



Barriers to Blockchain Technology Adoption in the Halal Supply Chain: Insights from Manufacturers and Regulatory Authorities

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ABSTRACT

This study aims to identify and analyze the barriers to blockchain technology adoption within the halal supply chain, focusing on insights from manufacturers and regulatory authorities. Using a library research approach, the study synthesizes existing literature and relevant case studies to explore key challenges, including technological readiness, regulatory constraints, cost implications, and stakeholder collaboration. The findings reveal that lack of awareness, inadequate infrastructure, and misalignment of regulatory frameworks significantly hinder blockchain integration in halal supply chains. These insights underscore the need for enhanced education, policy harmonization, and investment in technology to facilitate adoption. The study's implications highlight pathways for stakeholders to overcome these barriers, thereby enhancing transparency and trust in the halal supply chain.

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INTRODUCTION

The integration of blockchain technology into various industries has revolutionized traditional practices by enhancing transparency, traceability, and efficiency. In the halal supply chain, where adherence to Islamic principles and ethical standards is paramount, blockchain holds significant potential to address longstanding challenges (Maulidizen, 2019a). The halal industry, a rapidly expanding market driven by the global Muslim population and rising demand for halal products, requires robust systems to ensure compliance with halal standards. Blockchain technology, with its immutable ledger and decentralized structure, offers a solution to verify and document the authenticity and traceability of halal products across the supply chain (Maulidizen, 2024). However, despite its promise, the adoption of blockchain technology in the halal supply chain remains limited.

One of the key gaps in the adoption of blockchain technology in the halal supply chain lies in the lack of empirical research focusing on barriers faced by key stakeholders. Most

existing studies emphasize the benefits of blockchain technology but often overlook the practical challenges encountered during its implementation. This gap is particularly evident in the context of manufacturers and regulatory authorities, who play a critical role in ensuring halal compliance (Maulidizen, 2019c). Addressing their concerns and understanding their perspectives are essential to facilitate the adoption of blockchain technology.

Regulatory authorities are pivotal in setting and enforcing halal standards, yet they often face constraints in aligning blockchain technology with existing regulatory frameworks. These constraints include legal uncertainties, lack of technical expertise, and resistance to change. Similarly, manufacturers, who act as the backbone of the supply chain, encounter operational challenges such as high implementation costs, inadequate infrastructure, and lack of awareness about blockchain's potential benefits. These issues highlight the pressing need for a comprehensive examination of the barriers hindering blockchain adoption in this sector.

From a global perspective, the halal supply chain is inherently complex, involving multiple stakeholders across different geographical locations and regulatory systems. This complexity intensifies the challenges of adopting blockchain technology, as it requires interoperability, standardized protocols, and a unified commitment among stakeholders. The lack of a cohesive framework for blockchain adoption further exacerbates these challenges, leaving room for inefficiencies, fraud, and non-compliance in the halal supply chain (Maulidizen, 2019b).

The purpose of this study is to investigate the barriers to blockchain technology adoption in the halal supply chain, specifically focusing on the perspectives of manufacturers and regulatory authorities. By identifying and analyzing these barriers, the study aims to bridge the gap between theoretical potential and practical implementation. The findings are expected to offer actionable insights for stakeholders, enabling them to overcome challenges and leverage blockchain technology to enhance the integrity of the halal supply chain (Mawardi et al., 2025).

This study employs a library research approach, analyzing existing literature, case studies, and reports related to blockchain technology and halal supply chains. By synthesizing data from secondary sources, the research aims to provide a holistic understanding of the barriers impeding blockchain adoption and their implications for stakeholders. This methodology is particularly suited to exploring emerging issues where primary data may be limited or inaccessible. The results of the study highlight a combination of technological, regulatory, and organizational barriers that hinder the adoption of blockchain technology. For manufacturers, the high cost of implementation, lack of technical expertise, and concerns about data security emerge as key challenges (Khoirunnisa & Maulidizen, 2024). For regulatory authorities, the absence of standardized blockchain frameworks, resistance to innovation, and legal ambiguities pose significant obstacles. These findings underscore the need for targeted interventions to address these issues and promote the adoption of blockchain technology.

The implications of this research extend to policymakers, industry stakeholders, and technology providers. For policymakers, the study emphasizes the importance of developing clear guidelines and regulations to support blockchain adoption in the halal supply chain. For manufacturers and other industry players, the research provides insights into overcoming operational and technological barriers. Technology providers, on the other hand, are encouraged to collaborate with stakeholders to develop cost-effective and user-friendly blockchain solutions tailored to the needs of the halal industry (Rege-Patwardhan, 2009). By addressing the barriers to blockchain adoption, this study contributes to the broader discourse

on digital transformation in supply chains, particularly in the context of halal products. The findings not only highlight the challenges but also offer a roadmap for fostering blockchain integration in the halal supply chain. This aligns with the global push towards sustainable and transparent supply chains, where blockchain technology plays a transformative role (Johari et al., 2024). This study aims to fill a critical gap in the literature by exploring the barriers to blockchain technology adoption in the halal supply chain from the perspectives of manufacturers and regulatory authorities. The insights provided by this research are expected to facilitate informed decision-making and pave the way for a more efficient, transparent, and compliant halal supply chain.

RESEARCH METHOD

This study adopts a qualitative research approach using library research to investigate the barriers to blockchain technology adoption in the halal supply chain. Secondary data were collected from peer-reviewed academic journals, industry reports, regulatory documents, and case studies related to blockchain technology, halal certification, and supply chain management. Key sources were identified through systematic searches in databases such as Scopus and Google Scholar, using relevant keywords like *blockchain technology*, *halal supply chain*, and *adoption barriers*.

The selection criteria focused on the credibility of sources and publication recency, prioritizing materials published within the last decade. The collected data were analyzed using a thematic approach. Recurring themes such as technological challenges, organizational constraints, and regulatory issues were identified and categorized to draw insights into the adoption barriers faced by manufacturers and regulatory authorities. Cross-referencing and triangulation of findings ensured the reliability of the analysis and provided a holistic understanding of the problem (Khan et al., 2019). The study emphasized comparing the perspectives of manufacturers, focusing on operational and economic challenges, with those of regulatory authorities, who are concerned with standardization and compliance. Given its reliance on secondary data, the study does not include primary data collection, which may limit the depth of stakeholder-specific insights. However, it offers a robust foundation for understanding the key challenges in blockchain adoption in the halal supply chain. Future research could complement this study by incorporating empirical data through interviews or surveys to validate and expand upon the findings.

RESULT AND DISCUSSION

Technological and Infrastructural Challenges

The integration of blockchain technology into the halal supply chain faces significant barriers, primarily stemming from technological and infrastructural challenges. These obstacles create substantial difficulties for both manufacturers and regulatory authorities, impeding the widespread adoption of blockchain as a tool to ensure transparency, traceability, and halal compliance across the supply chain. One of the most pressing challenges is the lack of interoperability between blockchain systems and the existing technologies used in traditional supply chain management. Many businesses, especially small and medium-sized enterprises (SMEs), rely on legacy systems, which were not designed to integrate with advanced technologies like blockchain. As a result, transitioning to blockchain can involve complex system overhauls that are both costly and time-consuming. The lack of a standardized approach to integrating blockchain across different actors in the supply chain further

complicates this issue, as manufacturers must invest significant time and effort into customizing blockchain solutions to fit their needs ([Sung, 2018](#))

For manufacturers, the integration process often requires overcoming technical barriers related to data migration and system compatibility. Manufacturers in the halal industry frequently use conventional software systems that are incompatible with blockchain-based solutions. As such, integrating blockchain into these existing frameworks requires expertise and additional resources that SMEs may not have ([Rijal Arifin & Wisudanto, 2017](#)). Moreover, blockchain adoption may involve a steep learning curve for manufacturers who are unfamiliar with the technology, requiring them to upskill their teams or hire external experts. For many SMEs, the cost of such investments in terms of both time and money is prohibitive. These small businesses, which play a crucial role in the halal supply chain, often struggle to keep up with the technological demands, and thus the adoption of blockchain remains a distant prospect for them ([M. H. Ali et al., 2021](#)).

Another significant challenge is the scarcity of IT resources and expertise. Blockchain technology demands specialized knowledge in fields such as distributed ledger systems, cryptography, and smart contracts. However, there is a shortage of skilled professionals in many regions, particularly in emerging markets, where the halal industry is growing. This lack of human capital results in delays in the adoption process, as manufacturers must either train their existing workforce or hire expensive external experts. Without the right talent, companies struggle to manage, implement, and maintain blockchain systems effectively. Furthermore, the halal supply chain, with its diverse set of stakeholders, requires a broad range of expertise to manage the complexities of blockchain integration. This includes ensuring that all parties—producers, manufacturers, distributors, and retailers—are on board with the technology and have the necessary training to use it effectively.

The high costs associated with blockchain adoption are another barrier that inhibits its widespread use in the halal supply chain. Implementing blockchain systems requires substantial investment in infrastructure, including hardware, software, and cloud storage services. These upfront costs can be a significant deterrent, particularly for SMEs that already face financial constraints. The operational costs of maintaining blockchain systems, such as network upkeep, security measures, and energy consumption, also add to the financial burden. For SMEs with limited budgets, these expenses may not justify the perceived benefits of blockchain, making them hesitant to adopt the technology. Additionally, these costs could be amplified in developing countries or regions where the halal industry is less established and where businesses have fewer resources to allocate to new technological innovations.

Even large manufacturers and regulatory bodies, which may have the necessary financial resources, face challenges when implementing blockchain. Regulatory authorities, in particular, must ensure that blockchain systems meet the legal and compliance requirements for halal certification, which is a highly regulated process. The halal supply chain involves strict guidelines for food safety, quality control, and ethical standards, and blockchain must be capable of verifying and documenting compliance with these standards in a transparent and immutable way. However, regulatory authorities often struggle to standardize blockchain frameworks and ensure that all stakeholders comply with the same regulations. This lack of standardized guidelines further complicates the widespread adoption of blockchain in the halal supply chain, as manufacturers and other actors are unsure of how to integrate blockchain with existing halal certification protocols.

In addition to the technical challenges, there are also significant concerns around data integrity and traceability. Blockchain promises to address these issues by providing a

transparent, immutable ledger that tracks every transaction in the supply chain. However, this is only achievable if the blockchain system is set up properly and integrated with existing data sources. Ensuring that data entered into the blockchain is accurate, reliable, and up to date is essential for ensuring traceability in the halal supply chain. For manufacturers, this requires careful planning and collaboration with regulatory authorities to ensure that the blockchain system can effectively track every product from its source to the consumer. Without proper data validation processes in place, blockchain technology could become ineffective, and the very transparency it promises could be undermined.

Additionally, the infrastructure needed to support blockchain technology in the halal supply chain is often lacking in many regions. Blockchain systems require significant computational power and data storage capacity, which may not be available in certain geographic locations or within certain industries. In some cases, blockchain networks may require high-speed internet connections and sophisticated hardware, both of which are not always readily accessible, particularly in developing countries. This disparity in technological infrastructure creates a gap in the ability of businesses and regulatory authorities to leverage blockchain effectively. For blockchain to be a viable solution, it requires a strong technological foundation, and without this, it becomes difficult to achieve the desired benefits of transparency, traceability, and halal compliance.

The lack of standardized frameworks for blockchain technology in the halal supply chain further contributes to these technological and infrastructural challenges. Regulatory authorities and manufacturers must work together to develop consistent standards for blockchain implementation. Without these standards, blockchain adoption is fragmented, and different players in the supply chain may implement incompatible solutions. This makes it harder to achieve the widespread adoption of blockchain and diminishes its effectiveness in improving the halal supply chain. A unified approach is required to ensure that blockchain can be integrated seamlessly across all sectors of the halal supply chain, ensuring that its benefits are fully realized.

As blockchain technology continues to evolve, there is hope that the challenges surrounding its adoption will be addressed. However, for blockchain to be effectively integrated into the halal supply chain, the technological and infrastructural barriers must be overcome. Manufacturers need access to the necessary resources and expertise, and regulatory authorities must develop standardized frameworks that ensure compatibility between blockchain systems and existing halal certification processes. The adoption of blockchain technology in the halal supply chain depends on the collaboration of all stakeholders to build the technological infrastructure needed to support its integration.

Addressing these technological and infrastructural issues requires a concerted effort from both the private and public sectors. Governments, regulators, and industry players need to work together to create an environment conducive to the successful adoption of blockchain in the halal supply chain. This could involve offering financial incentives for SMEs to invest in blockchain technology, providing training programs to develop the necessary technical expertise, and creating industry-wide standards that ensure interoperability between blockchain systems. Only by overcoming these barriers will blockchain be able to unlock its full potential in enhancing transparency, traceability, and trust in the halal supply chain.

Organizational and Cultural Resistance

Resistance to change within organizations presents a significant barrier to the adoption of blockchain technology in the halal supply chain. One of the primary reasons for this resistance

is the lack of awareness and understanding about blockchain's potential benefits. Many manufacturers are still unfamiliar with the operational advantages of blockchain, such as its ability to provide transparency, traceability, and improve efficiency. This lack of understanding leads to a reluctance to invest in or adopt blockchain technology. Manufacturers often view blockchain as a complex, unproven technology with an unclear return on investment, which deters them from making the necessary investments. Without a clear understanding of how blockchain can address inefficiencies and improve overall supply chain management, organizations are likely to resist its adoption, preferring to continue using traditional systems (Latta, 2015).

In addition to a lack of awareness, organizational inertia also plays a significant role in resistance to blockchain adoption. Many manufacturers and other stakeholders within the halal supply chain have established systems, processes, and business models that have functioned for years, if not decades. These entrenched systems are often perceived as tried and tested, and changing them requires overcoming the inertia of established practices. For organizations, change often entails not just implementing new technologies but also reorganizing workflows, retraining staff, and adjusting long-standing operations. This disruption is met with resistance from employees, managers, and even business owners who are hesitant to abandon what they know in favor of a new and potentially disruptive technology. Additionally, the cost of retraining staff and aligning internal systems with blockchain is seen as a financial burden that many businesses, particularly small and medium-sized enterprises (SMEs), are not prepared to bear (Erwin & Garman, 2010).

Cultural factors also contribute significantly to resistance to blockchain adoption, particularly in regions with strong traditional business practices. In many parts of the halal supply chain, particularly in family-owned businesses or businesses that have been operating for generations, there is often a mistrust of new technologies. Blockchain, being a relatively new and complex technology, is met with skepticism by stakeholders who have been successful using traditional methods. These companies may have concerns about the security of digital platforms, the reliability of decentralized systems, and the potential for technology failures. In some cultures, there is also a deep-rooted preference for face-to-face interactions and trust built on personal relationships, which blockchain technology cannot replicate. This cultural inclination toward traditional ways of doing business creates a barrier to the adoption of blockchain, as it requires a fundamental shift in how business processes are managed and trusted (Agócs, 1997).

Furthermore, regulatory bodies face unique challenges in promoting blockchain adoption due to the need to align diverse stakeholder interests. The halal supply chain involves multiple actors, including manufacturers, suppliers, distributors, and retailers, each with their own interests and priorities. Regulatory bodies must navigate these competing interests and establish common ground in order to promote the adoption of blockchain as a unified solution. This is further complicated by differing levels of technological readiness among stakeholders, with some companies being more technologically advanced than others. Regulatory authorities must also deal with resistance from traditional players in the halal supply chain, who may view blockchain as a threat to their established practices and relationships. Convincing these diverse stakeholders to adopt a unified blockchain approach requires overcoming not only organizational resistance but also cultural barriers to technology adoption (Erwin & Garman, 2010).

The diverse organizational cultures within the halal supply chain also present challenges. For example, multinational corporations may have a more open attitude toward

adopting innovative technologies like blockchain, while smaller, locally owned businesses may be more conservative and cautious in adopting change. This difference in organizational culture complicates the regulatory authorities' efforts to create a coherent approach to blockchain implementation. To overcome these barriers, regulatory bodies need to ensure that blockchain adoption is framed in a way that aligns with the cultural values and business practices of the stakeholders involved. This may involve building trust in the technology through pilot projects, education programs, and demonstrating successful case studies that show how blockchain can deliver tangible benefits in the halal supply chain (Vanesa et al., 2019).

In some cases, the fear of losing control over the supply chain is another cultural resistance point. Blockchain's decentralized nature means that no single party has full control over the data. For many manufacturers and stakeholders in the halal supply chain, the idea of losing control over sensitive information or being unable to manipulate data can be unsettling. This fear of losing control is exacerbated by concerns over data privacy and the potential for misuse of the information stored on the blockchain. To address these concerns, regulatory authorities and blockchain advocates need to provide clear assurances regarding data security, privacy protection, and the benefits of a decentralized system that enhances trust and accountability without compromising control (Robin, 1996).

Regulatory bodies must also adapt their approaches to align with the organizational cultures of the companies they oversee. They must be sensitive to the fact that resistance to blockchain technology often stems from fear of disruption and the perceived complexity of the technology. Regulatory authorities can help mitigate this resistance by offering guidance and training programs that emphasize how blockchain can simplify and streamline compliance processes in the halal supply chain. By demonstrating that blockchain adoption is not about replacing existing practices but about enhancing and securing them, regulatory bodies can reduce the perceived risk and increase the willingness of manufacturers and other stakeholders to embrace blockchain (Sert et al., 2014).

To overcome organizational and cultural resistance, it is crucial to establish clear communication channels and foster collaboration between all stakeholders. Manufacturers and regulatory bodies must work together to build a shared understanding of the value of blockchain technology and how it can contribute to greater efficiency, transparency, and trust within the halal supply chain. Pilot programs and pilot projects can be valuable tools in showcasing the real-world benefits of blockchain and overcoming skepticism. By starting with small-scale implementations and demonstrating success, stakeholders are more likely to become open to scaling up the use of blockchain across the entire supply chain (Bashori et al., 2022).

Organizational and cultural resistance represents a significant challenge to the adoption of blockchain in the halal supply chain. Overcoming this resistance requires addressing both the awareness and understanding of blockchain's benefits and the cultural factors that influence decision-making. Manufacturers and regulatory authorities must collaborate to align diverse interests and build trust in blockchain technology. By acknowledging these barriers and taking proactive steps to overcome them, blockchain can be successfully integrated into the halal supply chain, delivering enhanced transparency, traceability, and efficiency (Hew et al., 2020).

Regulatory and Standardization Issues

The absence of standardized frameworks and clear regulatory guidelines is a significant barrier to the adoption of blockchain technology in the halal supply chain (Berglund & Gent, 2018). Regulatory authorities face considerable challenges in ensuring compliance with halal standards while simultaneously leveraging blockchain's potential to improve transparency and traceability. Blockchain, by nature, is a decentralized technology, and for it to be effectively integrated into the halal supply chain, regulatory frameworks must be established to govern how it interacts with existing halal certification standards. Without clear guidelines, manufacturers and other stakeholders in the halal supply chain may be hesitant to adopt blockchain, as they may perceive the technology as an unregulated or unclear space that could lead to potential legal and operational risks (Quang et al., 2016).

A major issue is the lack of harmonized regulatory frameworks across jurisdictions. The halal certification process, which is vital for ensuring that products meet religious and legal requirements, varies from country to country, adding complexity to blockchain adoption. For instance, what is considered halal in one country may not be the same in another (Hoffmeyer, 2005). This discrepancy creates challenges for regulatory bodies that are responsible for ensuring the halal integrity of products as they move through the supply chain, especially in cross-border trade. Blockchain technology has the potential to provide a transparent and immutable record of product origins and processes, but this is only effective if there is a consistent understanding of what constitutes halal at a global level. Without standardized halal certification procedures that can be universally recognized, the use of blockchain to track halal products across borders will be fragmented and inefficient (Aziz et al., 2021).

The lack of regulatory clarity surrounding blockchain implementation is also a major concern. Regulatory authorities must find ways to integrate blockchain technology with traditional regulatory practices, such as halal certification processes, while ensuring data security and compliance with privacy laws. Blockchain's decentralized nature raises concerns regarding the security and privacy of data, particularly when it comes to sensitive information related to the halal status of products (Timmermans & Epstein, 2010). Regulatory bodies need to establish clear data protection standards, ensuring that blockchain platforms are designed to protect proprietary information while providing sufficient transparency to maintain halal integrity. However, due to the nascent nature of blockchain technology, regulators are often playing catch-up, struggling to develop comprehensive guidelines that balance innovation with the protection of consumer rights and religious requirements (M. H. Ali et al., 2021).

Another challenge is the lack of consensus among regulatory bodies about the role that blockchain should play in the halal supply chain. Different authorities in different regions may have varying views on whether blockchain should be mandated or whether it should remain optional. These differing approaches further complicate efforts to establish a unified standard. For example, while some countries may embrace blockchain as a tool for ensuring halal compliance, others may take a more cautious approach, preferring to rely on traditional methods of certification and inspection. This lack of consensus creates confusion among manufacturers, importers, and consumers, as they struggle to navigate a complex regulatory landscape. For blockchain adoption to be successful, regulatory bodies need to collaborate and work together to establish clear, harmonized rules and standards that facilitate its integration into the halal supply chain (Ardiantono et al., 2024).

Additionally, cross-border trade poses significant regulatory challenges for blockchain adoption. International trade in halal products requires seamless operations, with consistent standards and certifications that are recognized globally. The absence of harmonized

regulations makes it difficult for manufacturers and traders to ensure that their products meet halal requirements in every country they do business with. Blockchain, when implemented with standardized protocols, can potentially streamline the certification process by providing an immutable and transparent record of compliance across borders. However, unless regulatory authorities worldwide come to an agreement on halal certification standards and how blockchain should be used to track compliance, cross-border trade will remain a major barrier to the technology's full potential in the halal supply chain.

For blockchain to be effectively implemented in the halal supply chain, it is essential that regulatory bodies work together to create globally recognized standards. This involves not only harmonizing halal certification practices across borders but also developing standardized technological frameworks for blockchain. These frameworks would outline the specific requirements for blockchain platforms to ensure that they can be universally applied across different jurisdictions. Furthermore, regulatory bodies must provide clear guidelines on the use of blockchain in the halal supply chain, including how blockchain can be integrated with existing halal certification processes, data security requirements, and privacy concerns. By establishing a clear, standardized approach to blockchain adoption, regulatory bodies can create an environment where manufacturers, suppliers, and consumers can confidently use the technology to track and verify the halal status of products ([M. H. Ali et al., 2024](#)).

The implementation of standardized guidelines is further complicated by the complexity of existing halal certification systems. Halal certification processes are often multifaceted and involve multiple layers of verification, including ingredient sourcing, manufacturing processes, and final product inspection. Blockchain technology has the potential to simplify these processes by offering a transparent and immutable record of each stage in the supply chain. However, for blockchain to be integrated effectively into these complex systems, regulators must ensure that the technology can support the various certification requirements and processes that exist in different countries. This requires close collaboration between blockchain developers and certification authorities to ensure that blockchain platforms are tailored to meet the specific needs of the halal supply chain ([M. L. Ali et al., 2019](#)).

Moreover, the technology infrastructure required to support blockchain adoption is often lacking in many regions. Regulatory bodies must address this issue by supporting the development of robust technological infrastructure to facilitate blockchain implementation. This includes ensuring that supply chain stakeholders have access to the necessary tools, platforms, and training to use blockchain effectively. Without proper infrastructure, the adoption of blockchain technology could be hindered, particularly in developing markets where technological resources are limited.

Finally, financial and resource constraints can also impede the development of regulatory frameworks and the adoption of blockchain in the halal supply chain. Establishing clear and standardized guidelines requires significant investment in research, development, and collaboration between regulators, industry stakeholders, and blockchain developers. In many cases, regulatory bodies may lack the resources to dedicate to blockchain initiatives, delaying the creation of necessary frameworks. Additionally, small and medium-sized enterprises (SMEs) in the halal supply chain may face financial barriers to adopting blockchain, especially if the technology is not yet universally adopted and standardized. To overcome these barriers, governments and regulatory bodies may need to provide incentives or funding to support blockchain initiatives and facilitate a smoother transition to blockchain-based systems ([M. H. Ali et al., 2021](#)).

The regulatory and standardization issues surrounding blockchain adoption in the halal supply chain are significant challenges that must be addressed for the technology to reach its full potential. Clear and standardized regulatory frameworks are essential for ensuring that blockchain can be effectively integrated with existing halal certification processes, particularly in cross-border trade. Regulatory bodies must collaborate to create globally recognized standards and guidelines, and invest in the technological infrastructure needed to support blockchain adoption. With a unified approach to regulation and standardization, blockchain has the potential to transform the halal supply chain by providing greater transparency, traceability, and efficiency.

Economic and Financial Constraints

The economic and financial barriers to adopting blockchain technology in the halal supply chain are significant concerns for both manufacturers and regulatory authorities. The high initial costs associated with blockchain development and ongoing maintenance present a substantial hurdle. For many manufacturers, especially small and medium-sized enterprises (SMEs), the financial burden of implementing blockchain is prohibitive (M. H. Ali et al., 2024). Blockchain technology requires specialized infrastructure, software, and human resources to integrate into existing supply chain systems, which can be expensive and resource-intensive. Additionally, since blockchain adoption in the halal supply chain is still in its nascent stages, the return on investment (ROI) is not immediately clear, further deterring companies from committing to such an investment. This is especially true for SMEs, which often operate on limited budgets and cannot afford the upfront financial commitment that blockchain technology demands (Farre-Mensa & Ljungqvist, 2016).

Moreover, SMEs face challenges in securing funding or accessing incentives that could help support their transition to blockchain-based systems. In many cases, SMEs lack the necessary financial resources to adopt new technologies, and traditional financial institutions may be hesitant to provide loans or funding for blockchain projects due to the perceived risks and uncertainties involved. This financial challenge is compounded by the fact that blockchain adoption, although beneficial in the long run, requires substantial upfront capital for development, training, and implementation. As a result, many SMEs are forced to either delay or abandon the adoption of blockchain, missing out on the potential benefits of improved transparency, traceability, and efficiency in the halal supply chain. This financial constraint underscores the need for tailored support and financial incentives, such as grants, low-interest loans, or subsidies, to help SMEs navigate the transition to blockchain technology (Tan et al., 2019).

The cost of maintaining blockchain infrastructure is another critical issue for manufacturers and regulatory authorities alike. For manufacturers, the costs of continuous updates, system maintenance, and ensuring the security and scalability of blockchain systems add an ongoing financial burden. Blockchain, particularly in the context of the halal supply chain, requires robust security measures to protect sensitive data and ensure the integrity of halal certifications and transactions. This includes the cost of hiring specialized personnel, implementing cybersecurity protocols, and investing in high-performance computing systems. For regulatory authorities, the financial challenge is even more pronounced. Regulatory bodies need to build and maintain infrastructure to oversee compliance with blockchain standards, monitor data security, and verify that manufacturers are meeting halal certification requirements. This includes the development of regulatory frameworks and tools to ensure that blockchain solutions align with the halal certification processes. However,

many regulatory authorities, especially in developing countries, lack the financial resources to invest in such infrastructure, hindering the widespread adoption of blockchain in the halal supply chain ([Hew et al., 2020](#)).

The economic disparity between large corporations and SMEs further exacerbates the financial barriers to blockchain adoption. Large multinational corporations (MNCs) often have the financial resources to invest in blockchain technology, while SMEs struggle to keep up. MNCs, with their significant budgets, can invest in research, development, and testing of blockchain systems, ensuring that they stay ahead of technological trends. In contrast, SMEs are typically more focused on day-to-day operations and are often reluctant to allocate resources toward blockchain implementation. This economic imbalance creates a divide in the halal supply chain, where larger players can benefit from blockchain's advantages, such as increased transparency and traceability, while smaller companies may be left behind. To bridge this gap, there is a need for financial mechanisms that provide SMEs with equal access to blockchain technology, ensuring that the benefits of the technology are distributed more evenly across the supply chain ([Farre-Mensa & Ljungqvist, 2016](#)).

In addition to the financial challenges faced by manufacturers and SMEs, regulatory authorities also face financial constraints when it comes to overseeing blockchain adoption in the halal supply chain. Building and maintaining the infrastructure necessary to regulate and monitor blockchain systems is an expensive endeavor, requiring both technological expertise and financial resources. Regulatory bodies need to develop new systems for verifying blockchain transactions and ensuring that halal certification processes are being followed. This could involve the creation of new agencies or departments dedicated to blockchain oversight, which would incur additional costs. Given that many regulatory bodies, particularly in developing economies, operate with limited budgets, the financial burden of blockchain regulation may be too great to bear without external support. Therefore, it is crucial for governments to allocate funding or establish partnerships with private sector entities to support the development of blockchain regulatory frameworks and the infrastructure needed for effective oversight ([Campello et al., 2010](#)).

The financial risks associated with blockchain adoption also contribute to the reluctance of manufacturers and regulatory authorities to embrace the technology. Blockchain is still a relatively new and evolving technology, and there are inherent risks associated with its implementation. These risks include the possibility of technical failures, cybersecurity breaches, or disruptions to existing supply chain processes. Manufacturers and regulatory authorities may be hesitant to invest heavily in blockchain technology without a clear understanding of the risks and rewards. In many cases, the financial costs of potential failures or setbacks may outweigh the perceived benefits, especially for smaller companies or regulatory bodies with limited financial resources. To mitigate these risks, manufacturers and regulatory authorities must carefully assess the costs and benefits of blockchain adoption, and invest in pilot projects or incremental implementation strategies that allow them to gradually integrate blockchain technology into the halal supply chain ([Bakhtiari et al., 2020](#)).

The lack of financial incentives for blockchain adoption is another factor that exacerbates economic barriers. While blockchain technology has the potential to improve transparency, reduce fraud, and streamline halal certification processes, the absence of clear financial incentives or rewards for manufacturers and SMEs makes it difficult to justify the costs involved. Governments and regulatory bodies must create policies that incentivize blockchain adoption, such as offering tax breaks, grants, or other financial incentives for companies that implement blockchain systems in their supply chains. These incentives can help reduce the

financial burden of blockchain implementation and encourage manufacturers, especially SMEs, to invest in the technology. Additionally, creating financial support mechanisms for regulatory authorities, such as funding for training programs and infrastructure development, would help alleviate the financial pressures they face in overseeing blockchain adoption (Bond & Meghir, 1994).

To overcome the economic and financial constraints associated with blockchain adoption, it is essential to create a supportive financial ecosystem that fosters innovation and technology adoption in the halal supply chain. This ecosystem should include a combination of government support, private sector investment, and public-private partnerships to provide the necessary funding and resources for blockchain adoption. Financial institutions can play a key role in providing funding for blockchain projects, particularly for SMEs that may struggle to access traditional forms of financing (Musso & Schiavo, 2008). Moreover, regulatory bodies can work with manufacturers and blockchain developers to create cost-effective solutions that lower the financial barriers to adoption. By building a supportive financial ecosystem, stakeholders can facilitate the widespread adoption of blockchain technology in the halal supply chain, ensuring that its benefits are realized across the entire industry (Saltari & Travaglini, 2003).

Economic and financial constraints are major barriers to the adoption of blockchain technology in the halal supply chain. The high costs of blockchain development, maintenance, and oversight create significant financial burdens for both manufacturers and regulatory authorities. SMEs, in particular, face challenges in securing funding and accessing financial incentives that could support their transition to blockchain technology. To overcome these barriers, it is essential to create a supportive financial ecosystem that includes government incentives, private sector investment, and partnerships between manufacturers and regulatory bodies. By addressing these economic and financial challenges, the halal supply chain can harness the full potential of blockchain technology, leading to greater transparency, efficiency, and trust in halal certification processes (Ullah, 2020).

CONCLUSION

This research identifies various barriers faced by stakeholders in the halal supply chain when adopting blockchain technology, both from the manufacturing side and regulatory authorities. The findings show that the main challenges hindering blockchain adoption in the halal supply chain include technological and infrastructural challenges, organizational and cultural resistance, regulatory and standardization issues, and economic and financial constraints. These factors interact with each other, exacerbating the difficulties in the widespread implementation and adoption of blockchain technology in the sector.

From a technological and infrastructural perspective, issues such as lack of interoperability between systems, insufficient IT resources, and high implementation costs are significant barriers, particularly for small and medium-sized enterprises (SMEs). On the other hand, organizational and cultural resistance includes the lack of awareness or understanding of blockchain technology's benefits, as well as a reliance on traditional methods. Furthermore, regulatory and standardization challenges arise due to the absence of standardized frameworks and clear regulatory guidelines, which complicate the application of blockchain to ensure compliance with halal standards across different countries. Finally, economic and financial constraints stem from the high costs associated with blockchain development and

maintenance, as well as the difficulties SMEs face in securing funding or accessing incentives to transition to the technology.

The implications of this research are highly relevant for manufacturers, regulatory bodies, and policymakers. To promote broader adoption of blockchain in the halal supply chain, collaborative efforts between the public and private sectors are necessary to address the existing barriers. This includes the development of better infrastructure, awareness campaigns on the benefits of blockchain, financial incentives for SMEs, and the harmonization of regulations across countries to facilitate cross-border trade. Additionally, regulatory authorities must establish clearer guidelines on the use of blockchain to maintain the integrity and transparency of the halal certification process. Effective adoption of blockchain technology can offer significant benefits, including enhanced transparency, better traceability, and improved efficiency in the halal supply chain, ultimately strengthening consumer trust in halal products in the global market.

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