International Journal of Scientific Research and Engineering Development-– Volume 8 Issue 4, July-Aug 2025
Available at www.ijsred.com

RESEARCH ARTICLE OPEN ACCESS

Factors Affecting Blockchain Technology Adoption Among Manufacturing Firms in Batangas and Its Effect on Operational Excellence: An Investigation of Cultural Compatibility as Moderator

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Abstract:

The increasing globalization of supply chains has revolutionized business operations, enabling seamless connections among supply chain players. However, this interconnectedness has also amplified challenges, particularly in managing the vast volumes of transactions and data inherent in supply chain systems. This study investigates the adoption of blockchain technology in manufacturing companies registered under the Philippine Economic Zone Authority (PEZA) in Batangas. The research also aims to analyze the influence of technological, organizational, and environmental (TOE) factors on blockchain adoption and assess its impact on operational excellence. Furthermore, the study evaluates the mediating role of cultural compatibility in the relationship between blockchain adoption and operational excellence. The research utilized a descriptive research design to systematically explore the relationships and characteristics associated with blockchain adoption. Data were collected and the respondents included 135 manufacturing companies located in the top three economic zones in Batangas. The survey instrument covered the demographic profiles of companies, TOE factors influencing blockchain adoption, blockchain's impact on operational excellence, cultural compatibility. Statistical tools were employed to analyze relationships and determine the significance of the findings. Key findings indicate that manufacturing companies are generally open to adopting blockchain technology. Relative advantage and openness to innovation significantly influence adoption, with positive coefficients and high statistical significance. While blockchain adoption positively impacts operational excellence, cultural compatibility moderates this relationship, with higher compatibility reducing the strength of blockchain's impact. Notably, significant differences in adoption levels were observed based on the product industry, with electronics companies showing the highest adoption rates.

Keywords — ***Blockchain Adoption, Supply Chain Systems, Operational Excellence, Cultural Compatibility, Manufacturing Companies, TOE factors***

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1. INTRODUCTION

The increasing globalization of supply chains has transformed the way businesses operate, enabling organizations to connect with suppliers, manufacturers, and consumers across the world. However, this interconnectedness has also introduced several challenges, particularly in managing the high volumes of transactions and data that flow through supply chains. Manufacturing firms, which are integral to these networks, often face difficulties in ensuring the transparency, security, and accuracy of transactional data across multiple touchpoints. Additionally, the integration of new technologies to streamline these processes can be hampered by the complexity of global operations, making the optimization of supply chain systems a persistent struggle. As these firms handle ever-growing datasets and face higher expectations for efficiency and reliability, identifying innovative solutions to address these pain points becomes imperative. One critical but underexplored challenge in this context is the role of cultural compatibility in achieving operational excellence within supply chains, particularly for manufacturing firms. Cultural dynamics, including organizational values, leadership styles, and employee readiness for change, can significantly influence the success of operational improvements and the adoption of new technologies. Misalignment between cultural practices and technological implementation often leads to resistance, inefficiency, and suboptimal outcomes. In manufacturing firms, where operational excellence relies heavily on consistency, collaboration, and adaptability, cultural compatibility can either be a driver of or a barrier to innovation and growth. As such, it is vital to examine how cultural factors interact with technological advancements to shape the outcomes of operational strategies.

Blockchain technology has emerged as a promising solution to many of the challenges facing modern supply chains. As a decentralized, secure, and transparent ledger system, blockchain offers significant advantages in

managing the complexities of global supply chains, including improving data accuracy, reducing fraud, and enhancing trust among stakeholders. By streamlining the processing of large transaction volumes and providing a reliable mechanism for tracking goods and verifying transactions, blockchain has the potential to address issues of scalability and data management. Furthermore, its ability to provide real-time visibility across supply chain networks can greatly enhance decision-making and operational efficiency. However, despite these benefits, the widespread adoption of blockchain technology remains limited, particularly among manufacturing firms.

This lack of adoption highlights a critical gap in understanding the factors that influence blockchain acceptance in the manufacturing sector. This study aims to address this gap by investigating the key factors affecting blockchain technology adoption among manufacturing firms in Batangas, a region with a thriving industrial sector. Moreover, the study explores how cultural compatibility moderates the relationship between blockchain adoption and operational excellence. By examining these relationships, this research seeks to offer actionable insights for both researchers and industry practitioners, ultimately contributing to strategies that enhance blockchain adoption and drive operational excellence in manufacturing contexts.

Objectives

This objective of the study is to describe the adoption of blockchain technology in manufacturing companies in Batangas, focusing on the technological, organizational, and environmental (TOE) factors that influence adoption and the impact of blockchain adoption on operational excellence. Additionally, the study aims to measure the moderating effect of cultural compatibility on the relationship between blockchain adoption and operational excellence.

2. MATERIALS AND METHOD

Research Design

To meet this objective, the researcher used the descriptive approach design using quantitative research, in which numerical data were used to obtain information about the variables as its research design.

Respondents of the study

The respondents of the study were PEZA-registered manufacturing firms located in the top three economic zones in Batangas: First Philippine Industrial Park (FPIP), Light Industry & Science Park III & IV (LISP), and Lima Technology Center (LIMA). These firms, representing diverse industries such as electronics, automotive parts, metals, and packaging, were chosen due to their potential to adopt advanced technologies like blockchain, given their exposure to global standards and competitive pressures.

To ensure fair representation, stratified random sampling was used to allocate respondents proportionally across the three zones. According to the PEZA website, there were 206 registered manufacturing firms across the three industrial zones. A minimum sample size of 135 respondents was determined using Raosoft's calculator. The fishbowl method was then applied within each stratum to ensure an equal chance of selection for all firms, minimizing bias and enhancing the reliability of the study's findings.

Data Gathering Instrument

The data gathering for this study utilized a combination of an online survey via Google Forms and printed questionnaires. The online survey, deployed through Google Forms, provided a convenient and efficient method for collecting data from respondents who are comfortable with digital platforms and prefer the ease of online participation. This approach allowed for quick dissemination and collection of responses, ensuring a broad reach and timely feedback. On the other hand, printed questionnaires were distributed due to the difficulty in getting responses solely through the online method. Some participants might be more responsive to traditional paper-based surveys, which can be more noticeable and harder to overlook than emails or digital forms. This dual approach ensured inclusivity and maximized response rates by addressing the challenges of respondent engagement. The survey questionnaire was adapted and modified from the study of AlKubaisy & Al-Somali (2023). The data gathering instrument was composed of four parts: demographic profile of the manufacturing companies; assessment of the technological, organizational, and environmental factors of blockchain adoption; assessment of the blockchain adoption and its perceived effect on operational excellence and assessment of the cultural compatibility of blockchain solutions. The researcher also attached a consent form which addressed issues of the risks and benefits, confidentiality and voluntary participation. The statistician performed the reliability testing and the results were tallied and every construct resulted to Cronbach's alpha values exceeding 0.9 and manifested internal consistency in the items created for the instrument. This ensured the questionnaire's consistency in the measurement of variables and the validity of the research findings.

Data Gathering Procedure

The data gathering procedure followed a systematic approach to ensure accurate and reliable results. The researcher began by identifying manufacturing firms registered with the Philippine Economic Zone Authority (PEZA) in Batangas and securing endorsement from PEZA's Office of the Director General to distribute questionnaires. Data were collected using two methods: online surveys via Google Forms for respondents preferring digital communication and printed questionnaires for firms with limited digital engagement. A pilot test was conducted with a small sample in Laguna to ensure the reliability of the survey instrument before full deployment. The actual data collection took place between September and November 2024, with detailed instructions provided to respondents and follow-up reminders sent to maximize response rates. After data collection, the researcher meticulously checked the dataset for errors, inconsistencies, and redundancies, removing duplicate entries and excluding responses from non-target populations to maintain data integrity. Challenges such as refusals to participate were addressed to minimize their impact on the dataset. The cleaned and validated data were then forwarded to a professional statistician for comprehensive analysis, employing advanced statistical tools to derive meaningful insights. This structured process ensured a robust dataset, enabling an in-depth analysis of the factors influencing blockchain adoption and its impact on operational excellence in manufacturing firms.

Statistical Treatment of Data

To arrive at factual findings and conclusions, the researcher applied a statistical method to obtain an accurate and reliable result of the interpretation. The following statistical tools were used in the study. Frequency and Percentage, Mean, Analysis of Variance (ONEWAY) and Simple and Multiple Linear Regression.

3. RESULTS AND DISCUSSION

This consists of the data of the study which was presented, analyzed, and interpreted by the researcher. The data were derived from the answers to the questionnaire issued by the researchers to the respondents. It also included the presentation of the data in tabular form along with the corresponding interpretation.

Table 1. Number of Years in Operation

Years in Operation	Frequency	Percentage
Less than 5 years	30	22.22%
5years to 10years	40	29.63%
11years to 15years	31	22.96%
More than 15years	34	25.19%
Total	**135**	**100%**

The results reveal a diverse distribution of manufacturing firms in Batangas based on their years of operation, offering insights into blockchain adoption trends. The largest group (29.63%) comprises firms operating for 5 to 10 years, suggesting they are well-established yet flexible and open to innovations like blockchain to enhance competitiveness. Firms operating for more than 15 years (25.19%) represent experienced players with the resources to adopt blockchain strategically, despite a cautious approach. Mid-stage companies, operating for 11 to 15 years (22.96%), are likely exploring blockchain to modernize and sustain growth. Meanwhile, newer firms with less than 5 years of operation (22.22%) demonstrate agility and openness to adopting blockchain early, using it to build credibility and gain a competitive edge in the market. This distribution highlights the varying motivations for blockchain adoption across firms at different stages of their lifecycle.

Table 2. Number of employees

No. of Employees	Frequency	Percentage
Less than 1,000	81	60.00%
1,000 to 3,000	29	21.48%
3,001 to 5,000	13	9.63%
More than 5,000	12	8.89%
Total	**135**	**100%**

The results on Table 2 shows that the majority of manufacturing firms in Batangas have fewer than 1,000 employees, comprising 60% of the respondents. This indicates that the industry is largely composed of small to medium-sized enterprises (SMEs), which are typically more agile and may adopt emerging technologies like blockchain to address operational challenges, enhance efficiency, and improve supply chain transparency. Firms with 1,000 to 3,000 employees make up 21.48% of the respondents, suggesting a notable presence of medium to large enterprises that are likely more structured and capable of investing in advanced technologies. Meanwhile, larger companies with 3,001 to 5,000 employees (9.63%) and more than 5,000 employees (8.89%) represent a smaller proportion of the sample. These organizations are typically well-established and may already have advanced systems in place. Their adoption of blockchain may be driven by the need to enhance existing operations or to meet global standards in transparency, traceability, and sustainability.

Table 3. Product Industry

Product Industry	Frequency	Percentage
Electronics / Electronic components and/or assembly	29	21.48%
Rubber and/or Plastic	28	20.74%
Automotive products / components	12	8.89%
Fabricated Metal	23	17.04%
Paper Products	11	8.15%
Others	32	23.70%
Total	**135**	**100%**

The distribution of respondents across different product industries indicates a diverse mix of sectors represented in the sample. The largest proportion of businesses (23.70%) falls under the "Others" category (includes tobacco, food and beverage, chemicals, medical, and aviation industry), which likely includes various niche or specialized industries not explicitly listed in the options. The next most prominent industry is Electronics/Electronic components and/or assembly, which accounts for 21.48% of the respondents, highlighting the significant role of the electronics sector in the sample. Additionally, the Rubber and/or Plastic industry is close behind with 20.74%, pointing to a strong presence of companies involved in manufacturing products from synthetic materials, which are essential in a wide range of industries, from consumer goods to industrial applications.

Table 4. Ecozone

Ecozone	Frequency	Percentage
FPIP	52	38.52%
LIMA	53	39.26%
LISP	30	22.22%
Total	**135**	**100%**

The results show that the majority of manufacturing firms surveyed are located in two major industrial parks in Batangas: LIMA (39.26%) and FPIP (38.52%), with the remaining 22.22% situated in LISP. The relatively equal distribution between LIMA and FPIP highlights the prominence of these locations as hubs for manufacturing activities. Their advanced facilities and support for industries likely contribute to higher interest and capacity for adopting innovative technologies, particularly for supply chain optimization and operational transparency. LISP, while representing a smaller proportion (22.22%) of respondents, also plays a significant role in the region's manufacturing landscape. These parks are strategically positioned and well-equipped with infrastructure, making them attractive to both local and multinational companies.

Table 5. Level of Blockchain Technology Adoption of Manufacturing Firms

Statement	Mean	Interpretation
Our company is optimistic about embracing blockchain technology.	4.56	Open to adoption
Our company is willing to explore the implementation of blockchain solutions.	4.85	Open to adoption
Our company is prepared to adopt blockchain technology across various functions of supply chain.	4.67	Open to adoption
Our company has been introduced to and is informed about blockchain technology and its potential benefits.	4.44	Uncertain on adoption
Blockchain technology has been incorporated into our long-term strategic business plans.	4.46	Uncertain on adoption
Our company believe that blockchain technology will positively impact our business.	4.87	Open to adoption
Our company aims to be a leader in the adoption of blockchain technology within our sector.	4.57	Open to adoption
Our company will strongly advise others to adopt blockchain technology to manage supply chain operations.	4.67	Open to adoption
Composite Mean	**4.64**	Open to adoption

The assessment of blockchain adoption among manufacturing firms reveals a generally positive yet cautious approach, with a composite mean of 4.64, indicating openness to adoption but hesitance toward full-scale implementation. The highest-rated statement, with a mean of 4.87, reflects strong optimism about blockchain's positive impact on business, suggesting that firms recognize its potential to improve supply chain transparency, traceability, and efficiency. This optimism aligns with the findings of Saberi et al. (2018), who highlighted that firms view blockchain as a tool to enhance transparency and operational efficiency, motivating companies to explore its adoption as a competitive advantage. Conversely, the lowest-rated statement, with a mean of 4.44, highlights uncertainty regarding firms' understanding of blockchain technology and its benefits. This suggests a lack of awareness or technical knowledge among some respondents, as well as potential gaps in long-term strategic planning for adoption. Queiroz et al. (2020) emphasized that while manufacturing firms acknowledge blockchain's transformative potential, challenges like technological complexity and integration costs hinder full-scale adoption.

Table 6. Assessment on Relative Advantage

Statement	Mean	Interpretation
Blockchain technology will significantly improve the efficiency of our business processes.	5.58	Significant Advantage
Adopting blockchain will reduce the company's operational costs in comparison to traditional systems.	5.41	Moderate Advantage
Blockchain technology will enable our company to have faster and more reliable transactions.	5.52	Significant Advantage
Blockchain's decentralized nature will reduce risks related to data breaches and fraud in our company's operations.	5.51	Significant Advantage
The transparency offered by blockchain technology will enhance trust with our stakeholders.	5.59	Significant Advantage
Adopting blockchain will enable the company to streamline processes and reduce the need for intermediaries.	5.44	Moderate Advantage
The traceability offered by blockchain can enhance our ability to meet compliance standards more effectively.	5.48	Moderate Advantage

Blockchain technology can simplify our company's audit processes, making them faster and more transparent.	5.45	Moderate Advantage
Composite Mean	**5.50**	Significant Advantage

The results from the study reveal that manufacturing firms in Batangas view blockchain technology as highly beneficial for business operations, with a composite mean score of 5.50, indicating a strong agreement with the technology's potential advantages. The highest mean score of 5.59 reflects strong support for blockchain's ability to enhance trust with stakeholders through its transparent and immutable record-keeping system. However, the study also highlighted a more cautious view regarding some benefits of blockchain, with a lower mean score of 5.41 for cost reduction. This suggests that while blockchain is seen as a tool for enhancing efficiency and trust, some respondents are more reserved about its ability to significantly reduce costs or streamline processes. This aligns with findings by Kamble et al. (2019), who also noted that transparency and improved stakeholder trust are key perceived benefits of blockchain in supply chain management. Additionally, Queiroz et al. (2020) found that blockchain improves transaction reliability and reduces errors.

Table 7. Assessment on Top Management Support

Statement	Mean	Interpretation
The top management in our company is committed to the adoption of blockchain technology.	3.85	Uncertain support
Senior leaders actively advocate for blockchain adoption within the organization.	3.87	Uncertain support
Top management has a clear vision for how blockchain technology fits into the company's overall strategy.	3.98	Uncertain support
Top management supports investment in blockchain technology and are willing to allocate resources.	3.88	Uncertain support
Our top management advocates for blockchain adoption in industry forums and partnerships.	3.83	Uncertain support
Top management encourages employees to learn about blockchain technology.	3.90	Uncertain support
Top management actively engages with external stakeholders (e.g., partners, customers, regulators) to facilitate blockchain adoption.	3.87	Uncertain support
Composite Mean	**3.88**	**Uncertain support**

The results on Table 7 indicate that top management's commitment to blockchain adoption is characterized by uncertainty, as reflected in a composite mean score of 3.88, which suggests "Uncertain Support." The highest mean score of 3.90 was given to encouraging employees to learn about blockchain, indicating a moderate level of interest in developing internal capabilities. However, the lowest mean score of 3.83 was associated with advocating blockchain adoption in industry forums and partnerships, reflecting a lack of strong advocacy and proactive leadership in pushing for blockchain integration. This neutral stance on top management's support for blockchain is in line with findings from Obidallah et al. (2024), who noted that passive leadership involvement can delay blockchain adoption. Similarly, Malik et al. (2021) emphasized the importance of active leadership in driving the integration of blockchain within organizations.

Table 8. Assessment on Openness to Innovation

Statement	Mean	Interpretation
Our company actively seeks opportunities to pilot blockchain initiatives to explore new business possibilities.	4.62	Open to innovation
Our company takes a proactive approach in adopting innovative technologies, including blockchain.	4.90	Open to innovation
Our company is open to embracing the changes that come with blockchain technology adoption.	4.93	Open to innovation
Our company is flexible and ready to adapt changes in our processes to accommodate blockchain innovations.	4.93	Open to innovation
Our company actively participate in industry forums, workshops, and seminars to stay informed about blockchain innovations.	4.60	Open to innovation
Our company will be open to adjusting our current systems to accommodate the integration of blockchain-based innovations.	4.90	Open to innovation
Our industry partners are open and willing to adopt blockchain technology to streamline the supply chain processes.	4.90	Open to innovation
Composite Mean	**4.83**	**Open to innovation**

The study reveals a generally open stance on blockchain technology adoption among manufacturing firms in Batangas, with a composite mean score of 4.83, indicating slight agreement with the companies' openness to innovation. The highest mean score of 4.93 reflects firms' strong willingness to embrace changes and adapt processes to integrate blockchain. In contrast, the lowest mean score of 4.60 pertains to participation in industry forums, showing a moderate engagement with blockchain developments but indicating less active involvement in leading industry discussions. The results suggests that while firms are willing to experiment with blockchain, they are likely taking careful steps to assess its impact and suitability for their operations before fully committing. These findings align with studies such as

AlKubaisy & Al-Somali (2023), who noted that firms typically adopt a cautious approach to blockchain, weighing opportunities against risks. Similarly, Sciarelli et al. (2021) emphasize that measured openness to innovation, as seen in the results, helps organizations mitigate uncertainty and strategically align new technologies with their business goals.

Table 9. Assessment Competitor's Influence

Statement	Mean	Interpretation
Our company assess the competitive landscape to understand how other companies are utilizing blockchain.	4.90	Fair influence
Our company feels the need to adopt blockchain technology to remain competitive in the industry.	5.24	Fair influence
The strategies of our competitors influence the company's decision-making process.	5.43	Fair influence
The growing use of blockchain by competitors can drive us to accelerate our own adoption efforts.	5.40	Fair influence
The adoption of blockchain by major competitors signals a shift in industry standards that we need to align with.	5.16	Fair influence
The company is willing to adopt blockchain technology to keep pace with industry leaders who have already implemented it.	5.27	Fair influence
The success of our competitors with blockchain adoption can increase the pressure for our company to adopt similar technologies.	5.41	Fair influence
Composite Mean	**5.26**	**Fair influence**

The data in Table 9 reveals that while competitors influence blockchain adoption, the overall impact is moderate, with a composite mean score of 5.26, indicating "Fair Influence." The highest mean score of 5.43 highlights that competitor strategies significantly influence decision-making, and the recognition that the success of competitors drives adoption efforts received a score of 5.41. However, the lowest mean score was observed for the statement about companies actively assessing the competitive landscape, suggesting that while companies are aware of competitive pressures, they do not feel an urgent need to adopt blockchain simply because others are doing so. This reflects a measured approach to adoption, where firms recognize the need to stay competitive but weigh external pressures alongside internal readiness. These findings align with research by Queiroz et al. (2020), which emphasized that firms often adopt blockchain to align with industry leaders but proceed cautiously.

Table 10. Assessment on Government Support.

Statement	Mean	Interpretation
Government policies and legislation plays a critical role in our company's decision to adopt blockchain technology.	4.69	Moderate impact
The regulatory environment in our country supports and encourages the adoption of blockchain technology in our industry.	4.75	Moderate impact
Government incentives, such as grants or tax breaks, will motivate us to adopt blockchain technology.	5.08	Moderate impact
Government-sponsored blockchain initiatives will positively influence our decision to implement blockchain solutions.	4.93	Moderate impact
The legal framework established by the government for blockchain technology may guide our implementation process.	5.13	Moderate impact
International regulatory trends in blockchain technology will influence our approach to compliance and implementation.	5.10	Moderate impact
Government regulations in other countries will have an impact on our decision to adopt blockchain in global operations.	5.15	Moderate impact
Composite Mean	**4.98**	**Moderate impact**

The data reveals that government regulations and incentives significantly influence blockchain adoption decisions among manufacturing firms, with a composite mean score of 4.98. The highest mean score of 5.15 suggests that firms are particularly influenced by global government regulations, recognizing the importance of aligning their operations with international standards. However, the lowest mean score of 4.69, regarding the direct impact of government policies on blockchain adoption, indicates a more moderate influence. The findings also highlight that government incentives are seen as supportive but are not the primary motivator. AlKubaisy & Al-Somali (2023) suggest that while government incentives and policies play an enabling role, companies often view these as complementary rather than central motivators for innovation. This indicates a general agreement on the supportive role of government without reliance on it as the primary driver. Similarly, the assessment for government incentives aligns with insights from Janssen et al. (2020) and Hao et al. (2024), who identified financial and non-financial incentives as factors that encourage experimentation and early adoption.

Table 11. Assessment on Vendor Orientation and Support

Statement	Mean	Interpretation
Our company works closely with vendors who are leaders in blockchain technology that can ensure successful adoption.	4.71	Moderate impact
Vendors that offer blockchain solutions which can be customized to meet the specific needs of our business will make adoption easier.	5.33	Moderate impact
Vendors with a strong reputation for reliability and excellence in new technology solutions can make the company motivated to adopt blockchain.	5.39	Moderate impact
Vendors that provide specialized knowledge and technical expertise in	5.43	Moderate impact

blockchain solutions encourages our company to adopt blockchain.		
Having vendors that can cater to all types of business that are engaged in our company's supply chain will make blockchain adoption easier.	5.36	Moderate impact
Vendors that have established networks and partnerships that can facilitate collaborations within the supply chain will make adoption easier.	5.42	Moderate impact
Vendors that offer excellent post-implementation support, maintenance and troubleshooting can make our company confident in adopting blockchain technology.	5.50	High impact
Composite Mean	**5.31**	**Moderate impact**

The data in Table 11 reflects the importance of vendor relationships in blockchain adoption, with a composite mean score of 5.31, indicating that vendors have a "Moderate Impact" on the adoption process. The highest individual mean score of 5.50 is attributed to post-implementation support, indicating that companies value ongoing maintenance, troubleshooting, and support from vendors. The lowest mean score of 4.98 pertains to companies working closely with blockchain technology leaders. The respondents likely view vendor relationships as an essential complement to its internal capabilities, being key enablers for successful blockchain implementation. This indicates that firms see vendors as essential for providing localized, hands-on support, ensuring the technology's smooth operation and addressing specific business needs. The results align with existing literature. AlKubaisy & Al-Somali (2023) emphasize the importance of vendor relationships in successful technology adoption, highlighting that strong partnerships help overcome adoption barriers. Sciarelli et al. (2021) and Kamble et al. (2019) further stress that vendors are critical enablers of technology adoption, as they offer technical guidance and strategic support, ensuring that businesses can effectively navigate the complexities of blockchain implementation.

Table 12. Level of Cultural Compatibility of Blockchain Technology.

Statement	Mean	Interpretation
Our company's culture supports innovation, making it compatible with the adoption of blockchain technology.	5.34	Moderately compatible
There is a strong alignment between our organizational values and the innovative nature of blockchain technology.	5.27	Moderately compatible
Employees are open to new ideas and technologies, which can support the integration of blockchain into our operations.	5.34	Moderately compatible
Our company culture promotes internal and external collaboration, which is essential for blockchain adoption.	5.56	Highly Compatible
Blockchain technology complements our culture of openness and transparency in business operations.	5.39	Moderately compatible
The cultural flexibility within our organization will allow us to quickly adjust to the complexity of blockchain adoption.	5.38	Moderately compatible
Our company's organizational culture embraces change, making it open to adopt blockchain technology.	5.34	Moderately compatible
Our company culture supports decentralized decision-making, which aligns with the decentralized nature of blockchain technology.	5.17	Moderately compatible
Composite Mean	**5.35**	**Moderately compatible**

The data in Table 12 suggests that the company's culture is moderately compatible with blockchain adoption, with a composite mean score of 5.35. The highest mean score of 5.56 reflects the importance placed on internal and external collaboration, indicating that firms strongly value teamwork for successful blockchain implementation. The lowest mean score of 5.17 relates to support for decentralized decision-making, indicating that companies face challenges in fully adopting blockchain's decentralized nature. The findings suggest that while there is foundational cultural compatibility with blockchain, further adjustments may be required for complete integration. Companies recognize the importance of collaboration, transparency, and openness, all of which align well with blockchain technology's benefits. These results align with existing literature on the role of cultural compatibility in blockchain adoption. AlKubaisy & Al-Somali (2023) highlight the importance of a culture that is open to change and innovation, a key factor for integrating disruptive technologies.

Table 13. Level of Impact on Operational Excellence

Statement	Mean	Interpretation
Blockchain adoption will give our company a competitive edge in the market.	5.76	High impact
The use of blockchain technology will enhance our company's reputation as an innovator in the industry.	5.67	High impact
Blockchain technology provides long-term strategic value that exceeds that of traditional systems.	5.62	High impact
Our company believes that blockchain adoption positions our company for future growth and sustainability.	5.60	High impact
Blockchain's ability to enhance inter and intra-organizational collaboration offers long-term advantages over competitors.	5.60	High impact
Implementing blockchain technology will make it easier to achieve the company's vision and mission.	5.55	High impact

Blockchain adoption will lead to improved customer satisfaction through faster, more transparent, and secure services.	5.68	High impact
Blockchain technology will provide insights on the overall supply chain operation where the company operates and can make informed decisions based on this information.	5.78	High impact
Composite Mean	**5.66**	**High impact**

Table 13 reveals that the manufacturing firms in Batangas strongly believes blockchain adoption will have "High Impact" to its operational performance, with a composite mean score of 5.66, indicating agreement with the statements related to the technology's competitive advantage. The highest mean score of 5.78 reflects the companies' belief that blockchain provides insights into supply chain operations, improving decision-making through better transparency. However, the lower score related to aligning blockchain with the company's vision and mission reflects some uncertainty or cautiousness regarding the technology's immediate impact on long-term goals. The findings suggest that manufacturing firms recognize blockchain as a key enabler of operational efficiency, market competitiveness, and transparency. These results align with existing literature that underscores blockchain's transformative potential. AlKubaisy & Al-Somali (2023) highlighted that blockchain enhances competitive advantage by improving transparency, security, and efficiency. Sciarelli et al. (2021) and Queiroz et al. (2020) noted that blockchain adoption enables firms to establish a market-leading position by committing to technological innovation.

Table 14. Factors with Significant Effect on Blockchain Adoption

Blockchain technology Adoption	B	Std. Error	t-value	p-value	Decision on H_o	Interpretation
Constant	-0.665	0.308	-2.159	0.033	Reject	Significant
Relative Advantage	0.379	0.102	3.724	<0.001	Reject	Significant Effect
Top Management Support	0.093	0.052	1.805	0.073	Failed to Reject	No Significant Effect
Openness to Innovation Use	0.699	0.095	7.343	<0.001	Reject	Significant Effect
Competitor's Influence	0.031	0.110	0.279	0.781	Failed to Reject	No Significant Effect
Government Support	-0.028	0.068	-0.417	0.678	Failed to Reject	No Significant Effect
Vendor orientation and support	-0.101	0.098	-1.029	0.306	Failed to Reject	No Significant Effect

Model Summary: R = 0.881; R2 = 0.777
Regression Model: F = 74.333 p = <0.001

The findings on Table 14 highlight that relative advantage and openness to innovation are the most significant factors influencing blockchain adoption among manufacturing firms in Batangas. These factors suggest that companies are more likely to adopt blockchain technology when they see clear benefits over traditional systems and are open to embracing new technologies. Companies that recognize blockchain's potential to improve their operations and are receptive to innovation tend to be more proactive in integrating it into their processes. On the other hand, while top management support and vendor orientation might play a role in the process, they do not seem to be as critical in determining whether blockchain technology is adopted. The significant influence of relative advantage and openness to innovation use on blockchain adoption is strongly supported by extensive research. Kamble et al. (2019) emphasized that the perceived relative advantage of blockchain, such as its ability to enhance transparency, efficiency, and trust, is a critical driver of adoption in manufacturing firms. Their structural equation modeling study revealed that firms with a clear understanding of blockchain's benefits over traditional systems were significantly more likely to adopt the technology, aligning with the current findings of a positive coefficient for relative advantage.

Table 15. Effect of Blockchain Technology Adoption on Operation Excellence

Operational Excellence	B	Std. Error	t-value	p-value	Decision on H_o	Interpretation
Constant	2.871	0.240	11.940	<0.001	Reject	Significant
Blockchain technology Adoption	0.601	0.050	12.077	<0.001	Reject	Significant Effect

Model Summary: R = 0.723; R^2 = 0.523
Regression Model: F = 145.850 p = <0.001

The findings on Table 15 reveals a significant positive relationship between blockchain technology adoption and operational excellence. For blockchain technology adoption, the regression coefficient (B = 0.601) demonstrates that for every unit increase in blockchain adoption, operational excellence improves by approximately 0.601 units. The baseline level of operational excellence, which exists even without adopting blockchain, signifies that organizations are maintaining a certain standard of efficiency and performance. However, the data indicates that the adoption of blockchain further enhances operational excellence. As blockchain adoption increases, so does the level of operational excellence, suggesting that blockchain technology has a tangible, positive impact on operational processes, efficiency, and overall performance. This positive relationship emphasizes the idea that blockchain is not just a theoretical innovation, but a practical tool that can lead to measurable improvements in operations. Blockchain's ability to streamline processes, improve transparency, and secure transactions likely contributes to these improvements in operational excellence.

The positive relationship between blockchain technology adoption and operational excellence is well established in academic literature. For instance, Kamble et al. (2019) found that implementing blockchain in supply chains enhances transparency and efficiency, leading to improved operational performance. Additionally, Noor (2022) emphasized that blockchain's decentralized nature reduces the risk of data tampering, thereby improving data integrity and operational reliability. Wang et al. (2022) discussed how blockchain's real-time data processing capabilities streamline operations and enhance decision-making processes.

Table 16. Moderating Effect of Cultural Compatibility

Operational Excellence	B	Std. Error	t-value	p-value	Decision on H_o	Interpretation
Constant	0.297	0.090	3.288	0.001	Reject	Significant
Cultural Compatibility* Blockchain technology Adoption	-0.365	0.059	-6.148	<0.001	Reject	Significant Effect

Model Summary: R = 0.470; R^2 = 0.221
Regression Model: F = 37.802 p = <0.001

The results on Table 16 indicate that cultural compatibility significantly moderates the relationship between blockchain technology adoption and operational excellence. The interaction term between cultural compatibility and blockchain adoption has a negative coefficient of -0.365, with a highly significant p-value of less than 0.001. The significant F-value of 37.802 (with a p-value less than 0.001) confirms that the model is robust and statistically significant. This finding highlights the need for organizations to ensure cultural compatibility when integrating blockchain to avoid adverse effects on performance. The negative sign of the coefficient suggests that cultural compatibility reduces the strength of the positive effect of blockchain adoption on operational excellence. This finding implies that when cultural compatibility is high, the benefits of blockchain adoption on operational performance may be less pronounced, perhaps due to many processes might already align well with the cultural framework of the companies, limiting the scope to maximize blockchain's potential to achieve operational excellence.

The negative coefficient suggests potential challenges when these factors are not fully aligned. This highlights the importance of ensuring cultural compatibility when implementing blockchain technology as it can diminish or enhance operational excellence. The results offer an intriguing perspective on the role of cultural compatibility in blockchain adoption and operational excellence. While high cultural compatibility is often seen as an enabler of smooth adoption, the results suggest that blockchain's transformative potential might unexpectedly be more pronounced in environments with lower cultural compatibility.

The findings are aligned with AlKubaisy and Al-Somali (2023), who note that organizations in resistant cultural contexts must build robust strategies to overcome challenges, often leading to a more profound technological and organizational transformation. Conversely, in environments with high cultural compatibility, the urgency to leverage blockchain's full potential might diminish. Leaders and teams may assume that the technology will naturally align with existing practices, potentially leading to complacency and a less rigorous implementation process. This perspective is supported by Kamble et al. (2019), who discuss how perceived ease of integration in compatible environments can sometimes lead to underutilization of advanced technologies.

Table 17. Difference in Blockchain Adoption When Grouped According to Product Industry

Variables	Product Industry	Mean	f-value	p-value	Decision on H_o	Interpretation
Blockchain Technology Adoption	Electronics / Electronic components and/or assembly	5.11	2.520	0.033	Reject	Significant
	Rubber and/or Plastic	4.37				
	Automotive products / components	4.04				
	Fabricated Metal	4.58				
	Paper Products	3.89				
	Others	4.96				
	Others	5.80				

Table 17 shows that there is a significant difference in blockchain technology adoption based on the product industry. The p-value for blockchain technology adoption (0.033) is less than the 0.05 threshold, indicating that the product industry plays a significant role in determining the extent to which blockchain is adopted. Specifically, companies in the "Electronics / Electronic components and/or assembly" industry reported the highest mean adoption score (5.11), suggesting that some industries are more inclined to adopt blockchain technology than others. Companies in the "Electronics / Electronic components and/or assembly" industry exhibited the highest adoption scores, which can likely be attributed to the industry's emphasis on innovation, complex supply chains, and a strong need for transparency, traceability, and efficiency areas where blockchain offers clear advantages. This industry's focus on high-tech solutions and precision may make it more receptive to adopting disruptive technologies like blockchain. The results were supported by the study conducted by Queiroz and Wamba (2021). They conducted a comprehensive investigation into blockchain adoption across various industries, specifically targeting its applications in operations and supply chain management.

4. CONCLUSIONS

Based on the findings of the study, the following conclusions were drawn:

1. Companies in the study tend to have moderate sized operations, with a majority having fewer than 1,000 employees and being in business for 5 to 10 years, indicating a trend of stable, medium-sized companies within the LIMA Ecozone.
2. While companies show a general openness towards blockchain adoption, their cautious stance suggests that while they recognize its potential, they may be hesitant to implement it fully without further clarity on its benefits.
3. Technological factor in terms of perceived relative advantage of blockchain technology in enhancing operational efficiency, are seen as the most significant drivers of adoption, with companies also demonstrating a moderate willingness to embrace blockchain-related innovations.
4. Companies generally display a positive cultural alignment with adopting blockchain, reflecting a supportive attitude towards technology and innovation, though the support is not overwhelmingly strong.
5. Blockchain technology adoption is widely regarded as a contributor to improving operational excellence, indicating that companies believe it will enhance key operational functions such as efficiency, transparency, and reliability.
6. The strong influence of relative advantage and openness to innovation underscores that companies are more likely to adopt blockchain when they see clear benefits and when their organization is open to new technologies.
7. The adoption of blockchain technology significantly enhances operational excellence, confirming its potential to positively impact various aspects of company performance.
8. Cultural compatibility plays a critical role in moderating the effect of blockchain adoption, highlighting the importance of a company's cultural readiness in optimizing the technology's impact on operational excellence.
9. The electronics and electronic components industry stands out in blockchain adoption, suggesting that certain industries may be more inclined to integrate blockchain due to their unique operational needs or technological readiness.

5. RECOMMENDATIONS

Based on findings, several recommendations are proposed for key stakeholders:

1. Manufacturing companies may prioritize enhancing awareness and training to build employee understanding of blockchain technology and its potential benefits. Starting with pilot projects can help mitigate risks and build confidence before full-scale implementation. Organizations may also foster a culture of innovation and openness, ensuring alignment between blockchain adoption and existing organizational values.
2. Blockchain solutions providers may focus on developing cost-effective, scalable platforms tailored to medium-sized enterprises, along with comprehensive support for integration and customization. Conducting seminars on blockchain use cases across various industries can further educate and engage companies, highlighting success stories and best practices. Additionally, providers may strengthen their post-implementation services, such as maintenance, technical support, and ongoing system upgrades, to ensure long-term functionality and reliability. Strategic partnerships with academic institutions and industry clusters can also promote blockchain innovation and adoption.
3. Regulatory bodies may establish clear guidelines to provide legal certainty and address adoption hesitancy among businesses. They can promote cross-border collaboration to streamline trade and compliance, ensuring that blockchain adoption is seamless and globally recognized. Additionally, offering financial incentives such as grants, tax benefits, and subsidies would encourage companies to adopt blockchain technology, particularly for small and medium-sized enterprises that may face budget constraints. Investing in digital infrastructure to support blockchain systems will further facilitate its integration into the economy.
4. Future researchers are encouraged to explore cultural dimensions influencing blockchain adoption, such as leadership styles and employee attitudes. Comparative studies across industries could identify unique drivers and barriers, while long-term analyses of blockchain's sustained effects on operational excellence would provide valuable insights. Additionally, research on the interplay between blockchain and emerging technologies like AI and IoT could uncover innovative solutions for supply chain management challenges.

These recommendations aim to create a comprehensive approach to overcoming adoption barriers and maximizing blockchain's potential in the manufacturing sector.

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Acknowledgment

The researcher would like to acknowledge and give her sincerest gratitude to the following for their meaningful contributions during the conduct of this study: First and foremost, to the Almighty God for guiding her to make wise decisions. The success of the study could not be possible with the help of my TW II professor and thesis adviser for their exceptional patience and understanding in addressing all the researchers' inquiries, as well as for offering crucial advice, time, suggestions, and support throughout the research process. To the panel and the chairperson for the valuable suggestions and advise, lastly to Everyone who had shown support while completing this research, whether directly or indirectly.

