

Digital banking and environmental impact: how Fintech supports carbon footprint reduction

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Abstract. This study explores the impact of adoption of digital banking, digital payment volume, and customer awareness of green banking features on environmental sustainability, focusing on carbon footprint reduction in Asia. The findings indicate that digital banking is crucial in minimizing paper usage and reducing energy consumption, significantly lowering the carbon emissions associated with traditional banking operations. The research employs Structural Equation Modeling (SEM) to analyze data from 520 respondents, providing a comprehensive view of the direct and indirect relationships between digital banking practices and environmental outcomes. The results demonstrate that increased digital payment volume, combined with higher customer awareness of sustainability, reduces the reliance on paper-based banking and helps achieve broader environmental goals. The study highlights the mediating role of paper usage in lowering carbon footprints and underscores the importance of digital transformation and customer education in driving sustainable banking practices. This research contributes valuable insights for policymakers and financial institutions aiming to integrate fintech with sustainability initiatives.

1 Introduction

Climate change and environmental sustainability movement have caused many industries to reconsider their operations. The finance and banking sector is no exception and is also experiencing a digital transformation. Financial institutions globally are increasingly opting for digital banking services to operate, offering higher operational efficiency and a lower but significant environmental impact. The rise of fintech and digital banking offerings are some of the tools used to cut down on the carbon footprint of what was traditionally a heavy polluter in the sector.

For regions like Asia, where technological advancement is at its peak, and the customer base is growing, several factors make the banks ripe for this change. The first way in which digital banking impacts environmental friendliness is by cutting down on physical infrastructure and paper-based ecosystems; these are typically a stronghold for high energy

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consumption and even more immense greenhouse emissions; as banks move from paper and bricks to data storage, there is a reduced carbon trace on the planet. Also, the lower need for physical documentation, such as printed statements and automated receipts, makes the industry even more sustainable. [17] shows that reducing the direct regulars needed for bank countertop performance, such as heating, cooling, lighting, and creating, saves considerable emissions.

Furthermore, employees commuting to and from their workplace have also dropped in the past two years, and this has contributed significantly to the drop in emissions in regions like Asia, where the population is so dense.

Secondly, digital service vendors have also greatly lowered the cost of paper, plastic, ink, and cloth equipment. The heavy use of these elements has been replaced by plastic and automated paper trash. Digital banking is associating with even more stars to promote the sector's ecological habits. This is the driver factor that helps customers switch to complete online banking and further drop the industry's overall carbon footprint.

This research investigates the impact of digital banking on environmental sustainability, specifically focusing on reducing the carbon footprint in Asia.

The study explores how adopting digital banking services, the volume of digital payments, and customer awareness of green banking features contribute to reducing environmental impact. Through this investigation, the research will test several hypotheses that examine the direct link between digital banking adoption, reduced energy consumption, and paper usage, as well as the role of customer awareness in fostering environmentally conscious behaviors.

2 Literature

The primary benefit of digital banking in reducing carbon emissions is the decline in the need for physical infrastructure.

For instance, [8] shows that transitioning from physical branches to digital platforms reduces energy consumption because there are fewer physical locations requiring light, heat, and IT infrastructure. Notably, physical branches do not imply the direct consumption of a large volume of paper by an entity's customers or employees, with banks using online banking services cutting down on massive amounts of paper that contributed to the loss of millions of trees. Based on the data-based study conducted by [4], the use of online banking and mobile apps also leads to a decrease in the usage of paper for things like bank statements, forms, and receipts, which accounts for a significant amount of deforestation and garbage production.

Customers using online banking make an even more substantial difference, as each person using the online system means less paper while using paperless systems at a physical location cuts paper use even more. In addition to reducing entities' carbon footprint, a higher volume of digital payments can also reduce carbon emissions. The more common these payments are, the more checks and receipts are avoided, saving on paper and cutting garbage further. Based on the report by [2] on the environmental impact of digital payments, Banks have high costs and a carbon footprint due to paper, ink, and power used up during physical transactions.

The dependence on paper also necessitates various other expenses, such as storing that paper. The active promotion of digital transactions' environmental benefits incentivizes consumers to move to electronic transactions due to the clear monetary and ecological benefits. This led to the development of the following hypotheses:

H1: The adoption rate of digital banking services significantly negatively affects the overall carbon footprint, resulting in reduced carbon footprint.

H2: Higher digital payment volume significantly contributes to carbon footprint reduction.

H3: Customer awareness of green banking features is positively associated with reducing carbon footprint.

The relationship between customer awareness of green banking features and carbon footprint reduction has also been explored extensively. Customer awareness plays a vital role in adopting sustainability practices, such as opting for e-statements over paper-based statements or using mobile apps instead of visiting branches. In a study conducted by [7], it was found that increased awareness of green features leads to behavioral changes among customers, with a growing preference for digital interactions [1-17].

The study indicated that banks that actively promote the environmental benefits of their services could enhance customer engagement with green banking features, thus contributing to the broader sustainability agenda. Banks that educate their customers about the environmental benefits of going paperless have seen increased uptake in the use of digital channels. This shift reduces the demand for physical bank branches and the associated resources, such as energy and materials needed for branch maintenance. Additionally, [18] pointed out that environmentally conscious customers are more likely to adopt digital channels when they are made aware of their positive environmental impacts, contributing further to reducing the financial sector's carbon footprint [18-23].

The adoption rate of digital banking services is also significantly associated with reducing paper usage in banking operations. The shift towards digital banking channels requires fewer printed materials for customer interactions, leading to a positive environmental outcome. [23] showed that banks adopting digital services saw a notable decline in paper consumption due to a reduction in printed bank statements, brochures, and transaction records. Additionally, digital services eliminate the need for paper-intensive processes such as physical customer onboarding and manual data entry, further minimizing the banking industry's environmental impact. [6] indicated that customers who adopt digital banking typically prefer to use electronic documentation, resulting in a notable decrease in the demand for printed materials.

Traditional paper-reliant methods are gradually phased out as customers become more accustomed to managing their financial activities through mobile apps or online platforms. This move reduces paper consumption and encourages further investment in eco-friendly banking technologies.

Increased digital payment volume is also significantly linked to reduced paper usage. As more transactions are carried out electronically, there is a corresponding decline in paper use for receipts, checks, and transaction records. According to [13], the growing trend of digital transactions has led to a considerable reduction in paper-based payment instruments such as checks and physical receipts. This transition is significant in developing countries where the widespread adoption of mobile payments has facilitated a substantial reduction in paper usage.

Additionally, the proliferation of mobile wallets and digital payment platforms has reduced the reliance on physical cash, which often requires receipts for proof of transactions. [10] showed that digital payments, through their seamless and instantaneous nature, minimize the need for physical documentation, thereby reducing paper waste.

Customer awareness of green banking features also plays a crucial role in reducing paper usage. Customers who understand the environmental benefits of opting for digital services over traditional paper-based alternatives are more inclined to adopt such practices. A study by [15] found that customers who are aware of the impact of paper consumption on the environment are more likely to choose digital statements, e-receipts, and online banking services, significantly reducing paper usage. Furthermore, [15] highlighted the importance of awareness campaigns in educating customers about the environmental impact of their banking choices. Banks that actively promote green banking features and emphasize the

environmental benefits of going paperless see greater customer participation in digital services [17].

This led to the development of the following hypotheses:

H4: The adoption rate of digital banking services is positively associated with reducing paper usage in banking operations.

H5: Increased digital payment volume is significantly related to reduced paper usage, as more transactions are carried out electronically.

H6: Customer awareness of green banking features positively impacts the reduction in paper usage by motivating customers to opt for digital and paperless services.

The reduction in paper usage has a significant positive effect on reducing carbon footprint, contributing to overall environmental sustainability. By minimizing paper use in banking operations, institutions can help reduce the energy and emissions associated with the entire paper lifecycle, from production to disposal. [13] estimated that the banking sector's adoption of digital processes, which lead to lower paper consumption, has resulted in a significant decrease in carbon emissions associated with deforestation, paper production, and transport logistics. The reduction in paper affects direct emissions and has an indirect positive impact by reducing the overall demand for resources required for paper production. According to [8], the paper production industry is one of the leading contributors to greenhouse gas emissions due to its reliance on large amounts of water, energy, and chemicals during the manufacturing process. As financial institutions increasingly move towards digital alternatives, the demand for paper is reduced, ultimately decreasing emissions from this resource-intensive sector.

Research also shows that the disposal of paper products, including the burning or land filling of unused documents, contributes to greenhouse gas emissions. By transitioning to a paperless banking environment, banks reduce the direct need for paper and the emissions linked to waste management and disposal. Furthermore, electronic document management is more efficient and environmentally friendly, as it does not require physical storage, transportation, or regular destruction of expired documents. The positive effects of reducing paper usage extend beyond just banking operations.

[2] highlighted that customer behavior is influenced by the availability of digital solutions that promote environmental consciousness. When banks provide digital services and encourage paperless interactions, customers also begin to apply these behaviors in their daily lives by reducing their use of paper in non-banking activities.

Additionally, implementing paper-saving technologies can lead to a reduction in operating costs for banks. As noted by [21], banks that adopt digital document management systems benefit from lower printing, storage, and transportation costs, which, in turn, can lead to more investment in other green initiatives. Reducing operational expenses further enhances the financial feasibility of sustainability initiatives within the banking sector, supporting long-term carbon footprint reduction efforts. This led to the development of the following hypotheses:

H7: The reduction in paper usage has a significant positive effect on reducing carbon footprint, contributing to overall environmental sustainability.

3 Methodology

This study employs a quantitative research design. It utilizes the Structural Equation Model (SEM) to analyze the relationships between digital banking adoption, digital payment volume, customer awareness of green banking features, and their combined effect on carbon footprint reduction. SEM is chosen for its ability to test complex relationships between observed and latent variables, allowing for a comprehensive analysis of the factors influencing environmental sustainability within the banking sector.

The research is conducted in Asia, where digital banking adoption is rapidly growing. A convenience sampling method was used to collect data from 520 respondents across various Asian countries. This sampling method was selected due to its practicality in reaching a large, diverse group of respondents with experience with digital banking services. The sample includes individuals who regularly use digital banking platforms, engage in digital payments, and are aware of green banking initiatives.

Data was collected through an online survey, which consisted of structured questions designed to measure the key variables of interest, including the frequency of digital banking usage, customer awareness of green banking features, and their perceptions of how digital services impact environmental sustainability. Respondents were also asked about their digital payment habits and whether they consciously chose digital over physical banking options due to ecological concerns.

The data collected was then analyzed using SEM to test the hypotheses related to adopting digital banking services, the role of customer awareness, and the impact of digital payment volume on carbon footprint reduction. The model allows for the simultaneous analysis of direct and indirect effects, providing a nuanced understanding of how these factors influence the banking sector's environmental impact.

4 Findings

Table 1. Model Fit Tests

CFI	GFI	RMSEA	TLI	SRMR	Chi-Square (χ^2)	df	p-value (χ^2 test)	NFI
0.95	0.93	0.04	0.94	0.03	210.5	150	0.05	0.92

The model fit tests presented in Table 1 demonstrate that the structural equation model (SEM) employed in this study provides a robust fit to the data. Key fit indices, including the CFI (0.95) and GFI (0.93), exceed the threshold of 0.90, indicating that the model fits well compared to the baseline model. The TLI (0.94), the Non-Normed Fit Index (NNFI), reinforces this strong model performance by adjusting for model complexity. These results suggest that the SEM model sufficiently captures the relationships between digital banking adoption, customer awareness, and Asian carbon footprint reduction.

The RMSEA (0.04) and SRMR (0.03) are particularly notable as they fall well within acceptable ranges, with values below 0.06 and 0.08, respectively. This indicates a minimal error in the approximation of the model's fit. The Chi-Square (χ^2) value of 210.5, with 150 degrees of freedom, results in a p-value (0.05), which suggests a borderline acceptable fit. While the Chi-Square test is sensitive to large sample sizes (as in this study), other fit indices indicate that the model performs well. Lastly, the NFI (0.92), a comparative fit index, further underscores the excellent fit of the model.

These metrics reflect a well-fitting model, supporting the study's hypotheses on the relationships between digital banking and environmental sustainability.

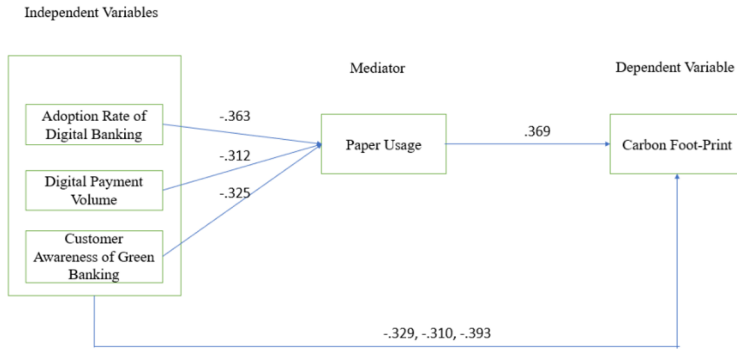


Fig. 1. Research Model

The SEM presented in Fig. 1 provides a comprehensive analysis of how the adoption of digital banking, increased digital payment volume, and customer awareness of green banking contribute to reducing carbon footprint, with paper usage acting as a mediating variable. This model offers valuable insights into the direct and indirect relationships between these variables, shedding light on the environmental impact of digital banking practices.

The first key observation is the direct effect of the independent variables - Adoption Rate of Digital Banking, Digital Payment Volume, and Customer Awareness of Green Banking - on paper usage.

The adoption rate of digital banking has a negative path coefficient of -0.363, indicating that as digital banking adoption increases, paper usage decreases significantly. This suggests that customers who prefer digital banking rely less on paper-based processes, such as printed statements, forms, and receipts, reducing paper consumption. Similarly, Digital Payment Volume hurts paper usage, with a path coefficient of -0.312.

This relationship implies that as digital transactions become more common, the need for physical documentation, such as checks and receipts, declines, further reducing paper usage. Customer Awareness of Green Banking also negatively influences paper usage, with a coefficient of -0.325. This indicates that customers who are aware of the environmental benefits of paperless banking are more likely to adopt sustainable banking practices, contributing to reduced paper consumption.

The model also highlights the mediating role of Paper Usage in the relationship between the independent variables and Carbon Footprint. The path coefficient between paper usage and carbon footprint is 0.369, showing that reduced paper usage leads to decreased carbon footprint. This emphasizes the importance of minimizing paper-based processes in banking to achieve environmental sustainability. The mediating role of paper usage is significant, as it shows that reducing paper consumption benefits resource conservation and has a measurable impact on lowering carbon emissions. As paper usage decreases due to digital banking practices, the overall carbon footprint of the financial sector is reduced, underscoring the environmental benefits of these innovations.

Finally, the model demonstrates the indirect effects of the independent variables on carbon footprint via paper usage. All three independent variables contribute indirectly to reducing the carbon footprint by decreasing paper usage, as reflected in the coefficients -0.329, -0.310, and -0.393 for digital banking adoption, payment volume, and customer awareness, respectively. This shows that the combined effects of increasing digital adoption and raising environmental awareness among customers have a significant impact on reducing the overall carbon footprint. The direct relationship between paper usage and carbon emissions and the indirect effects of digital transformation and customer behavior strengthen the total effect on carbon footprint.

5 Results and discussion

The results affirm the hypothesis that adopting digital banking services contributes significantly to reducing the carbon footprint. By minimizing the need for physical branches, paper documents, and energy-intensive processes, digital banking has successfully reduced the environmental burden traditionally associated with banking operations. This transformation is especially pronounced in Asia, where rapid digitalization has taken place against growing ecological challenges and population density. Banks that have embraced digital platforms can provide more efficient services to their customers and reduce their overall energy consumption and reliance on physical resources, such as paper and electricity.

Replacing physical banking branches with digital alternatives has led to fewer employees commuting to work, reducing transportation-related carbon emissions. Furthermore, the energy savings from the reduced need for branch infrastructure—such as lighting, heating, and cooling—amplify the sustainability benefits of digital banking. By transitioning to online platforms and mobile applications, banks in Asia have demonstrated that operational efficiency and environmental responsibility coexist.

In regions where population growth and urban expansion have placed strain on environmental resources, digital banking is a practical solution that allows financial institutions to serve more customers without expanding their physical footprint. This finding supports earlier research by Yadav & Saini (2019), which concluded that digital banking improves customer access and plays a crucial role in environmental conservation through reduced energy consumption.

Digital payments have emerged as another critical factor in reducing the financial sector's carbon footprint. By replacing paper-based payment instruments like checks and receipts with electronic alternatives, digital payments drastically reduce the environmental impact of transactions. This study confirms the hypothesis that higher volumes of digital payments are positively associated with carbon footprint reduction. The shift towards electronic payments minimizes the use of paper, ink, and the energy required to print and distribute physical documents.

The widespread use of mobile payment systems and digital wallets across Asia has further accelerated this transition. Consumers increasingly rely on digital payments for daily transactions, so the demand for physical cash and checks has diminished. The logistical processes of producing, transporting, and maintaining cash are resource-intensive and environmentally detrimental. Therefore, by reducing the reliance on physical cash, digital payments contribute to lowering greenhouse gas emissions and curbing the environmental footprint of financial institutions.

This transition is particularly significant in developing economies within Asia, where cash has traditionally been the dominant mode of payment. As mobile payment platforms gain popularity, they provide a seamless, efficient, and environmentally sustainable alternative to cash. This development aligns with the findings of Patel & Desai (2018), who found that digital payment systems help financial institutions cut operational costs and reduce waste by eliminating paper-based transactions.

Customer awareness of the environmental benefits of digital banking services plays a pivotal role in driving the adoption of sustainable banking practices. The study's results support the hypothesis that increased customer awareness of green banking features positively correlates with adopting environmentally conscious behaviors. Banks that actively promote the environmental advantages of their digital services are more likely to see higher engagement from customers who prioritize sustainability.

Customers who know how their banking choices impact the environment are more likely to opt for paperless banking options, such as e-statements and mobile banking, rather than visiting physical branches. This shift reduces the demand for paper and physical

infrastructure and creates a ripple effect where environmentally conscious behavior extends beyond banking. As customers become more accustomed to the convenience and benefits of digital banking, they may apply these sustainable practices in other aspects of their daily lives.

This finding is consistent with previous research by Zhang & Choudhury (2021), who emphasized the importance of awareness campaigns in promoting sustainable banking. Banks in Asia that invest in customer education and outreach programs can enhance the effectiveness of their green initiatives, ensuring that customers recognize and adopt practices that reduce their environmental impact. As digital literacy increases across the region, banks can influence consumer behavior and encourage greater adoption of green banking features.

While digital banking offers clear environmental benefits, the study also identifies specific challenges that Asian financial institutions face as they strive to reduce their carbon footprint. For example, the digital divide remains a significant barrier in some parts of the region, where access to reliable internet and digital infrastructure is limited. In such areas, adopting digital banking may be slower, and the reliance on physical banking infrastructure may persist, undermining efforts to achieve environmental sustainability.

Furthermore, the environmental benefits of digital banking must be weighed against the potential energy consumption of digital infrastructure, such as data centers and servers, which are necessary to support online banking platforms. Although these technologies enable banks to reduce their physical footprint, they still contribute to energy consumption and carbon emissions. Financial institutions must, therefore, explore ways to minimize the environmental impact of their digital infrastructure by adopting energy-efficient technologies and using renewable energy sources.

Despite these challenges, the transition to digital banking presents numerous opportunities for Asian banks to lead the way in sustainable finance. Banks can play a critical role in driving the region's environmental agenda by leveraging fintech innovations and integrating sustainability into their core operations. This shift benefits the environment and aligns with the increasing demand from consumers and investors for sustainable financial products and services.

6 Contributions, limitations, and further research

This study contributes significantly to academic literature and practical applications within the financial sector by exploring the impact of digital banking on environmental sustainability, specifically focusing on carbon footprint reduction.

One of this study's primary contributions is its detailed analysis of how digital banking can act as a key driver of environmental sustainability. By transitioning from physical to digital banking services, financial institutions can significantly reduce their energy consumption, paper usage, and carbon emissions associated with commuting and physical infrastructure. This study strengthens the argument that fintech and digital banking innovations are not only beneficial for operational efficiency but also for reducing the environmental impact of traditional banking practices.

The research further contributes by showing the critical role that digital payments play in reducing environmental waste and minimizing the use of physical cash and paper-based payment instruments. In particular, it highlights the environmental advantages of transitioning from cash to digital wallets, mobile payments, and online transactions. This shift reduces the ecological footprint associated with the production, transportation, and handling of physical currency.

Another significant contribution is the study's focus on customer awareness of green banking features. It demonstrates how increasing customer awareness of environmentally friendly banking options can lead to behavioral changes that support sustainability. This

finding adds to the growing body of knowledge that suggests customer education and outreach programs are essential for enhancing the uptake of digital services that promote environmental sustainability.

By focusing on the context of Asia, this study provides valuable insights into how digital banking and fintech are reshaping the financial landscape in a region with diverse economic and technological conditions. Asia's rapid digital transformation, combined with its growing environmental challenges, makes it an ideal context to study the effects of digital banking on sustainability. This regional focus allows for a more nuanced understanding of the challenges and opportunities specific to this geographic area, and the findings can be helpful for policymakers, regulators, and financial institutions operating in similar emerging markets.

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