

Rawin Vongurai

Article

Investigating Industry 4.0, blockchain adoption, and sustainability on Thai finance's operational excellence

Global Business & Finance Review (GBFR)

Provided in Cooperation with:

People & Global Business Association (P&GBA), Seoul

Suggested Citation: Rawin Vongurai (2024) : Investigating Industry 4.0, blockchain adoption, and sustainability on Thai finance's operational excellence, Global Business & Finance Review (GBFR), ISSN 2384-1648, People & Global Business Association (P&GBA), Seoul, Vol. 29, Iss. 5, pp. 88-102, <https://doi.org/10.17549/gbfr.2024.29.5.88>

This Version is available at:

<https://hdl.handle.net/10419/306001>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc/4.0/>



Investigating Industry 4.0, Blockchain Adoption, and Sustainability on Thai Finance's Operational Excellence

Rawin Vongurai[†]

Associate Professor, Innovative Technology Management, Graduate School of Business and Advanced Technology Management, Assumption University, Thailand

ABSTRACT

Purpose: This study examines the impact of Industry 4.0, blockchain adoption, and sustainability on operational excellence within the Thai finance sector. Key variables include relative advantage, top management support, openness to use innovation, blockchain technology adoption, industry 4.0 practice, sustainable operation, and operational excellence.

Design/methodology/approach: Data was gathered through a survey administered to 278 participants comprising managers, IT experts, and banking and financial professionals, utilizing a quantitative methodology. Prior to data collection, the reliability of the questionnaire was evaluated via a pilot test involving 30 participants, assessing Item-Objective Congruence (IOC) index and reliability using Cronbach's Alpha. Sampling methods encompassed judgmental, convenience, and snowball techniques. Confirmatory Factor Analysis (CFA) and Structural Equation Modeling (SEM) were utilized to validate model fit and test hypotheses.

Findings: The study found that relative advantage, top management support, and openness to use innovation significantly influence blockchain technology adoption. Additionally, blockchain technology adoption and sustainable operation significantly impact operational excellence. However, industry 4.0 practice showed no significant influence on operational excellence.

Research limitations/implications: This study sheds light on blockchain adoption and operational excellence but faces limitations. Its context-specific nature may hinder generalization to other sectors or regions, compounded by a limited sample size. Moreover, reliance on self-reported survey data introduces potential response and social desirability biases.

Originality/value: The study's insights on Industry 4.0, blockchain adoption, sustainability, and operational excellence in Thai finance benefit practitioners, policymakers, and academics. By intertwining these concepts, it deepens understanding of their impact on operational performance. The confirmation of Blockchain Technology Adoption and Sustainable Operation highlights the necessity of strategic investments in these areas.

Keywords: Blockchain Technology Adoption, Industry 4.0 Practice, Sustainable Operation, Operational Excellence, Banking

I. Introduction

In the contemporary landscape of the finance

sector, the convergence of technological innovation and sustainable practices has become increasingly imperative for achieving operational excellence. This study aims to investigate the multifaceted impact of Industry 4.0, blockchain adoption, and sustainability on operational performance within the context of the Thai finance sector.

Received: Mar. 15, 2024; Revised: Apr. 19, 2024; Accepted: Apr. 22, 2024

[†] Corresponding author: Rawin Vongurai

E-mail: rawinwng@au.edu

The term "Industry 4.0" refers to the fourth industrial revolution characterized by the integration of digital technologies into manufacturing and service industries, leading to enhanced efficiency, productivity, and innovation (Schwab, 2016). In the finance sector, Industry 4.0 entails the adoption of advanced digital tools and automation processes to streamline operations, improve customer service, and optimize resource allocation (Fintechnews, 2020).

Blockchain technology has emerged as a disruptive force in the financial realm, offering decentralized and secure transaction mechanisms that enhance transparency, reduce fraud, and lower transaction costs (Swan, 2015). The adoption of blockchain technology in the finance sector has been associated with increased operational efficiency, faster transaction processing, and improved data integrity (Tapscott & Tapscott, 2016).

In the context of blockchain technology in Thai banking industry, Bank of Thailand (n.d.) underscores the pivotal role of financial technology (FinTech) in driving transformation within Thailand's financial sector, emphasizing innovation and digitalization. Through collaborative efforts between regulators, financial institutions, and technology companies, Thailand's FinTech ecosystem has experienced rapid growth, encompassing digital payments, peer-to-peer lending, robo-advisory services, and notably, blockchain technology.

Sustainability has also garnered significant attention in the finance industry, with organizations recognizing the importance of integrating environmental, social, and governance (ESG) criteria into their business strategies (Eccles & Serafeim, 2013; Sitorus et al., 2022). Sustainable practices not only mitigate environmental risks and enhance corporate reputation but also drive long-term financial performance and stakeholder value (Gibbs & Llewellyn, 2018).

While prior studies examined individual impacts, there's a gap in understanding their combined effects in the Thai finance sector. By synthesizing insights, this study builds upon existing knowledge by elucidating interactions and implications for operational performance. Clear definitions of key

terms like Industry 4.0 and blockchain ensure reader comprehension. Through this integrative approach, the study aims to advance understanding and offer practical insights for Thai finance stakeholders. This study contributes to filling the research gap by examining key variables such as relative advantage, top management support, openness to use innovation, blockchain technology adoption, industry 4.0 practice, sustainable operation, and operational excellence. The findings will provide valuable insights for stakeholders, policymakers, and academics, aiding strategic decision-making and enhancing operational practices in the dynamic landscape of the Thai finance sector.

By examining these variables in the specific context of the Thai finance sector, this research aims to provide actionable insights for industry stakeholders, policymakers, and academics. Understanding the drivers and outcomes of technological adoption and sustainable practices can inform strategic decision-making and facilitate the attainment of operational excellence in the dynamic landscape of the finance industry.

II. Literature Review

A. Relative Advantage

Relative Advantage, rooted in Rogers' Diffusion of Innovations theory, signifies the perceived superiority of a new technology over existing alternatives (AlKubaisy & Al-Somali, 2023; Jaruwanaikul, 2024). Within blockchain technology, perceived benefits like enhanced security, transparency, and efficiency in financial transactions are encompassed (Yli-Huumo et al., 2016). Empirical findings by Bhattacharjee (2001) underline the significant influence of relative advantage on individuals' technology adoption intentions, establishing it as a primary determinant of adoption behavior. In the banking sector, the allure of blockchain technology's relative advantage, evidenced by reduced transaction costs, accelerated settlement times, and

heightened data integrity (Swan, 2015; Tapscott & Tapscott, 2016), incentivizes financial institutions to consider its adoption. Studies such as Hileman and Rauchs (2017) and Higginson et al. (2019) corroborate the pivotal role of relative advantage in driving blockchain adoption within financial institutions, highlighting perceived benefits like cost savings and operational efficiencies. Thus, relative advantage emerges as a critical determinant influencing the adoption of blockchain technology within the banking sector:

Hypothesis 1: Relative advantage has a significant influence on blockchain technology adoption.

B. Top Management Support

Top management support is crucial for driving organizational change and technology adoption in banking (AlKubaisy & Al-Somali, 2023). Research by Zhang et al. (2008) emphasizes its significant impact on employees' attitudes towards technology adoption, catalyzing change implementation. In banking, top management support fosters an innovative culture (Luftman et al., 2017), as highlighted by Jaruwanaikul (2021), who underscores its role in shaping organizational strategies and technology investments, aligning goals, and overcoming resistance to change (Chang & King, 2005). Empirical evidence from Balasubramanian et al. (2021) and Mishra et al. (2023) further reinforces the importance of top management support in blockchain adoption readiness and success within financial institutions, aligning organizational objectives with technology initiatives and providing necessary resources. Thus, top management support is a critical determinant of blockchain adoption success in banks:

Hypothesis 2: Top management support has a significant influence on blockchain technology adoption.

C. Openness to Use Innovation

Openness to innovation, reflecting the willingness of individuals or organizations to embrace new technologies (Kim & Bae, 2020). It is crucial for the banking sector's adoption of innovations like blockchain (AlKubaisy & Al-Somali, 2023). Aboramadan et al. (2020) emphasize the role of organizational culture in fostering such openness, advocating for environments that encourage experimentation and risk-taking. In banking, cultivating openness to innovation is essential for adopting disruptive technologies like blockchain (Jena, 2022; Wang et al., 2022). Empirical findings from AL-Ashmori et al. (2023) and Javaid et al. (2022) affirm the influence of organizational openness on blockchain adoption readiness and successful implementation in the banking sector. These studies underscore the critical role of openness to innovation in shaping blockchain adoption within banking, aligning with the proposed hypothesis:

Hypothesis 3: Openness to use innovation has a significant influence on blockchain technology adoption.

D. Blockchain Technology Adoption

Blockchain technology, initially developed for cryptocurrencies like Bitcoin, offers decentralized and immutable ledgers, promising enhanced security, transparency, and efficiency in financial transactions within banking (Mhlanga, 2023). Its distributed and tamper-proof record of transactions can streamline processes such as cross-border payments, trade finance, and identity verification (Javaid et al., 2022). Empirical studies by Xie et al. (2023) and Weerawarna et al. (2023) demonstrate blockchain's positive impact on investment banks, leading to improved operational efficiency, reduced transaction costs, and increased transparency. Additionally, AlKubaisy and Al-Somali (2023) underscore blockchain's role in driving operational excellence through increased efficiency and process automation. Leveraging blockchain solutions allows banks to eliminate intermediaries,

minimize errors, and expedite transaction processing, ultimately enhancing operational performance. Thus, the literature supports the hypothesis regarding the influence of blockchain adoption on operational excellence within banking:

Hypothesis 4: Blockchain technology adoption has a significant influence on operational excellence.

E. Industry 4.0 Practice

Industry 4.0 practices, encompassing advanced technologies like artificial intelligence, big data analytics, IoT, and robotic process automation, offer opportunities for process optimization, improved customer experiences, and enhanced operational efficiency in banking (Gupta et al., 2022; Mekinjić, 2019). For instance, AI-powered chatbots provide personalized customer support, while big data analytics offers insights for risk management and decision-making (Bhattacharya & Sinha, 2022). Studies by Svoboda (2023), Javaid et al. (2022), and Yaqub and Alsabban (2023) demonstrate the positive impact of AI, analytics, and Industry 4.0 initiatives on banking operations, leading to efficiency gains, cost reduction, and increased agility. Additionally, Turek et al. (2023) highlight the role of Industry 4.0 technologies in driving operational excellence and competitive advantage in the financial services sector. Overall, the literature emphasizes the substantial influence of Industry 4.0 practices on operational excellence within banking, supporting hypothesis formulation:

Hypothesis 5: Industry 4.0 practice has a significant influence on operational excellence.

F. Sustainable Operation

Sustainable operation, integrating environmental, social, and governance (ESG) considerations, has gained traction in various industries, including banking (Gupta et al., 2022). Banks recognize sustainability's role in risk mitigation, reputation

enhancement, and long-term value creation (Abuatwan, 2023). Key practices such as environmentally friendly operations, financial inclusion promotion, and community support are integral to sustainable banking (Riegler, 2023). Studies by Rahi et al. (2022) and Stankeviciene and Nikonorova (2014) establish a positive correlation between sustainability performance and financial performance in banking. Additionally, Azmi et al. (2020) demonstrate that banks with robust ESG strategies outperform peers in operational efficiency, risk management, and customer satisfaction. Effectiveness of operation refers to achieving desired outcomes like cost reduction or productivity improvement (Mohd Isa et al., 2020). Furthermore, Kumar et al. (2016) highlights the financial benefits of sustainable investing for banks, including improved risk-adjusted returns and reduced volatility. Hence, this research proposes the significant influence of sustainable operation on operational excellence, as hypothesized below:

Hypothesis 6: Sustainable operation has a significant influence on operational excellence.

G. Operational Excellence

Operational excellence in banking involves executing processes effectively, leveraging technology, and optimizing resources to achieve superior performance in areas like cost-effectiveness, service quality, and risk management (Muazu & Nashehu, 2021). To stay competitive in a rapidly evolving market, banks prioritize streamlining operations, automating tasks, and ensuring regulatory compliance (Priyanto et al., 2023). Research by Fethi and Pasiouras (2009) indicates that banks focusing on efficiency and process optimization outperform peers in financial performance and customer retention. Similarly, Jena (2022) emphasizes the importance of operational excellence in facilitating successful blockchain adoption in banks. Additionally, Shehadeh et al. (2023) find that digital transformation initiatives, such as digitization and automation, drive efficiency gains and operational effectiveness. Embracing digital

innovation enables banks to enhance agility and competitiveness (Diener & Špaček, 2021). Therefore, operational excellence remains a strategic priority for banks navigating an increasingly competitive and digital-driven landscape.

H. Conceptual Framework

In the conceptual framework of this study, the hypothesis regarding the significant enhancement of operational excellence through blockchain technology adoption draws upon the Innovation Diffusion Theory (IDT) by Rogers (1962), which suggests that the adoption of innovative technologies follows predictable stages. Additionally, prior research by Gupta et al. (2022) demonstrated the significant relationship between Industry 4.0 practices, sustainable operations, and operational excellence within Indian SMEs. AlKubaisy and Al-Somali (2023) found that relative advantage, top management support, and openness to innovation significantly influence blockchain technology adoption, which in turn enhances operational excellence. Combining these insights, Figure 1 illustrates the study framework alongside proposed hypotheses.

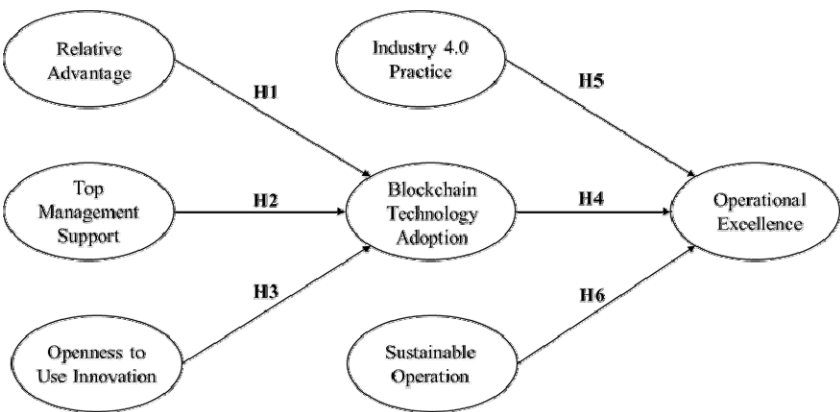
III. Methodology

A. Pre-Test

In the pre-test, this study ensured content validity by utilizing the Item-Objective Congruence (IOC) index, and reliability was assessed using Cronbach's Alpha during a pilot test involving 30 participants. This step is crucial for ensuring that the survey items accurately measure the intended constructs, and can be identified and addressed issues before the main data collection phase. For the IOC, three experts rated each item on a scale of 0, -1, or 1, where 1 indicated effective measurement of the objective, -1 denoted irrelevance, and 0 represented uncertainty. The average IOC index scored 0.67 and above, indicating a high level of content validity (Rovinelli & Hambleton, 1977), resulting in the retention of all scale items in the questionnaire. Prior to the main data collection, the pilot test involving 30 participants revealed Cronbach's alpha coefficient values exceeding the acceptable threshold of 0.7 (Nunnally, 1978).

B. Survey Methods

A quantitative approach allows for the collection



Source: Constructed by Author.

Figure 1. Conceptual Framework

of large amounts of data efficiently, facilitating statistical analysis to uncover patterns and relationships between variables. The research employed online distribution from September to December 2023. A screening question was included to qualify participants: "Are you a manager, IT expert, or banking and financial professional with relevance to blockchain technology adoption or operational excellence within a banking and financial company?" The survey comprised three sections: preliminary screening questions (2), items measured on a five-point Likert scale from 1 (strongly disagree) to 5 (strongly agree) (31), and demographic questions (4), covering gender, age, education, and job role.

C. Population and Sample Size

Data were gathered from various stakeholders, including managers, IT experts, and banking and financial professionals, utilizing a quantitative approach. A questionnaire, distributed via Google Forms to participants from financial enterprises in Thailand implementing Industry 4.0, blockchain adoption, sustainability, and operational excellence, served as the primary research instrument. To protect the data privacy and competitive advantages of companies, the names of these enterprises remain undisclosed. Utilizing structural equation modeling, Kline (2016) recommended a sample size of at least 200 respondents for robust and reliable results. To ensure a comprehensive dataset, an online survey was distributed to approximately 1,000 participants. However, only 278 qualified participants responded and were deemed valid for proceeding to the subsequent data analysis phase.

D. Sampling Technique

The sampling methodology utilized in this study includes judgmental, convenience, and snowball sampling approaches. This approach allows for the inclusion of participants with relevant expertise and

experience in the finance sector, ensuring the data collected is representative and informative. Initially, the researcher targeted managers, IT specialists, and banking and financial professionals relevant to blockchain technology adoption or operational excellence within a banking and financial institution. Despite the specificity of these roles and challenges in widespread distribution, convenience sampling was employed to recruit eligible participants via management channels, online channels (e.g. Email, Chat Application, LinkedIn, and Facebook), and referrals. An online survey distributed through Google Forms was then employed to attract voluntary respondents without guaranteeing a proportional representation. Additionally, snowball sampling was integrated, encouraging participants to share the survey link with their qualified peers and colleagues, thereby extending the study's reach. This amalgamation of sampling techniques is designed to ensure a varied and inclusive participant pool for the research inquiry.

E. Data Analysis

Confirmatory factor analysis (CFA) and structural equation modeling (SEM) were chosen as the statistical techniques for data analysis. CFA evaluates the validity of the measurement model by confirming the relationships between observed variables and their underlying latent constructs. SEM, on the other hand, examines the structural relationships between variables and constructs to test hypotheses and model fit. These techniques provide a comprehensive understanding of the relationships between variables and constructs in the study (Hair et al., 2010). By utilizing these advanced statistical techniques, the study aims to provide robust evidence and insights into the complex interplay between technology adoption, sustainability practices, and operational excellence in the Thai finance sector.

IV. Findings

From Table 1, the demographic data collected from 278 participants in Thailand's financial enterprises, spanning managers, IT experts, and banking professionals, revealed a predominantly male gender distribution (62.9%) and diverse age groups, with 40-49-year-olds forming the largest segment (36%). Educational attainment varied, with the majority holding bachelor's degrees (64.4%), followed by master's (27.3%) and doctoral degrees (8.3%). Job roles were diverse, including C-Level executives (10.4%), IT experts (39.9%), operational managers/directors (32.0%), and others (17.6%). This diverse representation provides valuable insights into the stakeholders involved in the study of Industry 4.0, blockchain adoption, sustainability, and operational excellence within Thailand's financial sector.

A. Confirmatory Factor Analysis

In Confirmatory Factor Analysis (CFA), data examination assessed convergence validity and

discriminant validity. Internal consistency was measured using Cronbach's Alpha, with a criterion of 0.70 or higher (Nunnally, 1978). Criteria for acceptability included t-values > 1.98 , p-values < 0.5 , and factor loadings > 0.5 . Composite reliability (CR) was also considered, with values > 0.7 , indicating significance. Additionally, following the guidance of Fornell and Larcker (1981), if the Average Variance Extracted (AVE) falls below 0.5 but the Composite Reliability (CR) exceeds 0.6, the convergent validity of the construct remains satisfactory. These criteria ensured robust estimates, confirming both convergence and discriminant validity within the measurement model, as results shown in Table 2.

B. Discriminant Validity

Hair et al. (2010) emphasized the importance of discriminant validity in structural equation modeling (SEM), where constructs should have lower correlations with other constructs compared to their own construct's indicators. According to Table 3, Fornell and Larcker (1981) proposed using the square root of the AVE for each construct to assess

Table 1. Demographic profile

Demographic and General Data (N=278)		Frequency	Percentage
Gender	Male	175	62.9%
	Female	103	37.1%
	Total	278	100%
Age	Below 30 Years Old	24	8.6%
	30-39 Years Old	98	35.3%
	40-49 Years Old	100	36.0%
	Over 49 Years Old	56	20.1%
	Total	278	100%
Level of Education	Bachelor's Degree	179	64.4%
	Master's Degree	76	27.3%
	Doctoral Degree	23	8.3%
	Total	278	100%
Job Role	C-Level/Founder/Co-founder	29	10.4%
	IT Experts	111	39.9%
	Operation Manager/Director	89	32.1%
	Other roles	49	17.6%
	Total	278	100%

Source: Constructed by Author.

Table 2. Confirmatory factor analysis result, composite reliability (CR) and average variance extracted (AVE)

Variables	Source of Questionnaire	No. of Items	Cronbach's	Factors Loading	CR	AVE
Relative Advantage (RA)	AlKubaisy and Al-Somali (2023)	3	0.881	0.809-0.865	0.882	0.714
Top Management Support (TOP)	Chong et al. (2021)	4	0.842	0.678-0.849	0.842	0.574
Openness to Use Innovation (OPN)	AlKubaisy and Al-Somali (2023)	3	0.908	0.846-0.903	0.908	0.767
Blockchain Technology Adoption (BCA)	AlKubaisy and Al-Somali (2023)	3	0.848	0.729-0.865	0.849	0.654
Industry 4.0 Practice (IN)	Gupta et al. (2022)	8	0.918	0.681-0.823	0.918	0.586
Sustainable Operation (SO)	Gupta et al. (2022)	8	0.863	0.576-0.736	0.866	0.448
Operational Excellence (OE)	AlKubaisy and Al-Somali (2023)	4	0.790	0.666-0.741	0.792	0.488

Source: Constructed by Author.

Table 3. Discriminant validity

	RA	TOP	OPN	IN	SO	BCA	OE
RA	0.845						
TOP	0.333	0.758					
OPN	0.752	0.424	0.876				
IN	0.338	0.170	0.329	0.765			
SO	0.582	0.282	0.548	0.221	0.669		
BCA	0.486	0.383	0.512	0.227	0.524	0.809	
OE	0.510	0.206	0.527	0.234	0.529	0.395	0.698

Source: Constructed by Author.

discriminant validity, with the requirement that the correlations between constructs should be smaller than the square roots of their respective AVEs.

C. Structural Equation Model (SEM)

In Table 4, the goodness of fit for both the measurement and structural models was assessed based on several statistical indices. For the measurement model, the CMIN/DF ratio was 1.975, slightly below the acceptable threshold of 3.00 (Hair et al., 2006), indicating a good fit. Similarly, the GFI, AGFI, NFI, CFI, TLI, and RMSEA values exceeded or were very close to the recommended thresholds of 0.80 for GFI, AGFI, NFI, CFI, and TLI, and less than 0.08 for RMSEA (Al-Mamary

& Shamsuddin, 2015; Bentler, 1990; Pedroso et al., 2016; Sharma et al., 2005; Sica & Ghisi, 2007; Wu & Wang, 2006), suggesting acceptable model fit. The structural model also demonstrated similar goodness-of-fit statistics, further confirming its acceptability. Thus, both the measurement and structural models exhibited satisfactory fits, as indicated by the calculated statistical values.

D. Research Hypothesis Testing Result

The results of hypothesis testing, derived from the Standardized Path Coefficients and t-values, are presented in Table 5 and visually depicted in Figure 2. Statistical significance, indicating support for the hypotheses, is determined at a significance level of $p = 0.05$ (Hair et al., 2010). This significance level

Table 4. Goodness of fit of measurement model & structural model

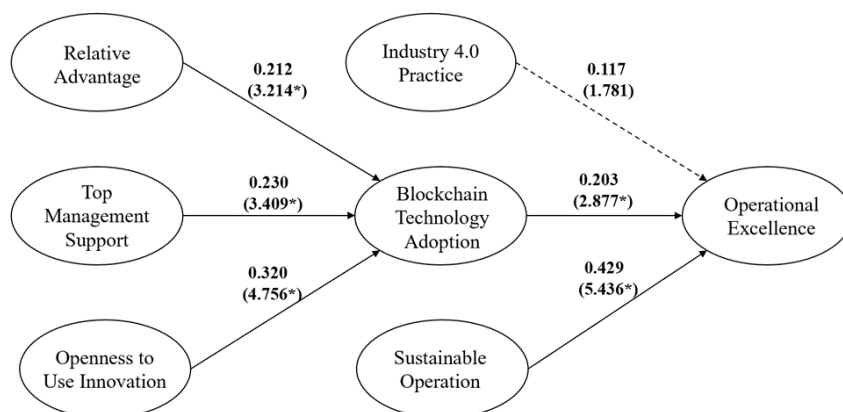
Index	Acceptable Values	Measurement Model	Structural Model
		Statistical Values (No Model Adjustment)	Statistical Values (No Model Adjustment)
CMIN/DF	< 3.00 (Hair et al., 2006)	936.142/474 = 1.975	967.353/479 = 2.020
GFI	≥ 0.80 (Al-Mamary & Shamsuddin, 2015)	0.844	0.839
AGFI	≥ 0.80 (Sica & Ghisi, 2007)	0.815	0.811
NFI	≥ 0.80 (Wu & Wang, 2006)	0.836	0.830
CFI	≥ 0.80 (Bentler, 1990)	0.911	0.905
TLI	≥ 0.80 (Sharma et al., 2005)	0.900	0.896
RMSEA	< 0.08 (Pedroso et al., 2016)	0.059	0.061
Model summary		Acceptable Model Fit	Acceptable Model Fit
Remark: CMIN/DF = The ratio of the chi-square value to degree of freedom, GFI = goodness-of-fit index, AGFI = adjusted goodness-of-fit index, NFI = normalized fit index, CFI = comparative fit index, TLI = Tucker-Lewis index, and RMSEA = root mean square error of approximation			
Source: Constructed by Author.			

Table 5. Hypothesis result of the structural model

Hypotheses	Paths	Standardized Path Coefficients (β)	S.E.	T-Value	Tests Result
H1	BCA<---RA	0.212	0.053	3.214*	Supported
H2	BCA<---TOP	0.230	0.057	3.409*	Supported
H3	BCA<---OPN	0.320	0.051	4.756*	Supported
H4	OE<---BCA	0.203	0.067	2.877*	Supported
H5	OE<---IN	0.117	0.056	1.781	Not Supported
H6	OE<---SO	0.429	0.078	5.436*	Supported

Note: *p<0.05

Source: Constructed by Author.



Remark: Dashed lines, not significant; solid lines, significant. *p<0.05

Source: Constructed by Author.

Figure 2. The Results of Structural Model

indicates that there is a 5% chance of obtaining the observed results if the null hypothesis (no relationship between variables) were true. Therefore, if the p-value associated with a hypothesis test is less than 0.05, the result is considered statistically significant, providing evidence to support the hypothesis. Conversely, if the p-value exceeds 0.05, the result is not considered statistically significant, suggesting insufficient evidence to support the hypothesis.

The results of the hypothesis testing, as depicted in the structural model, reveal significant findings regarding the influence of various factors on blockchain technology adoption and operational excellence within the context studied.

- H1:** Relative advantage has a significant influence on blockchain technology adoption. This hypothesis is supported, with a standardized path coefficient of 0.212 ($p < 0.05$), indicating that organizations perceiving relative advantages are more likely to adopt blockchain technology.
- H2:** Top management support has a significant influence on blockchain technology adoption. This hypothesis is supported, with a standardized path coefficient of 0.230 ($p < 0.05$), suggesting that strong support from top management increases the likelihood of blockchain technology adoption.
- H3:** Openness to use innovation has a significant influence on blockchain technology adoption. This hypothesis is supported, with a standardized path coefficient of 0.320 ($p < 0.05$), indicating that organizations open to innovation are more inclined to adopt blockchain technology.
- H4:** Blockchain technology adoption has a significant influence on operational excellence. This hypothesis is supported, with a standardized path coefficient of 0.203 ($p < 0.05$), demonstrating that the adoption of blockchain technology positively impacts operational excellence.
- H5:** Industry 4.0 practice has a significant influence on operational excellence. This hypothesis is

not supported, as the standardized path coefficient is 0.117 ($p > 0.05$), suggesting that Industry 4.0 practices may not significantly contribute to operational excellence in the studied context.

- H6:** Sustainable operation has a significant influence on operational excellence. This hypothesis is supported, with a standardized path coefficient of 0.429 ($p < 0.05$), indicating that sustainable operation positively influences operational excellence.

V. Discussion

The results of the hypothesis testing offer valuable insights into the factors influencing blockchain technology adoption and operational excellence within the context studied. Firstly, the significant positive influence of relative advantage, top management support, and openness to innovation on blockchain technology adoption underscores the importance of organizational perceptions and support structures in driving technology adoption initiatives. Organizations that perceive relative advantages, receive strong support from top management, and are open to embracing innovation are more likely to adopt blockchain technology, which aligns with prior literature emphasizing the role of organizational factors in technology adoption processes (Aboramadan et al., 2020; AlKubaisy & Al-Somali, 2023; Balasubramanian et al., 2021).

Furthermore, the significant positive impact of blockchain technology adoption on operational excellence highlights the transformative potential of blockchain technology in enhancing operational efficiency within organizations (Javaid et al., 2022; Mhlanga, 2023). This finding suggests that organizations that adopt blockchain technology are better positioned to achieve operational excellence through improved processes, transparency, and data integrity facilitated

by blockchain systems. However, it is noteworthy that Industry 4.0 practices did not exhibit a significant influence on operational excellence in the studied context, indicating that other factors may play a more prominent role in driving operational efficiency (Gupta et al., 2022; Mekinjić, 2019).

The notable positive influence of sustainable operation on operational excellence underscores the importance of integrating sustainability principles into organizational practices. Organizations that prioritize sustainable operations demonstrate higher levels of operational excellence, potentially due to factors such as cost savings, risk mitigation, and enhanced stakeholder relationships associated with sustainable practices. This finding aligns with Rahi et al. (2022) and Stankeviciene and Nikonorova (2014) that the growing emphasis on sustainability as a key driver of organizational performance and competitive advantage. Additionally, a study of Duong (2022) recommended managers to focus on strategic planning and business development with an emphasis on sustainability.

Overall, these results highlight the complex interplay between organizational factors, technology adoption, and operational performance. Organizations seeking to enhance operational excellence should consider factors such as relative advantage, top management support, openness to innovation, and sustainable operation, alongside the strategic adoption of blockchain technology, to achieve sustainable competitive advantage in today's dynamic business environment.

VI. Conclusion

This study investigated the factors influencing blockchain technology adoption and operational excellence within the context of the studied organizations. The findings revealed that factors such as relative advantage, top management support, and openness to innovation significantly influence

blockchain technology adoption, highlighting the importance of organizational perceptions and support structures in driving technology adoption initiatives. Additionally, the adoption of blockchain technology was found to positively impact operational excellence, indicating its transformative potential in enhancing organizational efficiency and transparency.

Furthermore, the study identified sustainable operation as a key driver of operational excellence, underscoring the importance of integrating sustainability principles into organizational strategies and practices. While Industry 4.0 practices did not exhibit a significant influence on operational excellence in the studied context, organizations are encouraged to critically evaluate the relevance and effectiveness of advanced technologies in driving operational performance.

Overall, the findings of this study contribute to our understanding of the complex relationship between technology adoption, sustainability, and operational performance. By leveraging the insights provided, organizations can develop informed strategies to enhance their operational efficiency, drive innovation, and achieve sustainable competitive advantage in today's dynamic business landscape. Further research is recommended to explore additional factors and contexts that may influence technology adoption and operational excellence, thereby advancing our knowledge and informing practical strategies for organizational success.

A. Theoretical Contributions

The study contributes to existing literature by empirically examining factors influencing blockchain technology adoption and operational excellence, enriching understanding of technology adoption dynamics. It extends insights by demonstrating a positive association between blockchain adoption and operational excellence, emphasizing blockchain's transformative potential in enhancing organizational efficiency. Additionally, the research highlights the positive influence of sustainable practices on

operational excellence, reinforcing the importance of integrating sustainability into organizational strategies. Despite not finding a significant impact of Industry 4.0 practices on operational excellence, the study offers insights into the role of advanced technologies in driving organizational performance, guiding further exploration in this area. Overall, the study's theoretical contributions advance understanding of organizational factors, technology adoption, sustainability, and operational excellence, benefiting both researchers and practitioners.

B. Practical Implications

The practical implications of the study findings are significant for organizations operating within the studied context and beyond. Firstly, the identification of factors such as relative advantage, top management support, and openness to innovation as key drivers of blockchain technology adoption suggests actionable strategies for organizations looking to leverage blockchain for operational improvement. Organizations should focus on building awareness of the benefits of blockchain technology, securing top-level support for adoption initiatives, and fostering a culture of innovation to facilitate successful adoption and integration of blockchain solutions into their operations.

Moreover, the study highlights the importance of sustainable practices in driving operational excellence. Organizations can benefit from incorporating sustainability principles into their operations, such as reducing energy consumption, minimizing waste, and promoting ethical supply chain practices. By aligning sustainability efforts with operational objectives, organizations can not only enhance their environmental and social impact but also improve overall operational performance and competitiveness.

Furthermore, while the study did not find a significant influence of Industry 4.0 practices on operational excellence in the studied context, it underscores the need for organizations to critically evaluate the relevance and effectiveness of advanced

technologies in their specific operational contexts. Rather than blindly adopting Industry 4.0 technologies, organizations should carefully assess their potential benefits and limitations and prioritize investments that align with their strategic objectives and operational needs.

Overall, the practical implications of the study findings emphasize the importance of strategic decision-making, organizational alignment, and continuous improvement in driving operational excellence and sustainable business practices. By leveraging the insights provided by this research, organizations can develop informed strategies to enhance their operational performance, drive innovation, and create value for stakeholders in an increasingly competitive and dynamic business environment.

VII. Limitation and Further Study

While this study provides valuable insights into the factors influencing blockchain technology adoption and operational excellence, several limitations should be acknowledged. Firstly, the research was conducted within a specific context and may not be generalizable to other industries or regions. The sample size was also limited to organizations within the studied context, which may restrict the generalizability of the findings. Additionally, the study relied on self-reported data from survey respondents, which may be subject to response bias and social desirability bias.

References

- Aboramadan, M., Albashiti, B., Alharazin, H., & Zaidoune, S. (2020). Organizational culture, innovation and performance: A study from a non-western context. *Journal of Management Development*, 39(4), 437-451. doi:10.1108/JMD-06-2019-

0253

- Abuatwan, N. (2023). The Impact of Green Finance on the Sustainability Performance of the Banking Sector in Palestine: The Moderating Role of Female Presence. *Economies*, 11(10), 247. doi:10.3390/economies11100247
- AL-Ashmori, A., Thangarasu, G., Dominic, P. D. D., & Al-Mekhlafi, A.-B. A. (2023). A Readiness Model and Factors Influencing Blockchain Adoption in Malaysia's Software Sector: A Survey Study. *Sustainability*, 15(16), 12139. doi:10.3390/su151612139
- AlKubaisy, Z. M., & Al-Somali, S. A. (2023). Factors Influencing Blockchain Technologies Adoption in Supply Chain Management and Logistic Sectors: Cultural Compatibility of Blockchain Solutions as Moderator. *Systems*, 11(12), 574. doi:10.3390/systems11120574
- Al-Mamary, Y. H., & Shamsuddin, A. (2015). Testing of The Technology Acceptance Model in Context of Yemen. *Mediterranean Journal of Social Sciences*, 6(4), 268-273.
- Azmi, W., Hassan, K. M., Houston, R., & Karim, M. S. (2020). ESG activities and banking performance: International evidence from emerging economies. *Journal of International Financial Markets, Institutions and Money*, 70(3), 101277. doi:10.1016/j.intfin.2020.101277
- Balasubramanian, S., Shukla, V., Sethi, J., Islam, N., & Saloum, R. (2021). A readiness assessment framework for Blockchain adoption: A healthcare case study. *Technological Forecasting and Social Change*, 165(1), 120536. doi:10.1016/j.techfore.2020.120536
- Bank of Thailand. (n.d.). Blockchain Technology and Financial Innovation Development. <https://www.bot.or.th/th/financial-innovation/digital-finance/fintech-in-thailand/FinTech.html>
- Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin*, 107(2), 238-246. doi:10.1037/0033-2909.107.2.238
- Bhattacharya, C., & Sinha, M. (2022). The Role of Artificial Intelligence in Banking for Leveraging Customer Experience. *Australasian Accounting Business and Finance Journal*, 16(5), 89-105.
- Bhattacharjee, A. (2001). Understanding Information Systems Continuance: An Expectation-Confirmation Model. *MIS Quarterly*, 25(3), 351-370. doi:10.2307/3250921
- Chang, M. K., & King, W. R. (2005). Measuring the Performance of Information Systems: A Functional Scorecard. *Journal of Management Information Systems*, 22(1), 85-115.
- Chong, K. W., Kim, Y. S., & Choi, J. (2021). A study of factors affecting intention to adopt a cloud-based digital signature service. *Information*, 12, 60.
- Diener, F., & Špaček, M. (2021). Digital Transformation in Banking: A Managerial Perspective on Barriers to Change. *Sustainability*, 13(4), 2032. doi:10.3390/su13042032
- Duong, N.-H. (2022). Relationship of Social Sustainability, Operational Performance and Economic Performance in Sustainable Supply Chain Management. *Global Business & Finance Review*, 27(4), 46-64. doi:10.17549/gbfr.2022.27.

4.46

- Eccles, R. G., & Serafeim, G. (2013). The Performance Frontier: Innovating for a Sustainable Strategy. *Harvard Business Review*, 91(5), 50-60.
- Fethi, M., & Pasiouras, F. (2009). Assessing Bank Efficiency and Performance with Operational Research and Artificial Intelligence Techniques: A Survey. *European Journal of Operational Research*, 204(2), 189-198. doi:10.1016/j.ejor.2009.08.003
- Fintechnews (2020, March 1). Cybersecurity-Biggest challenge to Industry 4.0. <https://www.fintechnews.org/cybersecurity-biggest-challenge-to-industry/>
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39-50. doi:10.2307/3151312
- Gibbs, D., & Llewellyn, M. (2018). International business strategy and innovation for society: Legitimacy reconsidered. *British Journal of Management*, 29(3), 423-440.
- Gupta, S., Prathipati, B., Dangayach, G. S., Rao, P. N., & Jagtap, S. (2022). Development of a Structural Model for the Adoption of Industry 4.0 Enabled Sustainable Operations for Operational Excellence. *Sustainability*, 14(17), 11103. doi:10.3390/su141711103
- Hair, J., Black, W., Babin, B., Anderson, R., & Tatham, R. (2006). *Multivariate Data Analysis* (6th ed.). Pearson Education.
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th ed.). Pearson.
- Higginson, M., Hilal, A., & Yugac, E. (2019, June 7). Blockchain and retail banking: Making the connection. McKinsey & Company. <https://www.mckinsey.com/industries/financial-services/our-insights/blockchain-and-retail-banking-making-the-connection>
- Hileman, G., & Rauchs, M. (2017). *Global Blockchain Benchmarking Study*. Cambridge Centre for Alternative Finance.
- Jaruwanakul, T. (2021). Key Influencers of Innovative Work Behavior in Leading Thai Property Developers. *AU-GSB E-JOURNAL*, 14(1), 61-70. doi:10.14456/auugsbejr.2021.7
- Jaruwanakul, T. (2024). The Influence of AI-CRM Adoption and Big Data Analytical Capability on Firm Performance of Large Enterprises in Thailand. *Global Business & Finance Review*, 29(2), 112-126. doi:10.17549/gbfr.2024.29.2.112
- Javaid, M., Haleem, A., Singh, R. V., Suman, R., & Khan, S. (2022). A review of Blockchain Technology applications for financial services. *Benchmark Transactions on Benchmarks, Standards and Evaluations*, 2(3), 100073. doi:10.1016/j.tbench.2022.100073
- Jena, R. K. (2022). Examining the Factors Affecting the Adoption of Blockchain Technology in the Banking Sector: An Extended UTAUT Model. *International Journal of Financial Studies*, 10(4), 1-20. doi:10.3390/ijfs10040090
- Kim, D., & Bae, J. K. (2020). The Effects of Protection Motivation and Perceived Innovation Characteristics on

- Innovation Resistance and Innovation Acceptance in Internet Primary Bank Services. *Global Business & Finance Review*, 25(1), 1-12. doi:10.17549/gbfr.2020.25.1.1
- Kline, R. B. (2016). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press.
- Kumar, N., Smith, C., Badis, L., Wang, N., Ambrosy Eyzaguirre, P., & Tavares, R. (2016). ESG factors and risk-adjusted performance: a new quantitative model. *Journal of Sustainable Finance & Investment*, 6(4), 292-300. doi:10.1080/20430795.2016.1234909
- Luftman, J., Lyytinen, K., & Zvi, T. (2017). Enhancing the measurement of information technology (IT) business alignment and its influence on company performance. *Journal of Information Technology*, 32(1), 26-46. doi:10.1057/jit.2015.23
- Mekinić, B. (2019). The Impact of Industry 4.0 On the Transformation of The Banking Sector. *Journal of Contemporary Economics*, 1(1), 7-28. doi:10.7251/JOCE1901006M
- Mhlanga, D. (2023). Block chain technology for digital financial inclusion in the industry 4.0, towards sustainable development? *Frontiers Blockchain*, 6, 1035405. doi:10.3389/fbloc.2023.1035405
- Mishra, R., Singh, R. K., Kumar, S., Mangla, S. K., & Kumar, V. (2023). Critical success factors of Blockchain technology adoption for sustainable and resilient operations in the banking industry during an uncertain business environment. *Electronic Commerce Research*, 22, 1-35. doi:10.1007/s10660-023-09707-3
- Mohd Isa, M. Y. B., Islam, G. M. N., & Mohamed, Z. (2020). Financing Services Sector: Effectiveness of Operational Coordination and Process Control, Evidence from Malaysia. *Global Business & Finance Review*, 25(4), 12-24. doi:10.17549/gbfr.2020.25.4.12
- Muazu, M., & Nashehu, H. (2021). Operational Excellence and Commercial Banking Performance: A Competitive Advantage Opportunity. *Journal of Technology Management and Innovation*, 8(1), 28-34. doi:10.30880/jtmb.2021.08.01.004
- Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). McGraw-Hill.
- Pedroso, R., Zanetello, L., Guimaraes, L., Pettenon, M., Goncalves, V., Scherer, J., ... Pechansky, F. (2016). Confirmatory factor analysis (CFA) of the crack use relapse scale (CURS). *Archives of Clinical Psychiatry*, 43(3), 37-40.
- Priyanto, P., Murwaningsari, E., & Augustine, Y. (2023). Exploring the Relationship between Robotic Process Automation, Digital Business Strategy and Competitive Advantage in Banking Industry. *Journal of System and Management Sciences*, 13(3), 290-305. doi:10.33168/JSM S.2023.0320
- Rahi, A. F., Akter, R., & Johansson, J. (2022). Do sustainability practices influence financial performance? Evidence from the Nordic financial industry. *Accounting Research Journal*, 35(2), 292-314. doi:10.1108/ARJ-12-2020-0373
- Riegler, M. (2023). Towards a definition of sustainable banking- a consolidated approach in the context of guidelines and strategies. *International Journal of Corporate Social Responsibility*, 8, 1-26. doi:10.1186/s40991-023-00078-4
- Rogers, E. (1962). *Diffusion of Innovation*. The Free Press.
- Rovinelli, R. J., & Hambleton, R. K. (1977). On the use of content specialists in the assessment of criterion-referenced test item validity. *Tijdschrift voor Onderwijsresearch*, 2(2), 49-60.
- Schwab, K. (2016). *The Fourth Industrial Revolution*. Crown Business.
- Sharma, G. P., Vema, R. C., & Pathare, P. (2005). Mathematical modeling of infrared radiation thin layer drying of onion slices. *Journal of Food Engineering*, 71(3), 282-286.
- Shehadeh, M., Almajali, D., Abu-AlSondos, I., Alkhwalid, F. A., & Al-Gasaymeh, A. (2023). *Digital Transformation and its Impact on Operational Efficiency and Competitive Advantage in Islamic Banks*. [Paper Presentation]. 2023 International Conference on Business Analytics for Technology and Security (ICBATS) Dubai, United Arab Emirates. doi:10.1109/ICBATS57792.2023.10111266
- Sica, C., & Ghisi, M. (2007). The Italian versions of the Beck Anxiety Inventory and the Beck Depression Inventory-II: Psychometric properties and discriminant power. In M. A. Lange (Ed.), *Leading - Edge Psychological Tests and Testing Research* (pp. 27-50). Nova.
- Sitorus, C., So, I. G., Furinto, A., & Kosasih, W. (2022). Exploring the Influence of Digital Model Business Innovation Factors on the Courier Service Company's Sustainability Innovation Performance. *Global Business & Finance Review*, 27(6), 98-113.
- Stankeviciene, J., & Nikonorova, M. (2014). Sustainable Value Creation in Commercial Banks During Financial Crisis. *Procedia - Social and Behavioral Sciences*, 110, 1197-1208. doi:10.1016/j.sbspro.2013.12.966.
- Svoboda, A. (2023). The Impact of Artificial Intelligence on the Banking Industry. *Journal of Banking and Finance Management*, 4(1), 7-13. doi:10.22259/2642-9144.0401002
- Swan, M. (2015). *Blockchain: Blueprint for a New Economy*. O'Reilly Media.
- Tapscott, D., & Tapscott, A. (2016). *Blockchain Revolution: How the Technology Behind Bitcoin Is Changing Money, Business, and the World*. Portfolio.
- Turek, J., Ocicka, B., Rogowski, W., & Jefmański, B. (2023). The role of Industry 4.0 technologies in driving the financial importance of sustainability risk management. *Equilibrium. Quarterly Journal of Economics and Economic Policy*, 18(4), 1009-1044. doi:10.24136/eq.2023.032
- Wang, X., Liu, L., Liu, J., & Huang, X. (2022). Understanding the Determinants of Blockchain Technology Adoption in the Construction Industry. *Buildings*, 12(10), 1709. doi:10.3390/buildings12101709
- Weerawarna, R., Miah, S. J., & Shao, X. (2023). Emerging advances of blockchain technology in finance: a content analysis. *Personal and Ubiquitous Computing*, 27, 1495-1508. doi:10.1007/s00779-023-01712-5

- Wu, J. H., & Wang, Y. M. (2006). Measuring KMS success: A respecification of the DeLone and McLean's model. *Information and Management*, 43(6), 728-739. doi:10.1016/j.im.2006.05.002
- Xie, P., Md Kassim, A. A., Wei, M., & Helmi, R. (2023). The Impact of Blockchain Adoption on Financial Performance in Fintech Firms: A Review of The Literature. *Frontiers in Business, Economics and Management*, 11(2), 302-305. doi:10.54097/fbem.v11i2.12627
- Yaqub, M. Z., & Alsabban, A. (2023). Industry-4.0-Enabled Digital Transformation: Prospects, Instruments, Challenges, and Implications for Business Strategies. *Sustainability*, 15(11), 8553. doi:10.3390/su15118553
- Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where Is Current Research on Blockchain Technology?-A Systematic Review. *PLoS One*, 11(10), e0163477. doi:10.1371/journal.pone.0163477
- Zhang, S., Zhao, J., & Tan, W. W. (2008). Extending TAM for Online Learning Systems: An Intrinsic Motivation Perspective. *Tsinghua Science and Technology*, 13, 312-317. doi:10.1016/S1007-0214(08)70050-6