

Examining the role of green Metaverse adoption in banking sector in Telangana

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Abstract

This study examines the role of green Metaverse adoption in the banking industry. The traditional banking system is on the verge of transformation to various adoption of technologies involving Augmented Reality (AR), Virtual Reality (VR) and Extended Reality (XR). A consumer model is developed by extending Technology-Organization-Environment (TOE) and Technology Acceptance Model (TAM) frameworks with sustainability linked factors. The proposed model is validated by conducting the Structural Equation Modelling (PLS-SEM) using SmartPLS 4 and Judgmental sampling method was used to collect data from 435 banking customers of public and private banks in Telangana Region. The findings show that Perceived Usefulness, Perceived Ease of Use and competitive pressure are strong predictors of Green Metaverse adoption. Adoption of Green Metaverse has a positive relationship with sustainability outcomes. Also, there is a significant indirect effect of Perceived Usefulness, Perceived Ease of Use, and competitive pressure on Metaverse sustainable outcomes through green Metaverse adoption.

Keywords: Metaverse Adoption, Green Metaverse, Financial investment, banking infrastructure, sustainable banking

1. Introduction

The degradation of environments, increasing carbon emissions and inefficiency of resources are the issues faced globally. The concept of sustainability consists of climate change rules and regulations, continued stakeholder activism and agreements on carbon neutrality internationally. The following concepts have provided environmental performance as significant measure of organisational sustainability. Metaverse is defined as interconnected network of various immersive virtual world where users in the form of avatars interact with content available and other users that is available digitally in real-time. Also, users consume and experience user generated content in an environment that is immersive, scalable, synchronous and persistent (Weinberger, 2022). Green Metaverse is defined as sustainability oriented Metaverse which is designed, developed and also operated so as to minimize the environmental impacts by immersive digital

technologies while supporting environmental, social and economic sustainability (Rajguru et al., 2024). Green Metaverse in banking is defined as use of immersive, integrated technologies in banking related services and operations to support the environmental sustainability, resource efficiency, sustainable finance while managing the environmental impacts associated with Metaverse infrastructure. Previous research shows that there are applications of banking viz., retail banking corporate banking, employee related activities, customer services and engagement. (Ooi et al., 2023, Aysan et al., 2024).

1.1. Theoretical Framework

The Technology- Organisation-Environment framework was developed by Tornatzky and Fleischer (1990) which explains technology adoption through three contexts viz., technology, organization and environment. The model is based on Technology-

Organization-Environment (TOE) extended with Perceived Use (PU) and Perceived Ease of Use (PEOU) from Technology Adoption (TAM) model (Oliveira et al.,2011). Also, the model is extended beyond technology acceptance to environmental performance with green Metaverse adoption (GM) as a mediator acting between the drivers and Metaverse sustainable outcomes (MSO). The TOE dimensions related to technology viz.,Perceived Use (PU), Perceived Ease of Use (PEOU); Organisational dimensions like Financial Investment (FI), Banking infrastructure (BI); environmental dimensions viz.,Regulatory influence (RI) and Competitive Pressure (CP).

2. Literature Review

2.1.Perceived Usefulness and green Metaverse adoption

Users and Banks are likely to adopt green technology like Artificial Intelligence (AI) and Metaverse if it enhances the energy efficiency, decision making process and reduces operational costs (Mohammad et al.,2022, Yaseen et al.,2025). Performance expectation impact the perceived value in Metaverse eco-systems[1 – 10] (Yaseen et al.,2025).

H1: Perceived Usefulness (PU) has a significant impact on green Metaverse adoption (GM).

2.2.Perceived Ease of Use and green Metaverse adoption

Perceived Ease of Use (PEOU) is explained by individual perception of how Metaverse technology can be utilized. Individual attitudes, perceptions, technology literacy are the indicators that influence technology adoption. Various attributes of Technology Adoption Model (TAM) can impact the willingness of employees in embracing the technology (Wang et al.,2022). If Metaverse models that are sustainable and streamlined into banking systems are easily integrated, banks can have inclination towards them.

H2: Perceived Ease of Use (PEOU) has a significant impact on green Metaverse adoption (GM).

2.3.Banking infrastructure and Green Metaverse adoption

The technology adoption can become success if the technological infrastructure viz.,high speed internet,VR/AR devices and tools that support virtual

environments are readily available (Gupta et al.,2022). Employees can adopt the technology if the banking infrastructure is readily available. Lack of these resources results in employees unwillingness to adopt the technology(Marei et al.,2023).Banks with stronger technological and organizational infrastructure such as high speed internet networks, cloud computing systems,VR and AR equipment's and sound cyber-security systems impact the green Metaverse adoption(Chandran et al.,2026)

H3: Banking infrastructure(BI) has a significant impact on green Metaverse adoption(GM).

2.4.Financial Investment and Green Metaverse adoption

Financial investments are necessary for technological adoption (ALHaderetal., 2021, Nguyen et al.,2017). The scope and pace of the adoption of new technologies are based on the investments made by the banks. Recent research showed that financial investment is the significant factor adopting the green Metaverse adoption (Chandran et al.,2026).

H4: Financial investment (FI) has a significant impact on green Metaverse adoption (GM).

2.5.Regulatory influence (RI) and green Metaverse adoption

Due to the increasing significance in environmental sustainability and responsibility related to Metaverse technologies, the organizations need to be educated about the regulations to be followed. Data localization laws in India which states that data should be stored in the country itself will make the companies to focus on compliance rather than sustainability. Absence of these regulations in utilization and application of Metaverse technologies will hinder the usage of Metaverse in environmental context. (Ray et al.,2025). Regulatory influence represents the various government policies, regulatory requirements, environmental standards and banking[11 – 20] regulations related to sustainability shall encourage the banks in adopting the green technologies (Aslam et al.,2025, Chandran et al.,2026). Regulatory pressure is found to be an environmental factor affecting the technology adoption (Alsmadi et al.,2025).

H5: Regulatory Influence (RI) has a significant impact on green Metaverse adoption (GM).

2.6.Competitive Pressure and Green Metaverse adoption

The competitions when they use Metaverse as a tool put pressure on the rivals leading to enhanced operations leading to intensification of competition. Competitive pressure[21] on business is through innovation and technological advantage (Kraus et al.,2023). Competitive pressure is said to influence the green AI adoption (Chandran et al.,2026).

H6: Competitive Pressure (CP) has a significant impact on green Metaverse adoption (GM).

2.7.Green Metaverse Adoption and Sustainability outcomes

With the integration of environmentally responsible activities into the banking operations, green capacity improves the financial sustainability. All the institutions that embrace green technologies can have advantage of improved[22] reputation, regulatory compliance and cost-effectiveness. Green oriented strategies embrace green oriented customers and investors that improves financial performance (Li et al.,2017). Green technology like Metaverse can have the positive indirect of digital innovation technology on sustainability outcomes. The investment for transforming the bank into a more sustainable way is a gradual process involving time and effort built around the capabilities. (Aljumah et al.,2026).

- H8a: Green Metaverse adoption mediates the relationship between PU and MSO.
- H8b: Green Metaverse adoption mediates the relationship between PEOU and MSO.
- H8c: Green Metaverse adoption mediates the relationship between BI and MSO.
- H8d: Green Metaverse adoption mediates the relationship between FI and MSO.
- H8e: Green Metaverse adoption mediates the relationship between RI and MSO.
- H8f: Green Metaverse adoption(GM) mediates the relationship between CP and MSO.

3. Method

3.1.Sampling and Data Collection

A judgmental sampling method was implemented to collect the responses from the customers by asking the kind of financial transaction they use for their transactions. A question related to the type of bank

(Public, Private bank) and mode of transaction usage (Online, offline, Physical Banking) was asked at the beginning of the questionnaire to make sure that instrument meet its goal[23]. The questionnaire was distributed among the customers of both public and private sector banks in Telangana region.

3.2.Demographic statistics

From Table 1, the highest number of respondents are between the age group of 25-35 years (n=155) followed by 35-50 years (n=110), 15-25 years(n=100) and greater than 50 years(n=70). The gender distribution shows[24] that about 300 respondents belong to male category and 135 were female. About, 254 respondents belong to private bank and 181 respondents belong to public bank.

3.3.Data Analysis

Descriptive statistics is calculated using SPSS 22. To validate the measurement model, Confirmatory Factor Analysis (CFA) is used.PLS-SEM was calculated using SmartPLS4 to test the hypothesized relationships. As shown in Table 1 Descriptive Statistics[25], Table 2 Measurement Model, Table 3 Construct validity and Reliability, Table 3 Construct validity and Reliability, Table 4 Fornell-Larcker Criterion, Table 5 Heterotrait-Monotrait Ratio, Table 6 Direct effects, Table 7 Indirect Effects Table 5 Heterotrait-Monotrait Ratio

3.4.Table

- PU-Perceived Usefulness PEOU-Perceived Ease of Use BI-Banking Infrastructure
- CP-Competitive Pressures FI-Financial Investments RI-Regulatory Influence
- GM-Green Metaverse adoption MSO-Metaverse Sustainable Outcomes as shown in Table 6 Direct effects
- PU-Perceived Usefulness PEOU-Perceived Ease of Use BI-Banking Infrastructure
- CP-Competitive Pressures FI-Financial Investments RI-Regulatory Influence
- GM-Green Metaverse adoption MSO-Metaverse Sustainable Outcome As shown in Figure1 Research Model, Figure 2 Structural Model[26].

Table 1 Descriptive Statistics

Variable	Category	Frequency	Percentage (%)
Age Group(in years)	15-25	100	22.99%
	25-35	155	35.63%
	35-50	110	25.29%
	Above 50	70	16.09%
	Total	435	100.00%
Gender	Male	300	68.97%
	Female	135	31.03%
	Total	435	100.00%
Bank Type	Private	254	58.39%
	Public	181	41.61%
	Total	435	100.00%

Table 2 Measurement Model

	BI	CP	FI	GM	MSO	PEOU	PU	RI	VIF
BI1	0.783								1.234
BI2	0.776								1.522
BI3	0.808								1.5
CP1		0.656							1.238
CP2		0.832							1.589
CP3		0.885							1.606
FI1			0.834						1.687
FI2			0.801						1.657
FI3			0.853						1.508
GM1				0.805					1.604
GM2				0.875					2.015
GM3				0.864					1.783
MSO1					0.925				3.065
MSO2					0.925				3.311
MSO3					0.918				3.038
PEOU1						0.852			1.302
PEOU2						0.783			1.551
PEOU3						0.726			1.421
PU1							0.866		1.918
PU2							0.877		2.042
PU3							0.875		2.081
RI1								0.807	1.681
RI2								0.908	1.966
RI3								0.833	1.764

Table 3 Construct validity and Reliability

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
BI	0.701	0.707	0.832	0.623
CP	0.715	0.783	0.837	0.635
FI	0.777	0.799	0.869	0.688
GM	0.806	0.814	0.885	0.72
MSO	0.913	0.915	0.945	0.851
PEOU	0.711	0.773	0.831	0.622
PU	0.843	0.843	0.905	0.761
RI	0.811	0.865	0.886	0.723

Table 4 Fornell-Larcker Criterion

	BI	CP	FI	GM	MSO	PEOU	PU	RI
BI	0.789							
CP	0.352	0.797						
FI	0.468	0.447	0.83					
GM	0.339	0.566	0.282	0.849				
MSO	0.307	0.467	0.234	0.767	0.923			
PEOU	0.52	0.324	0.243	0.551	0.561	0.789		
PU	0.347	0.368	0.149	0.619	0.593	0.696	0.872	
RI	0.371	0.487	0.438	0.285	0.276	0.293	0.209	0.85

Table 5 Heterotrait-Monotrait Ratio

	BI	CP	FI	GM	MSO	PEOU	PU	RI
BI								
CP	0.505							
FI	0.655	0.635						
GM	0.442	0.725	0.351					
MSO	0.373	0.574	0.276	0.884				
PEOU	0.767	0.436	0.329	0.678	0.683			
PU	0.433	0.445	0.176	0.744	0.675	0.861		
RI	0.489	0.662	0.532	0.343	0.313	0.391	0.251	

Table 6 Direct effects

		Original sample (O)	Sampl e mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values	Result
H1	PU -> GM	0.353	0.353	0.058	6.064	0.000	Accepted
H2	PEOU -> GM	0.195	0.194	0.061	3.222	0.001	Accepted
H3	BI -> GM	-0.023	-0.021	0.05	0.47	0.638	Rejected
H4	FI -> GM	0.04	0.042	0.043	0.929	0.353	Rejected
H5	RI -> GM	-0.041	-0.04	0.039	1.063	0.288	Rejected
H6	CP -> GM	0.383	0.381	0.052	7.381	0.000	Accepted
H7	GM -> MSO	0.767	0.768	0.028	27.725	0.000	Accepted

Table 7 Indirect Effect

Hyothesi s		Original sample (O)	Sample mean (M)	Stand ard deviat ion (STDE V)	T stati stics (O/ STD EV)	2.5 0%	97.5 0%	P valu es	Result
H8a:	PU -> GM -> MSO	0.271	0.271	0.045	6.07 9	0.1 85	0.36 2	0.00 0	Accepted
H8b:	PEOU -> GM -> MSO	0.15	0.149	0.047	3.15 9	0.0 56	0.24	0.00 2	Accepted
H8c:	BI -> GM -> MSO	-0.018	-0.016	0.038	0.46 9	- 0.0 89	0.06	0.63 9	Rejected
H8d:	FI -> GM -> MSO	0.031	0.032	0.033	0.92 5	- 0.0 34	0.09 8	0.35 5	Rejected
H8e:	RI -> GM -> MSO	-0.032	-0.031	0.03	1.06 3	- 0.0 89	0.02 9	0.28 8	Rejected
H8f:	CP -> GM -> MSO	0.294	0.292	0.042	6.98 7	0.2 12	0.37 5	0.00 0	Accepted

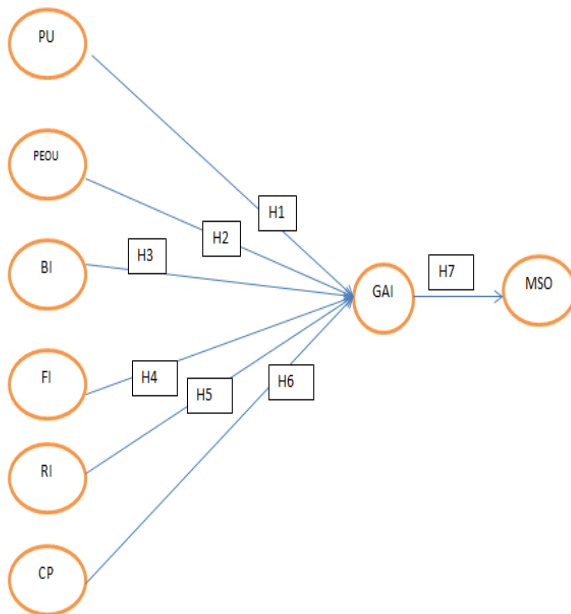


Figure 1 Research Model

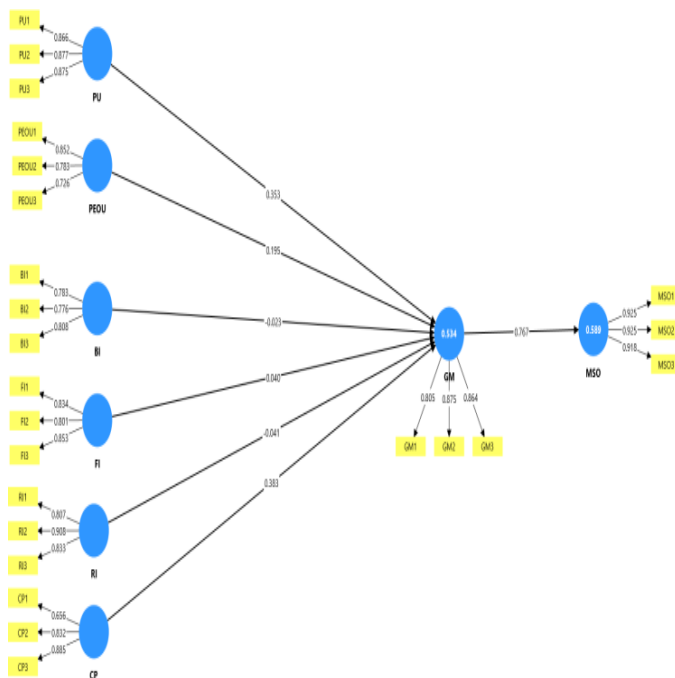


Figure 2 Structural Model

4. Results

4.1.Outer Loadings

Indicator reliability can be measured by the outer loadings of indicators. Indicators with loadings between 0.40 and 0.70 can be usually retained if the

removal of those items will not improve the measurement model as well as contribute to the content validity of the construct From Table 2, we can notice that all the indicator loadings are between 0.40 and 0.70 that provide adequate evidence of indicator reliability[27].

4.2.Convergent Validity

Internal consistency reliability, convergent validity was calculated using Cronbach's alpha, rho_A, and composite reliability (rho_C) and Average Variance Extracted (AVE) From Table 3, we can notice that the values of Cronbach's Alpha ranged from .701 to .913, while rho_c values between 0.831 and 0.945 exceeding the minimum threshold of 0.70 providing reliability and internal consistency among the constructs (Hair et al., 2022). Also, Composite reliability values are between .707 to .915 providing the reliability of the constructs. The Average Variance Extracted (AVE) values ranged from .622 to .761 which exceeds the recommended minimum threshold value of .50 for all constructs. Each construct can explain more than 50% of variance in its respective indicators resulting in providing evidence of convergent validity (Hair et al., 2022). The findings explain that there is good internal consistency, reliability and convergent validity among all the constructs indicating that measurement model is adequate for structural model assessment.

4.3.Divergent Validity

Discriminant validity was assessed using both the Fornell–Larcker criterion and the Heterotrait–monotrait (HTMT) ratio. According to the Fornell–Larcker criterion, the square root of the AVE of each construct has to be greater than its correlations with the other constructs. From Table 4, we can notice that each diagonal value is greater than the corresponding correlations with the other constructs. Therefore, the Fornell-Larcker criterion indicates adequate discriminant validity (Fornell & Larcker, 1981). From Table 5 further assessment of discriminant validity is provided by Heterotrait-Monotrait(HTMT) ratio.All the values remain below the liberal threshold of 0.90(Henseler et al.,2015)

4.4.Assessment of Collinearity

From Table 2, we can notice that collinearity was

assessed by using the variance inflation factor (VIF). The VIF values ranged from 1.500 to 3.311 indicating that all the values are below the recommended threshold of 5.00 (Hair et al., 2022). Hence, we can notice that there exists no multi-collinearity among the constructs.

4.5. Structural Equational Modelling

4.5.1. Direct effects

After confirming the adequacy of the measurement model, the bootstrapping ($n=10000$, significance level of 5%) to assess the structural model hypothesized relationships were performed using standardized path coefficients, t -statistics, and p -values. From Table 6, we can notice that PEOU has a significant impact on GM ($\beta = 0.195$, $t = 3.222$, $p = 0.001$). Similarly, PU has a significant impact on GM ($\beta = 0.353$, $t = 6.064$, $p < 0.001$). CP has a significant impact on GM ($\beta = 0.383$, $t = 7.381$, $p < 0.001$). These findings indicate that CP, PEOU, and PU are significantly related with GM in the estimated structural model. In contrast, BI does not have a significant impact on GM ($\beta = -0.023$, $t = 0.470$, $p = 0.638$). FI does not have a significant impact on GM ($\beta = 0.040$, $t = 0.929$, $p = 0.353$). RI does not have a significant impact on GM ($\beta = -0.041$, $t = 1.063$, $p = 0.288$). Since their p -values exceed 0.05, there is no sufficient statistical evidence to support these relationships. Furthermore, GM has a significant impact on MSO ($\beta = 0.767$, $t = 27.725$, $p < 0.001$).

4.5.2. Mediation effects

Specific Indirect effects A bootstrapping method ($n=1000$, level of significance=0.05) was employed to test the mediating role of GM. In PLS-SEM, bootstrapping is a recommended approach for measuring the indirect effects in mediation models (Sarstedt et al., 2020). From Table 7, we can notice that there is significant positive indirect effect of CP on MSO through GM ($\beta = 0.294$, $t = 6.987$, $p < 0.001$). PEOU has a significant positive indirect effect on MSO through GM ($\beta = 0.150$, $t = 3.159$, $p = 0.002$). PU also demonstrates a significant positive indirect effect on MSO through GM ($\beta = 0.271$, $t = 6.079$, $p < 0.001$). Contrastingly, the indirect effects of BI on MSO through GM ($\beta = -0.018$, $t = 0.469$, $p = 0.639$), FI on MSO through GM ($\beta = 0.031$, $t =$

0.925 , $p = 0.355$), and RI on MSO through GM ($\beta = -0.032$, $t = 1.063$, $p = 0.288$) are not statistically significant.

5. Discussion

The measurement model demonstrates indicator reliability, internal consistency reliability, convergent validity and discriminant validity. The structural model indicates statistically significant and positive relationships from CP, PEOU, and PU to GM, as well as from GM to MSO. BI, FI, and RI do not demonstrate statistically significant direct effects on GM. Perceived usefulness significantly drives Green Metaverse adoption, indicating that banks are more likely to embrace immersive technologies when they perceive clear operational and sustainability value (Aljumah et al., 2026). Perceived ease of use significantly encourages Green Metaverse adoption by making immersive banking technologies more accessible and usable for banking stakeholders (Aljumah et al., 2026). Banking investment does not significantly influence Green Metaverse adoption, suggesting that investment alone may be insufficient without complementing technological and organizational capabilities (Aljumah et al., 2026). Financial investment does not significantly drive Green Metaverse adoption, indicating that financial resources need to be translated into digital and green capabilities to support sustainable banking transformation (Aljumah et al., 2026). Regulatory influence does not significantly affect Green Metaverse adoption, suggesting that regulatory conditions alone may not be sufficient to stimulate immersive green-banking implementation (Aljumah et al., 2026). Competitive pressure significantly encourages Green Metaverse adoption, consistent with TOE research showing that competitive pressure is an important driver of enterprise-Metaverse adoption (Kumar et al., 2024). Green Metaverse adoption strongly contributes to sustainable banking outcomes, consistent with evidence linking Metaverse finance, digital innovation, green capacity and financial sustainability in banks (Aljumah et al., 2026).

5.1. Mediation Discussion

PU also demonstrates a significant positive indirect effect on MSO through GM. When users perceive the

Metaverse technology to be useful, the chances of using and adopting the same will be enhanced. Metaverse is found to have sustainable performance across social, environmental and economic dimensions (Kumar et al., 2024). Metaverse adoption can contribute to sustainable outcomes through various organisational capabilities viz., collaboration, empowering the stakeholders and pro-environmental activities (Papadopoulos et al., 2025). Perceived usefulness significantly drives Green Metaverse adoption, indicating that banks are more likely to embrace immersive technologies when they perceive clear operational and sustainability value (Aljumah et al., 2026). PEOU has a significant positive indirect effect on MSO through GM. When users perceive the Metaverse technology to be useful, the chances of using and adopting the same will be enhanced. Ease of interaction with Metaverse like immersive technologies results in reducing users effort and facilitate engagement with the Metaverse applications (Davis, 1989). Metaverse technologies will support environmental, economic and social sustainability when the adoption occurs and integrated with the organizational outcomes (Johri et al., 2024). There is no indirect effect of BI on MSO through GM which states that banking infrastructure alone is not sufficient but needs integration with other capabilities. Green banking practices has a positive influence on sustainability outcomes but technology infrastructure needs to be combined with organizational and human capabilities (Javed et al., 2026). The contrasting finding of indirect effect of FI on MSO through GM shows that financial investments alone may not be required to generate sustainable outcomes but they need to be converted into financial and organizational capabilities along with the effective implementation (Aljumah et al., 2026). Previous research shows that government policies and regulations enhances the technological adoption (Firman et al., 2025). The difference in the finding shows that regulatory influence not only encourages but also constrains technological adoption without directly ensuring that the resulting Metaverse applications are implemented in ways that generate environmental, economic or social sustainability benefits. Competitive pressure

encourages the banks to explore Metaverse technologies with green Metaverse adoption as a mediator that further helps in transforming technology response into sustainable outcomes (Ooi et al., 2023).

Conclusion

By adopting the TOE framework, the study relates to the empirical findings on green Metaverse adoption and its impact on sustainability outcomes in the Indian banking sector. The findings conclude that banking infrastructure, financial investments and regulatory requirements alone will not be sufficient in translating technology adoption into sustainability outcomes. Complementing the above resources with various digital innovations, organizational and green capabilities results in providing sustainability benefits. The TOE framework has been extended with TAM framework which demonstrates that perceived usefulness and perceived ease of use play a major role in green Metaverse enabled sustainability rather than the resource and regulatory factors alone. The study concludes that green Metaverse adoption provides a way for sustainable banking when there is an integration of immersive technologies with organizational capabilities and broader environmental, economic and social sustainability objectives. When immersive technologies are strategically integrated with organizational capabilities and broader environmental, economic, and social sustainability objectives.

Managerial implications

Banks need to explore green Metaverse applications that helps in minimizing competitive pressure and improve customer service, operational efficiency, accessibility as well as sustainability and make sure that it is just not merely as an innovation technology. Banks need to invest in simple immersive interfaces that are beneficial to the bankers as well as customers so that potential benefits will be utilized. Banks need to strengthen the capabilities surrounding the banking infrastructure. Financial investments should be accompanied along with capabilities that guarantee sustainability related outcomes. Focus should be more on measurable sustainable outcomes. As shown in Table 8 Sector Focused.



Limitations

Table 8 Sectoe Focused

1.	Cross-Sectionality	As the study captures Green Metaverse adoption during certain point of time, the changes in adoption as technology matures will not be explained.
2.	Sector focused	Findings of banking sector focused study are not generalizable to other industries.
3.	Lack of empirical studies	Green Metaverse applications in banking are in developing stage resulting in lack of established empirical evidence.
4.	Difference in context specific findings	Regulatory environments, digital infrastructure and sustainable practices are different in several countries and their banking systems.
5.	Further scope in the model	Factors such as trust, cyber-security,privacy,digital literacy, organisational and technology readiness are not included in the model

Future Research and Directions

1.	Longitudinal studies	Future research should focus on how green Metaverse adoption evolves over time with focus on immersive technologies.
2.	Cross-country studies	Comparative studies of Metaverse adoption between emerging countries can be studied.
3.	Multi-Stakeholder perspective	Green Metaverse adoption should be studied by considering the employee as well as customer perspectives.
4.	Sustainability Dimensions	Exclusive research can be done on environmental, social and economic dimensions instead of focusing on sustainability as a single construct.
5.	Integration with emerging technologies	Future research can be done on various technologies viz., Blockchain,VR/AR tehnologies,Artificial Intelligence(AI),generative AI and Metaverse banking.

References

- [1]. Al Hadwer, A., Tavana, M., Gillis, D., & Rezanian, D. (2021). A systematic review of organizational factors impacting cloud-based technology adoption using technology–organization–environment framework. *Internet of Things*, 15, 100407. <https://doi.org/10.1016/j.iot.2021.100407>
- [2]. Aljumah, A. I., Nuseir, M., Hameed, W. U., AlShawabkeh, A., & Ali, M. (2026). Financial sustainability and the integration of metaverse finance, fintech innovation, green capacity, digital innovation and digital marketing. *Discover Sustainability*, 7, 413. <https://doi.org/10.1007/s43621-026-02764-2>
- [3]. Alsmadi, A. A., & Al-Omoush, K. S. (2025). Adoption of green banking innovations: Drivers and outcomes. *Green Finance*, 7(4), 584–609.
- [4]. Aslam, W., & Jawaid, S. T. (2025). Green banking adoption practices: The pathway of meeting sustainable goals. *Environment, Development and Sustainability*, 27, 1015–1040. <https://doi.org/10.1007/s10668-023-03893-8>.
- [5]. Aysan, A. F., Gozgor, G., & Nanaeva, Z. (2024). Technological perspectives of metaverse for financial service providers. *Technological Forecasting and Social Change*.
- [6]. Chandran, M. C. S., Chandran, R., & Achuthan, K. (2026). Bridging technology and sustainability: Examining the role of green AI adoption in Indian banking sector. *Frontiers in Artificial Intelligence*, 8, 1692763. <https://doi.org/10.3389/frai.2025.1692763>.
- [7]. Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>.
- [8]. Firman, A., Chau, K. Y., Walawalkar, A. M., & Moslehpour, M. (2025). Navigating the future: Envisioning metaverse adoption in Indonesian tourism through the technological–organizational–environmental (TOE) framework. *Journal of Theoretical and Applied Electronic Commerce Research*, 20(2), 118. <https://doi.org/10.3390/jtaer20020118>
- [9]. Gupta, A., Singh, R. K., & Gupta, S. (2022). Developing human resource for the digitization of logistics operations: Readiness index framework. *International Journal of Manpower*, 43(2), 355–372.
- [10]. Hair, J. F., Hult, G. T. M., Ringle, G. T. M., & Sarstedt, M. (2022). A primer on partial least squares structural equation modeling (PLS-SEM) (3rd ed.). Sage. <https://doi.org/10.1007/978-3-030-80519-7>.
- [11]. Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, 43, 115–135. <https://doi.org/10.1007/s11747-014-0403-8>.
- [12]. Iqbal, M., Suhail, S., Milani, F., & Halas, Y. (2024). Metaverse in financial industry: Use cases, value, and challenges. *International Journal of Information Management Data Insights*, 4(2), 100302.
- [13]. Javed, M., Mohd Mustamil, N., Sadiq, U., Najam, U., & Nasir, N. (2026). Investigating the impact of green HRM practices on bank sustainability performance through parallel mediation of FinTech and green banking practices. *Discover Sustainability*, 7, 1129. <https://doi.org/10.1007/s43621-026-03397-1>.
- [14]. Johri, A., Joshi, P., Kumar, S., & Joshi, G. (2024). Metaverse for sustainable development: A bibliometric analysis and systematic literature review. *Journal of Cleaner Production*, 435, 140610.
- [15]. Kraus, S., Kumar, S., Lim, W. M., Kaur, J., Sharma, A., & Schiavone, F. (2023). From moon landing to metaverse: Tracing the evolution of technological forecasting and social change. *Technological Forecasting and Social Change*, 189, 122381. <https://doi.org/10.1016/j.techfore.2023.122381>

- [16]. Kumar, A., & Shankar, A. (2024). Building a sustainable future with enterprise metaverse in a data-driven era: A technology–organization–environment (TOE) perspective. *Journal of Retailing and Consumer Services*, 81, 103986. <https://doi.org/10.1016/j.jretconser.2024.103986>.
- [17]. Li, S., Ngniatedema, T., & Chen, F. (2017). Understanding the impact of green initiatives and green performance on financial performance in the U.S. *Business Strategy and the Environment*, 26(6), 776–790. <https://doi.org/10.1002/bse.1948>
- [18]. Marei, A. Z., Mustafa, J. A., Othman, M. D., Daoud, L., Lutfi, A., & Al-Amarneh, A. (2023). The moderation of organizational readiness on the relationship between TOE factors and FinTech adoption and financial performance. *International Journal of Professional Business Review*, 8(7), e02800. <https://doi.org/10.26668/businessreview/2023.v8i7.2800>
- [19]. Mohammad, A. B., Al-Okaily, M., Al-Majali, M., & Masa'deh, R. (2022). Business intelligence and analytics (BIA) usage in the banking industry sector: An application of the TOE framework. *Journal of Open Innovation: Technology, Market, and Complexity*, 8, 189. <https://doi.org/10.3390/joitmc8040189>
- [20]. Nguyen, T., & Petersen, T. E. (2017). Technology adoption in Norway: Organizational assimilation of big data [Master's thesis, Norwegian School of Economics]. Norwegian School of Economics Open Access.
- [21]. Ooi, K.-B., Tan, G. W.-H., Aw, E. C.-X., Cham, T.-H., Dwivedi, Y. K., Dwivedi, R., Hughes, L., Kar, A. K., Loh, X.-M., Mogaji, E., Phau, I., & Sharma, A. (2023). Banking in the metaverse: A new frontier for financial institutions. *International Journal of Bank Marketing*, 41(7), 1829–1846. <https://doi.org/10.1108/IJBM-03-2023-0168>
- [22]. Papadopoulos, T., Pattanayak, S., & Ramkumar, M. (2025). Exploring the impact of metaverse adoption on sustainability outcomes in retail organizations: A dynamic capabilities view perspective. *Technological Forecasting and Social Change*, 217, 124073.
- [23]. Rajguru, K., & Brüggemann, P. (2024). Sustainability meets metaverse: A conceptual framework of sustainable dimensions of the metaverse. *Journal of Consumer Behaviour*, 23(5), 2720–2729. <https://doi.org/10.1002/cb.2368>
- [24]. Ray, N., Bhanot, A., Mutsuddi, I., & Bose, I. (2025). Impact of metaverse initiatives on sustainability. In M. Al Aqad, A. Sorayyaei Azar, A. Albattat, & A. Singh (Eds.), *Navigating AI and the metaverse in scientific research* (pp. 521–536). IGI Global Scientific Publishing. <https://doi.org/10.4018/979-8-3373-0340-6.ch025>
- [25]. Sarstedt, M., Hair, J. F., Nitzl, C., Ringle, C. M., & Howard, M. C. (2020). Beyond a tandem analysis of SEM and PROCESS: Use of PLS-SEM for mediation analyses! *International Journal of Market Research*, 62(3), 288–299.
- [26]. Weinberger, M. (2022). What is metaverse?—A definition based on qualitative meta-synthesis. *Future Internet*, 14(11), 310. <https://doi.org/10.3390/fi14110310>
- [27]. Yaseen, H., Ayoub, M. A., Hattar, C., Al-Adwan, A. S., & Alsoud, M. (2025). Factors influencing meta-banking adoption: An empirical study. *Journal of Financial Reporting and Accounting*, 23(2), 811–829. <https://doi.org/10.1108/JFRA-12-2023-0765>.