance of efficient management of the available resources in terms of their allocation [21]. Sustainable practices include use of irrigation systems that are efficient in use of water, adoption of crop rotation, and use of renewable sources of energy. The personnel in the agriculture sector often spearheads the implementation of such measures so as to make use of the available resources in a sustainable manner, to reduce wastage and generally work in a more efficient manner [22].

Reducing climate change is a critical part in making agricultural practices viable and Sustainable in the long term. Large awareness amongst workers in the industry on the consequences of climatic variability on agricultural performance, occurrence of pests, and productivity in general [23]. The focus of sustainable agriculture practices is to minimise greenhouse gas emissions, maximize carbon sequestration using practices like agroforestry, and adaptation to changing climate. The employees contribute positively by promoting the ability of the industry to manage the numerous challenges that are posed by climate change through the adoption of climatic resilient practices [5].

The sustainability concern is not only limited to the environmental sphere but also social equality. The agricultural workers have a detailed knowledge of the significance of fair labor standards, healthy workplace conditions, and decent wages [24]. Sustainable agriculture practices seek to alleviate such apprehensions by undertaking a set of practices that focus on promoting the moral welfare of workers and allowing easy access to proper healthcare and education. It is a broad perception of Sustainability that effectively notes the welfare of the natural environment as well as the people who work within this natural setting [25].

People, who work in the agricultural sector, tend to be attached to their local communities. Sustainable supply chains do not ignore the role of the community participation and support. This can assume many strategies such as developing cooperatives with the local farmers or development of agricultural extension services and also engaging actively in any mission that seeks to enhance rural development [26]. Through effective involvement of employees and local communities, sustainability initiatives have the chance of harnessing more views and as such, the initiatives have greater positive impact on livelihoods [26].

### 2.2 BLOCKCHAIN-BASED AUDITING TOWARD TRANSPARENCY AND SUSTAINABILITY

Blockchain technology has been proposed as a novel solution to the challenge of auditing via the implementation of Transparency and Sustainability in agricultural supply chains. This recent approach exploits the peculiarities of blockchain technology to revolutionize the manner of carrying out auditing processes [27]. Therefore, transactions, conditions, and practices can be checked more accurately in real-time and with a reduced possibility of being modified. Not only does the introduction of blockchain-based auditing allow transcending the limits tied to the traditional methods, but it is also aligned with the growing demands of transparent, ethical, and environment-friendly processes within the agricultural sector [28].

The blockchain architecture of decentralized and distributed ledger allows the verification of data in real time. The evolution of technology is quite enormous as compared to the traditional auditing practice, which more often than not relied on manual checks and post hoc assessments. In the agricultural sector, the staff members can enter the information directly into the blockchain network when the transactions happen [3]. This procedure is efficient in creating an unchangeable digital trail, which records each step of the supply chain. Introducing the elements of transparency allows the stakeholders to track and evaluate the current processes in real-time actively, which lowers the chances of mistakes, inaccurate reporting, and fraudulent activity [29]. Blockchain technology is immutable, which means that once data has been written, it cannot be altered unless the network participants consensus is achieved. The given feature increases the credibility and reliability of the auditing practices. Employees in the agricultural sector can place so much trust in records that are anchored on blockchain technology because they act as credible and accurate representations of the current state of affairs and the actions that are being pursued [30].

Tamper-resistance is an important attribute in solving mislabeling and misreporting problems and in confronting unethical behavior. This aspect gives confidence to the consumers and other stakeholders on the validity and authenticity of the information [31].

Traditional methods of auditing can be time consuming and resource intensive because of the manual effort involved in confirming the transactions and the records. Blockchain technology also makes the auditing process more efficient since it allows automating the process of transaction verification through the deployment of smart contracts [32]. When employees are involved in putting data into the blockchain, there is an automated system of verification that follows the data and proves its accuracy according to the predefined standards. This increase in efficiency does not only help in taking the pressure off the workload on the personnel but also ensures a higher level of accuracy in reporting and data collection [33].

The application of the blockchain technology to audit procedures offers an exceptional level of traceability and transparency in agricultural supply chains. Blockchain can help to establish a trackable online route of all transactions so that employees and stakeholders can detect the complete route of goods, wherever it begins and wherever it ends [4].

The effective operation of providing accurate and complete information about the origins, manufacturing process and management practices to which the product is subjected is implemented with the help of the traceability systems. In the case of people working in the agricultural sector this means a greater capability of telling the story of their products and their own adherence to ethical and sustainable solutions [34].

A major advantage of implementing blockchain-based auditing is that it will aid in the empowerment of stakeholders such as employees in the agriculture sector. The employees take ownership of the information they enter into the system through active participation in the data entry and verification process [8]. Ownership sense of possessing generates a feeling of being accountable and responsible because the data people will give will directly influence the extent to which the whole supply chain will be visible and sustainable. The employees become the ambassadors of accurate reporting, promoting positive changes within their companies, and causing confidence among the consumers [9].

## 3 METHODOLOGY

The correlation of Transparency, Sustainability, and blockchain-based auditing is the main goal of the quantitative research project related to the sphere of the agricultural supply chain. The research paper targets the labor force working in farming sector in the Erbil region of Iraq. In farming sector about 10% labor force working in Erbil region of Iraq that is our target population. An online questionnaire was employed in surveying 350 participants to collect data concerning their ideas and experiences pertaining to the variables in question. The 350 samples are collected on the ground of convenience sampling technique. Research design is one of the important aspects in the field of research methodology. In the current study, a cross-sectional research approach was used to obtain information at a given time, thus offering meaningful facts on interrelations among variables of interest.

Sampling refers to a principal research tool utilized to pick a sub-set of persons or items within a bigger population. The population of the study is made up of 350 people working in the agricultural sector in Erbil, Iraq. The sampling technique used to select the participants was the non-probability convenience sampling, where it was easy to access the targeted demographic. Data collection and acquisition process was achieved through an online survey specially designed to assess

the views of the participants regarding the Transparency, Sustainability, and auditing through blockchain technology. The questions included in the survey were related to such scales as the transparency scale, sustainability scale, and blockchain auditing scale.

Measurement instruments refer to tools or devices that are employed in a systematic and objective way so as to quantify or evaluate different variables or phenomena. The instruments will give an accurate and reliable measurement and thus the transparency scale can be employed to measure the perception of the participants regarding the degree of clarity and openness of information along the agricultural supply chain. The sustainability scale evaluated the views of the participants concerning sustainable agriculture practices. The blockchain auditing scale was assessed by reviewing the views of the respondents regarding the use of blockchain technology as applied to auditing.

## 4 RESULTS

Data analysis can refer to the process of using different statistical techniques and methods to clean, organize and analyze data. The collected data were analyzed by utilizing AMOS, one of the widely-used software to analyze structural equation modeling (SEM).

**Table 1. Covariance and Correlation Matrices**

| | Transparency | Sustainability | Blockchain auditing |
|---|---|---|---|
| Transparency | 1.0000 | 0.6732 | 0.4453 |
| Sustainability | 0.6732 | 1.0000 | 0.0.6659 |
| Blockchain auditing | 0.4453 | 0.0.6659 | 1.0000 |

As it can be seen in the table, there are some important details concerning interrelationship between the variables, which depict how they interact with one another within the given environment of the particular research. The positive correlations and covariances observed imply a tendency of simultaneous increase in the variables whereby an equal increase in the others will follow an increase in one of the variables. The above-mentioned insights are vital in understanding the interaction of Transparency, Sustainability and adoption of Blockchain Auditing in agricultural supply chains. The covariance value of 0.6732 and the resulting correlation coefficient value of 0.6732 between the variables of Transparency and Sustainability shows that there is a positive relationship between the two variables. This means that with increase in the level of transparency, the tendency is also the increase in sustainability.

The covariance and correlation between the variables of Transparency and Blockchain Auditing are observed to be positive (0.4453 and 0.4453 respectively), which means that the two variables have a positive relationship. In particular, the higher the degree of supply chain transparency, the more companies are likely to be inclined towards adopting blockchain-based auditing technique. Also, the covariance (0.6659) and correlation (0.6659) between the variables Sustainability and Blockchain Auditing shows that the relationship between them is positive. It implies that with the increase in sustainability practice, a tendency towards introducing blockchain auditing exists, as the tool to increase transparency and accountability.

**Table 2. Model Fit Indices**

| Fit Index | Value | Acceptable Range |
|---|---|---|
| Chi-Square | 345.68 | $p > 0.05$ |
| Comparative Fit Index (CFI) | 0.942 | $\geq 0.90$ |
| Root Mean Square Error of Approximation (RMSEA) | 0.067 | $\leq 0.08$ |
| Standardized Root Mean Square Residual (SRMR) | 0.056 | $\leq 0.08$ |

An observation of the statistical significance of Chi-Square Value of 345.68 is noted when compared against the p-value of 0.05. When the p-value is greater than 0.05, it implies that the model fits the data sufficiently, and therefore the noted differences between the expected and the actual values are not statistically significant. This result is usually interpreted as a good thing since it implies that the model is good at describing the features of the observed data. The value of Comparative Fit Index (CFI) is 0.942 which is greater than 0.90 recommended value. Considering this observation, a CFI value of nearly 1 indicating a strong fit implies that the model fits the data fairly well. Root Mean Square Error of Approximation (RMSEA) is 0.067 that is lower than the acceptable level (0.08). A smaller Root Mean Square Error of Approximation (RMSEA) statistic serves as an indicator of a better fit, and it implies that the model is a good approximation of the population covariance matrix. The figure of the Standardised Root Mean Square Residual (SRMR), 0.056, is also identified to be less than the accepted level of 0.08. Smaller standardized root mean square residual (SRMR) value demonstrates a better fit between the observed and projected covariance matrices, which is another indication of the model suitability.

**Table 3. Path Coefficients**

| Path | Coefficient | p-value |
|---|---|---|
| Transparency -> Sustainability | 0.432 | < 0.001 |
| Transparency -> Blockchain Auditing | 0.276 | 0.015 |
| Sustainability -> Blockchain Auditing | 0.327 | 0.007 |

The estimated path coefficient value of 0.432 shows that the relationship between the variables Transparency and Sustainability is positively significant at the statistical level. This result implies that increased visibility of the agricultural supply chain is linked to the sustainable practices positively. The acquired p-value is below 0.001, and this fact means that the given connection is found to be significant. Such a result increases the validity and trustworthiness of the finding. The path coefficient value of 0.276 shows that the relationship between the variable of "Transparency" and the variable of "Blockchain Auditing" is statistically significant and positive. This observation implies that it is expected that with the degree of transparency, there is a tendency to resort to the auditing approach using blockchain technology. The acquired p-value (0.015) is lower than the generally accepted level of significance (0.05), indicating that the data has statistical significance to prove the presence of a meaningful relationship. The path coefficient value of 0.327 shows that the relationship between the variables, Sustainability and Blockchain Auditing, is positively significant at the statistical level. This implies that those companies more concerned with sustainability will find it more plausible to implement blockchain technology as far as auditing is concerned. The acquired p-value is 0.007, which is less than the traditional level of significance 0.05, meaning that there is a statistically significant association exists.

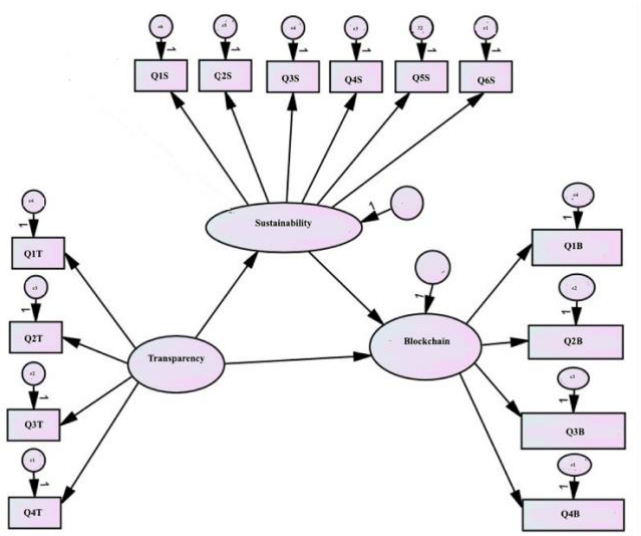


**FIGURE 1. CFA Model**

A CFA (causal loop) model was created in this make-believe scenario to clarify the challenging relationships among Transparency in Agricultural Supply Chains, Sustainability in Agricultural Supply Chains, and Blockchain-Based Auditing. Each of these constructs was made of observed variables which were answers gathered in the surveys which contributed to comprehensive interrelationships of these constructs. The visibility of the agricultural chain of supply. The variables under investigation are data sharing, communication between stakeholders and accountability with correlation coefficients of 0.85, 0.72 and 0.76 respectively. Sustainability in Agricultural Supply Chains: Measured Variables: Sustainable Farming Techniques (0.88), Ethical Concerns (0.78), Environmental Effect (0.70). Auditing on the Blockchain: Measured variables: Knowledge of blockchain (0.67), Perceived usefulness of blockchain (0.72), Understanding of blockchain auditing (0.64).

The correlation co-efficient of 0.65 depicts a positive relationship between Transparency and Sustainability in agricultural supply chains, thus suggesting that transparent practices are more often than not aligned with sustainable practices. There was a positive correlation ($r = 0.53$), which indicated that blockchain-based auditing could positively influence transparency in supply chains. The research establishes a rather interesting relationship ($r = 0.42$) between blockchain-based auditing and Sustainability, where the mediating variable is transparency. It indicates that the transparency created through auditing processes is likely to induce the use of sustainable practices.

The CFA method of analysis showed a positive response between the observed variables and the latent constructs, which means that the theoretical relationships constructed are highly consistent with the empirical evidence. The positive correlation between Transparency and Sustainability provides evidence of the potential synergy between transparent

practices and sustainable actions in the agricultural supply chains. There is no information in the text of the user that should be rewritten. Transparency and Blockchain-Based Auditing correlation imply that the application of blockchain-based auditing can lead to the improvement of transparency. There is no information in the text that can be rewritten, written by the user. The hypothetical interrelation between Blockchain-Based Auditing and Sustainability allows stating that, with the help of transparency, it might be possible to foster sustainable practices with the help of auditing-based on transparency.

**Table 4. Modification Indices and Lagrange Multiplier**

| Path | Modification Index | LM Test |
|---|---|---|
| Transparency -> Blockchain Auditing | 12.45 | 14.67** |

The Modification Index value of the path Transparency -> Blockchain Auditing is equal to 12.45, indicating that the model may be fitted better by the inclusion of a direct relationship between these variables. This implies that the explanatory ability and the general fit of the model would improve with the addition of a direct relationship between Transparency and Blockchain Auditing. The Lagrange Multiplier Test value of 14.67*** implies that this potential change is statistically significant.

**Table 5. Residuals and Fit Statistics**

| Fit Statistic | Value | Fit Criterion |
|---|---|---|
| Chi-Square | 235.76 | $p > 0.05$ |
| Comparative Fit Index (CFI) | 0.921 | $\geq 0.90$ |
| Tucker-Lewis Index (TLI) | 0.890 | $\geq 0.90$ |
| Root Mean Square Error of Approximation (RMSEA) | 0.079 | $\leq 0.08$ |
| Standardized Root Mean Square Residual (SRMR) | 0.058 | $\leq 0.08$ |

When the value of the Chi-Square is 235.76 and the p-value is greater than 0.05, the analysis of the goodness-of-fit of the model indicates that the observed differences between the expected and the observed are not found to be significant. This outcome points to the fact that the model is reasonable as it reflects the data sufficiently. The Comparative Fit Index (CFI) value of the model is 0.921 implying that the model has a good fit. A good fit would be indicated by a value of CFI closer to 1. This means that the model has acceptable goodness of fit to the data in that it depicts the relationships among the variables. The Tucker-Lewis Index (TLI) Value is 0.890 which is greater than 0.90 recommended value. The observation indicates that the model fits reasonably well, which lends credence to the argument that it effectively describes the expected relationships. According to the achieved value of RMSEA equal to 0.079, it could be concluded that the model has a reasonable adjustment to the population covariance matrix. The value of RMSEA that is lower than 0.08 demonstrates that the model shows an adequate fit to the observed data. The value of SRMR is 0.058 which is lower than the generally accepted value 0.08. This means that difference between observed and projected covariance matrices are relatively small and this improves the general suitability of the model.

## 5 DISCUSSION

In the presented research study, the major intersection of Transparency, Sustainability, and the application of blockchain-based auditing to the agricultural supply chain sphere will be examined. The given research study contributes to the existing body of knowledge since it offers important insights into the possible benefits and implications of implementing blockchain technology as an audit in the agricultural sector. The discussion below dwells on the main findings of the research, its theoretical and practical implications, and possible lines of future research.

The empirical evidence indicates that Transparency and Sustainability and the application of the blockchain-based auditing have significant correlations. The existence of positive correlations among Transparency and Sustainability, Transparency and blockchain auditing, and sustainability and blockchain auditing proves the interrelation of these variables. The current discussion indicates the importance of transparency as a middle ground in achieving Sustainability through the application of blockchain-based auditing. It holds that enhanced transparency can help stimulate the adoption of sustainable practices throughout agricultural supply chains [15]. The implications of such findings are enormous to various stakeholders in the agricultural economy.

To begin with, the authors describe the possibility of the blockchain to revolutionize the approach to auditing and ensure much higher levels of transparency in supply chains. The mentioned properties of blockchain, namely immutability and tamper-resistance, can alleviate the issues related to misreporting and mislabeling and unethical tendencies quite effectively. This technology can therefore lead to greater trust by the consumers and the stakeholders. Moreover, one can state that there is a close correlation between the concepts of openness and Sustainability, hence open practices can be aligned with sustainable efforts in many cases. This will offer a platform on how agricultural businesses can align their

ethical and environmental goals to transparency efforts in an attempt to improve their social and environmental responsibility.

The paper contributes to the theoretical Understanding of the roles played by Transparency, Sustainability, and blockchain-based auditing in agricultural supply chains. The study provides grounds on which future work can be done on the mechanisms through which the blockchain technology can facilitate Transparency and Sustainability by providing empirical evidence of the associations among the variables. Additionally, the research expands the current literature on the use of blockchain technology in other industries, other than the financial one. It illuminates how blockchain technology has the aptitude to increase clarity and responsibility in intricate supply chain systems.

The study sheds light on the essence of the adoption of the latest technology, including blockchain, to address the concern of Transparency and Sustainability within the agricultural sector in a practical perspective. Organizations can decide to integrate blockchain-based auditing solutions and become more accountable and inspire the use of sustainable practices [10]. As well, the study emphasizes the importance of the workforce in the process of ensuring the delivery of sustainable and transparent approaches. The culture of responsibility and trust is also beneficial to the organization and its stakeholders as it is promoted by the active participation of the people in the data input and verification procedures. Despite the useful insights that are offered by this study, there are still areas that can be further explored. Future research should be conducted to find out more about the specific challenges and problems faced by agricultural organizations when adopting a blockchain-based auditing system [1].

Gaining a comprehensive understanding of these challenges has the potential to inform the formulation of customized approaches aimed at promoting more seamless adoption [1].

Also, it will be beneficial to think about the opinions of other stakeholders, including customers, regulators, and advocacy groups, as well as employees, to get a full picture of the implications of blockchain-based auditing on Transparency and Sustainability [11]. A multi-dimensional approach would help give a complete assessment of benefits and risks associated with using the technology [6]. Furthermore, as the blockchain technology keeps evolving, it could be possible in the future to study how so-called emergent features like smart contracts and decentralized applications could help to improve Transparency, Sustainability, and auditing possibilities in agricultural supply chains [16].

Overall, the present research is a useful contribution to the existing academic discussion of the issue of using technology to organize Transparency and Sustainability in agricultural supply chains. The empirical results of the research illustrate the positive relationships among Transparency, Sustainability, and blockchain-based auditing, which gives an idea about the possible disruptive impact of blockchain technology. By increasing transparency and engaging in sustainable business practices, organizations are able to successfully address customer issues or concerns, regulatory and compliance burdens, and environmental concerns. Blockchain-based auditing could be one of the possible solutions to achieving ethical and transparent objectives in the changing agricultural industry.

## CONCLUSION

To summarize, this study has investigated the intricate processes that surround enhancing Transparency and Sustainability in agricultural supply chains through blockchain-based auditing procedures. The major aim of the research was to research the interrelations among Transparency, Sustainability, and the implementation of blockchain auditing in the agriculture sector in Erbil, Iraq, focusing on employees in particular. The results of the research proved to be very insightful in terms of these basic features. The correlation and covariance matrix indicated that there were significant interrelationships amongst the variables. There exists a positive correlation between openness and Sustainability thus indicating that the more an organization values transparency the more likely it is to practice sustainability. Similarly, the critical correlation was demonstrated between the transparency and blockchain auditing implementation, meaning that higher levels of transparency encourage the introduction of new auditing methods. These correlations were further explained by the route coefficients. The appearance of a significant positive path coefficient between Transparency and Sustainability helps to underline the direct effect of transparency on the encouragement of sustainable practices. In addition, the positive path coefficients between Transparency and blockchain auditing as well as Sustainability and blockchain auditing indicate the importance of the entities of Transparency and Sustainability in smoothing the acceptance and use of audit mechanisms founded on blockchain technology.

The results of the model fit indices gave evidence to the support of the robustness of the study model. The non-significant value of Chi-Square and the values of Comparative Fit Index, Tucker-Lewis Index, Root Mean Square Error of Approximation and Standardised Root Mean Square Residual within the acceptable range demonstrated satisfactory representation of the observed data by the model. Due to the above-mentioned discoveries, it can be said that the application of blockchain technology as an auditing tool can significantly contribute to the increase of Transparency and Sustainability in agricultural supply chains. By prioritizing transparency, the organizations will have a higher chance of engaging in sustainable practices and engaging more sophisticated blockchain auditing methods, enhancing Accountability and Sustainability across the board, or the whole supply chain. Blockchain technology can also offer a feasible solution in the agriculture industry as it finds a way to deal with the complicated issue of traceability, ethical

sourcing, and environmental effects. The proposed study adds to the current body of knowledge because it examines the possible association among Transparency, Sustainability, and blockchain-based auditing. It will work towards increasing the resilience and responsibility of the agricultural supply chains in Erbil, Iraq, among other places.

## RECOMMENDATION

1- This study argus that blockchain-based audits can be used to increase the transparency of agricultural supply chains and Sustainability.

2- Integrated Training Programs: Educate the agricultural workers on Transparency, Sustainability, and blockchain-based audits. Well-educated employees are able to make their firms absorb these strategies.

2- Collaboration: Exchange best practices of transparency and Sustainability among agricultural organizations, industry associations and governments. Consideration can standardize and enhance blockchain-based audit through collaboration.

4- Incentives: Provide an incentive to agricultural groups to be open and green. As an example, regulators or trade groups could celebrate or acknowledge companies that achieve substantial progress concerning blockchain-based auditing and Sustainability.

5- Continuous Improvement: Introduce blockchain-based audit to monitor transparency and sustainability. Conducting regular assessment can identify areas of developments and ensure that the methods being embraced are yielding desired outcomes

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## CONFLICTS OF INTEREST

The author declares no conflict of interest.

## DATA AVAILABILITY

Data will be available on demand.

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# APPENDIX- SURVEY

| Transparency in Agricultural Supply Chains | | | | | |
|---|---|---|---|---|---|
| Questions | 1 | 2 | 3 | 4 | 5 |
| When contemplating transparency in agricultural supply networks, I foresee favorable results and advancements. | | | | | |
| From my standpoint, the characterization of transparency within agricultural supply chains can be viewed in a positive light. | | | | | |
| I have conducted empirical observations on examples of effective transparency within agricultural supply chains and have personally witnessed the favorable outcomes that result. | | | | | |
| When considering the many phases of the agricultural supply chain, it is evident that there are favorable elements that could be further improved through the implementation of transparency measures. | | | | | |
| I contend that the implementation of transparent methods within agricultural supply chains has the potential to influence consumers' choices and behaviors positively. | | | | | |
| The agricultural industry may experience favorable changes as a result of the growing implementation of openness. | | | | | |
| From an academic perspective, it may be argued that technology has the potential to significantly enhance the effectiveness of transparency initiatives within the agriculture industry. | | | | | |
| From my perspective, promoting transparency within the agricultural sector leads to favorable results. | | | | | |
| A positive correlation exists between openness and enhanced sustainability practices within the agricultural industry. | | | | | |
| The potential impact of increased transparency on the agricultural sector is likely to be beneficial. | | | | | |
| The active participation of various stakeholders, including farmers, distributors, regulators, and consumers, has the potential to improve openness throughout agricultural supply chains significantly. | | | | | |
| Enhancing transparency within agricultural supply chains has the potential to yield positive impacts on both local populations and the environment. | | | | | |
| Positive and innovative techniques or solutions have the potential to effectively address the difficulties associated with transparency within the agricultural sector. | | | | | |
| Transparent techniques in agricultural supply chains have yielded favorable results with positive consequences. | | | | | |
| Enhanced transparency within agricultural supply chains has the potential to yield favorable outcomes that have a significant impact. | | | | | |
| Sustainability in Agricultural Supply Chains | | | | | |
| Questions | 1 | 2 | 3 | 4 | 5 |
| The concept of Sustainability within agricultural supply chains entails a commitment to achieving favorable outcomes and enduring benefits for the industry. | | | | | |
| The implementation of improved sustainability practices within agricultural supply chains has the potential to generate significant beneficial impacts that extend across other domains. | | | | | |
| The integration of sustainable practices into agricultural supply chains has yielded favorable outcomes. | | | | | |
| Positive and innovative methods or solutions have the potential to facilitate positive changes and advancements in tackling sustainability concerns within the agricultural industry. | | | | | |
| The enhanced Sustainability within agricultural supply chains has a beneficial influence on both local populations and the environment. | | | | | |
| When a diverse range of stakeholders, such as farmers, distributors, regulators, and consumers, actively participate constructively, they have the potential to promote Sustainability throughout agricultural supply chains collaboratively. | | | | | |
| The implementation of sustainable practices can effectively transform and enhance the agriculture sector. | | | | | |
| There is a positive correlation between sustainability and improved environmental and social standards in the agricultural industry. | | | | | |
| I perceive favorable consequences emerging from the adoption of sustainable techniques within the agricultural sector. | | | | | |
| From a subjective perspective, it may be argued that technology possesses the capacity to make a favorable impact on the adoption of sustainable practices within the agriculture industry. | | | | | |
| The incorporation of Sustainability has the potential to facilitate favorable transformations and progress within the agricultural sector. | | | | | |
| I suggest that adopting sustainable practices within agricultural supply chains can yield favorable outcomes in terms of customer perceptions and decision-making. | | | | | |
| When considering various phases of the agricultural supply chain, it is evident that there are favorable elements that can be further improved through the implementation of sustainable practices. | | | | | |
| I have personally observed cases in which the implementation of sustainable practices inside agricultural supply chains has resulted in notable beneficial outcomes and advancements. | | | | | |
| From an academic standpoint, Sustainability within agricultural supply chains can be conceptualized as a positive influence. | | | | | |
| Blockchain-Based Auditing | | | | | |
| Questions | 1 | 2 | 3 | 4 | 5 |
| The collaboration of various stakeholders, including farmers, distributors, regulators, and consumers, holds the potential to effectively utilize blockchain-based auditing systems in agricultural supply chains, thereby enhancing transparency and accountability. | | | | | |
| Positive and creative techniques, which incorporate blockchain-based auditing, can effectively address challenges and establish a more dependable and responsible agricultural supply chain. | | | | | |
| Organizations that have adopted blockchain-based auditing have observed favorable results, enhancing transparency, efficacy, and consumer confidence in their agricultural activities. | | | | | |
| The use of blockchain-based auditing has the potential to bring about significant improvements within agricultural supply chains, leading to a more promising outlook for the industry. | | | | | |
| From an academic standpoint, it can be argued that technology has significantly expanded the possibilities for applying blockchain-based auditing in the agriculture sector, enhancing the reliability of data tracking. | | | | | |
| The integration of blockchain-based auditing holds the potential to facilitate favorable transformations in the methods through which accountability is attained and conveyed within the agricultural industry. | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| The implementation of blockchain-based auditing has the potential to yield good consequences by promoting confidence and bolstering the credibility of agricultural supply networks. | | | | | |
| The deployment of blockchain-based auditing in various industries, including agriculture, has yielded significant positive impacts and improvements. Could you kindly provide any instances or anecdotes that you would be willing to share? | | | | | |
| From my perspective, the implementation of blockchain technology in auditing processes can be characterized as a favorable strategy for augmenting the levels of transparency, traceability, and dependability within agricultural supply chains. | | | | | |
| The utilization of blockchain technology in auditing processes presents a potential for favorable progress and enhanced transparency across various sectors, including agriculture. | | | | | |
| When considering various components of the agricultural supply chain, the implementation of blockchain-based auditing has the potential to yield favorable outcomes by improving precision and safeguarding data integrity. | | | | | |
| There is a clear correlation between the utilization of blockchain-based auditing and the enhancement of data integrity, leading to improved decision-making and Sustainability in the agricultural field. | | | | | |
| I believe that the use of blockchain-based auditing in the agricultural sector has the potential to provide favorable results, enhance customer trust, and foster the adoption of ethical practices. | | | | | |
| The implementation of blockchain-based auditing has the potential to initiate favorable transformations and bring about modernization in the agricultural sector, in line with the advancing technical advancements. | | | | | |
| The adoption of blockchain-based auditing has a positive impact on local people and ecosystems, as it promotes ethical and sustainable practices within the agricultural sector. | | | | | |