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Continuous effect of fintech adoption on SME sustainable performance of SMEs: A moderating and mediating model based on multi-country comparison approach

Asad Ur Rehman[1]
Muhammad Ahmad[2+]
Siti Hajar Mohamed[3]
Ihtisham Ullah[4]
Ayesha Nawal[5]

[1,2,3,5]*Management and Science University, University Drive, Off Persiaran Olahraga, 40100, Shah Alam, Malaysia.*
[1]*Email: asad_ur@msu.edu.my*
[2]*Email: muhd_ahmad@msu.edu.my*
[3]*Email: sitihajar_mohamad@msu.edu.my*
[5]*Email: ayesha_nawal@msu.edu.my*
[4]*Asia Pacific University of Technology and Innovation, Kuala Lumpur, Malaysia.*
[4]*Email: Ihtisham.ullah@apu.edu.my*

(+ Corresponding author)

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ABSTRACT

A scarce literature guides the examination of FinTech adoption on SMEs' sustainable performance via the mediation of green finance on green innovation, with the moderating effect of ESGTL and green innovation strategy. Data were collected from 250 SME managers and owners from Pakistan and Malaysia for comparative perspectives, and CB-SEM was applied for data analysis. Results revealed FA's significant effect on SMEs' SP in both countries. GF partially mediates the effect of FA on GI in Malaysia, whereas complete mediation prevails between the constructs in Pakistan. GI fully mediates the effect of GF and SP in both countries. Higher involvement in green innovation strategy moderates the increase in the changes to focus on green finance practices. The higher commitment to ESGTL increases the influence of green financing on green innovation applications in both countries. Lastly, ESGTL improves green innovation's role in attaining sustainable performance for Malaysian SMEs compared to Pakistan. Findings contribute to the enduring literature on fintech and the sustainable performance of SME firms from the perspective of growing economies. Furthermore, it confirms the importance of FA, GF, and GI in enhancing the SP of SME firms, and in due course, confirms the sustainable financial advancement of a country.

Contribution/ Originality: This study contributes to the existing literature by examining the influence of FinTech adoption on the sustainable performance of SMEs in Malaysia and Pakistan. It employs CB-SEM methodology, incorporating sequential mediation and moderation analysis. The primary contribution of this research is the finding that FinTech promotes sustainability through green finance, green innovation, and transformational leadership.

1. INTRODUCTION

Sustainable economic models are becoming more prevalent worldwide, and they will potentially generate $12 trillion in annual economic opportunities by 2030 (Van Tulder, Rodrigues, Mirza, & Sexsmith, 2021). Nations, especially emerging economies, have prioritized economic advancement over environmental progress in modern times. Consequently, various ecological problems have emerged, including air pollution, microclimate variation, biodiversity loss, land degradation, deforestation, and ecological deterioration. The world's sustainable lifestyle is in

trouble due to climate change; therefore, developed and developing nations must take immediate action. For example, the global consensus on atmosphere conservation, the fight against environmental degradation, and the UN's push for the SDGs by 2030 (Akomea-Frimpong, Adeabah, Ofosu, & Tenakwah, 2022). Nations have recently experienced an interest in green finance (Amidjaya & Widagdo, 2020). Therefore, a fundamental path to grow economically and achieve sustainability is to adopt a green economy that works through green financing (Liu, Liu, Xia, Ren, & Liang, 2020). Thus, to guarantee sustainable growth, stakeholders such as academics, bankers, investors, administrations, lawmakers, advocacy organizations, businesses, and communities should be aware of environmental challenges. However, it is still impossible to anticipate the extent of sustainability that has been successful among stakeholders. For several reasons, the interaction between monetarist knowledge (FinTech) and the environment is essential for further study and regulation. In the banking, securities, and asset management industries, as well as among researchers, academics, and practitioners, fintech and sustainability have recently gained popularity. To increase environmental sustainability, governments have simultaneously launched initiatives in support of green finance. Issues related to economic sustainability garner much attention, and FinTech adoption for businesses is seen as an essential facilitator of sustainability (Macchiavello & Siri, 2022). In response, investors have a growing desire for green investment solutions to anticipate it; FinTech adoption for businesses must provide fresh and sophisticated financial products to facilitate the world's transition to a low-carbon economy (Brühl, 2022).

Fintech adoption is an expanding industry that utilizes the revolutionary advantages of technology to offer innovative financial outcomes and services. Recently, it has been regarded as an imaginative and revolutionary sector (Liu et al., 2021; Najaf, Subramaniam, & Atayah, 2022). So, to counter the dynamic competition, financial institutions have started innovating; for example, they include blockchain, peer-to-peer lending, cryptocurrency, artificial intelligence (AI), machine learning, digitalization, payment automation, investing, and customer support (Pizzi, Corbo, & Caputo, 2021). Here, the debate is related to fintech and sustainability. Therefore, businesses espousing fintech can advance sustainability by increasing ecological investment, reducing carbon emissions, fostering green innovation, and enhancing resource efficiency. For instance, Siddik, Yong, and Rahman (2023) argue that firms must adopt fintech to drive sustainable performance through better economic practices. In particular, small and medium-sized enterprises (SMEs) face significant financial obstacles in developing countries, especially when they aim to expand internationally. Specifically, "information friction" is the leading cause of this financial gap (Nassiry, 2018). Fintech products have the potential to help close the finance gap caused by information friction. Using these emerging fintech solutions allows firms to improve the processing and collection of information through digitalization, robotics, biometrics, identity authentication, and blockchain activities, enabling these organizations to access more financing (Pizzi et al., 2021). Fintech innovations can enhance performance in high-pollution businesses and help to alleviate environmental issues. In addition, Fintech is an indispensable cause of green finance that improves the environmental performance of SMEs and ecological investments (Nassiry, 2018).

Previous researchers have not yet comprehensively investigated the influence of FinTech adoption on the performance of firms in Malaysia and Pakistan. However, various studies (Ferdaous & Rahman, 2021; Ryu, 2018) have focused on customers' acceptance and use of fintech; yet, there is little research on how fintech adoption affects the sustainable performance of SMEs. Previous research on fintech examines how it influences businesses' social and environmental performance (Charilaos, 2023), monetary performance (Liu et al., 2021), banks performance (Dwivedi, Alabdooli, & Dwivedi, 2021) sustainable performance (Baeshen, Soomro, & Bhutto, 2021) usage of renewable resources (Croutzet & Dabbous, 2021) and economics availability (Abbasi, Hussain, Radulescu, & Ozturk, 2021). The involvement of Fintech in enhancing a firm's sustainability performance has not been acknowledged as a significant consideration in the literature (Pizzi et al., 2021), with studies concentrating on assessments and case studies. Additionally, previous studies focused on how financial technology affects organizational sustainability. According to Pizzi et al. (2021), academics should use primary data from empirical studies to examine how FinTech affects businesses' long-term success. However, this study supports the outcomes of prior research that measure the

sustainable performance of manufacturing firms and adds to the existing literature by focusing on various environmental and strategic factors influencing corporate environmental performance (Masud, Ahmad, Cho, & Fakhr, 2019) ignoring the SME's SP in developing countries (Baeshen et al., 2021), our study conducted with respondents from developing countries.

Furthermore, previous studies rarely utilize multi-state investigations, contributing to a more comprehensive understanding of FinTech adoption and its outcomes. Additionally, these studies examine the involvement of various mediators in the relationship between FinTech technology adoption and a firm's sustainable performance. To fill these literature gaps, this study examines how, in sequential mediation, green finance and green innovation affect the relationship between SMEs' FinTech adoption and sustainable performance. Also, no such studies inspect the position of green innovation strategy as a moderator between the connection of FinTech adoption and green finance (Mirza, Umar, Afzal, & Firdousi, 2023) and moderate the influence of green transformational leadership; hence, encouraging green innovation. Leadership must be strengthened, comprehended, and envisioned towards common goals (Northouse, 2015). In promoting and upholding the internal competencies for green innovation, SMEs must achieve sustainable performance and possess environmentally specific green transformation leadership (Zhou et al., 2018). Thus, this study investigates the influence of FinTech adoption on the SP of service SMEs in a multi-country analysis, as suggested by Baeshen et al. (2021).

The findings of this study may clarify the debate on technology use, GHRM, and ecological management in four practices. First, via the lenses of Pizzi et al. (2021) and Baeshen et al. (2021) studies, an investigation of FinTech's role in enhancing firm sustainability performance was conducted. The study found that SMEs using FinTech can increase green finance use and innovation and achieve sustainable performance. Thus, there is a dearth of debate on FinTech adoption among service SMEs and sustainable performance, so this research addresses the gap by identifying FinTech adoption as a significant driver for improving SME service performance. Second, this study impacts the literature on green finance and innovation with pragmatic confirmation that will indirectly influence the adoption of FinTech among SMEs to improve the performance of sustainable SME services. An investigative analysis compared Malaysia and Pakistan with the sequential mediation of green finance and green innovation. Thirdly, our study covers the scope of two critical theories, AMO and modern monetary theory hypotheses. Here, AMO theory claims that environmental-specific green transformational leadership, as a crucial deliberate source of businesses, can help to improve competencies, inducements, and opportunities for workers to support green innovation and improve sustainable performance. Subsequently, modern monetary theory serves as the theoretical foundation for the FinTech issue. Griffith and Austin (2004) asserted that lessons on electronic money and monetary policy are taught in the modern monetary theory rather than money supply and cash stream velocity. Another articulation of its idea concerned the impact of digital monetary streams on the financial system. The subsequent grand theory additionally developed the intermediate theory. Finally, by investigating the service SMEs in multiple countries, i.e., Malaysia and Pakistan, this study expands the available literature on Fintech adoption in emerging countries. Using CB-SEM analysis, the study provides empirical evidence to support hypotheses on how Fintech adoption influences SP through green financing and green innovation among service SMEs in countries with the moderating effect of green innovation strategy and ESGTL.

1.1. Theoretical Foundation and Hypotheses

According to the ability motivation theory (AMO), GTL helps GHRM to improve staff members' abilities and drive, opening doors for environmental management programs connected to green innovation and businesses' long-term success (Haddock-Millar, Sanyal, & Müller-Camen, 2016). In GHRM performance studies, AMO theory is frequently used (Bos-Nehles, Van Riemsdijk, & Kees Looise, 2013). For example, various techniques, such as hiring, selection, development, and training agendas, confirm that staff members possess the knowledge and abilities needed for a given role. Similarly, monetary and non-monetary incentives and performance evaluations are the foundation

for motivating people to achieve their goals. In conclusion, opportunity pertains to policies that promote worker participation in diverse endeavors using improved communication, exchange of information, and individual autonomy (Sun, El Askary, Meo, & Zafar, Hussain, 2022). Firms should use green technology to recruit, motivate, promote, and maintain employee work behavior in achieving the objectives and goals of environmental care, which is in line with the AMO perspective (Sun et al., 2022).

In addition, the conceptual framework was studied under the lenses of grand theory, middle theory, and applied theory. It claims that contemporary monetary theory is the theory that underlies the FinTech issue. Griffith and Austin (2004) assert that modern monetary theory teaches more about digital currency than money supply and flow rates. The modern monetary theory focuses on electronic money compared to the rate of money flow and money supply. It is also related to the articulation of the theory of the impact of electronic cash flow on the financial system. This theory will develop the intermediate theory. First, RBV is applied as a middle theory. RBV theory's central tenet is that enterprises could establish and sustain a competitive edge by building and applying valued resources and competencies (Mercurius & Sorongan, 2020). Further, Melville, Kraemer, and Gurbaxani (2004) make it abundantly evident that technology and resources are tangible assets, while organizational management skills are intangible assets. Roger's Diffusion of Innovations Theory is a component of management and technology theory (Rogers, 1995). The diffusion of innovation theory explains how to produce, amend, and augment technological acceptance. Additionally, businesses use IT for finance, which creates competition in financial technology (FinTech). A company must absorb innovations quickly (Pease & Rowe, 2005).

Technology and resources are both explicitly stated by Melville et al. (2004) as perceptible resources, and expertise in handling firms is an intangible asset. Technology, Theory, and Management both address the diffusion of innovations. Rogers (1995) created the theory. The diffusion of innovation theory explains how to generate, amend, and augment technological acceptance. Additionally, businesses use IT for finance, which creates rivalry in financial technology (FinTech). A company must absorb innovations quickly (Pease & Rowe, 2005). According to Porter and Millar (1985) competitive theory explains how businesses innovate to create new markets, goods, services, and business models. Business drivers are the initial concepts that emerge from translating different philosophies (Fernandes, Ferreira, & Raposo, 2013). Therefore, Fintech is a type of financial service innovation that has recently gained popularity as a means of streamlining companies, particularly those related to financial services (Varga, 2017). Ultimately, it is because of a construct for technological innovation that includes marketplace advancement, owing to a novel service or product, due to innovative procedures and commercial models (Mercurius & Sorongan, 2020). Therefore, we proposed the subsequent hypothesized statements.

1.2. Fintech Adoption Effect on Green Finance

The term "Fintech" describes the adoption of technological innovation to provide financial products and services to clients (Dwivedi et al., 2021). Fintech has become increasingly popular among experts and consumers seeking sustainable, user-friendly solutions. Financial institutions can accelerate their services while improving ecological performance. Studies have indicated that Internet banking can boost socioeconomic resilience (Adaba, Ayoung, & Abbott, 2019; Karusala, Holeman, & Anderson, 2019). According to Li, Ozturk, Majeed, Hafeez, and Ullah (2022) the scope of financial penetration should be extended to support environmental sustainability. Fintech contributes to developing sustainable corporate models, economic and societal plans, and procedures (Mirza et al., 2023). It mitigates lending risks and fosters economic and financial development (Sachs et al., 2019). Both fintech and green finance are essential for achieving the Sustainable Development Goals (Zhang, 2023). Fintech significantly enhances the competitiveness and performance of financial institutions, thereby increasing their financing capabilities (Dwivedi et al., 2021). Green finance involves financial products and services integrating ecological attention into loan decisions, measuring, and managing risk. It promotes ecologically accountable investments and encourages low-carbon advancements, plans, businesses, and industries (Afzal, Rasoulinezhad, & Malik, 2022; Kemfert & Schmalz, 2019).

Green finance encourages investors to make eco-friendly investments at the industrial level and allows firms to carry out eco-friendly activities with renewable resources. Fintech firms can leverage technology to rationalize procedures, reduce costs, and improve the efficiency of financial services (Nassiry, 2018). Empirical literature has often found that Fintech adoption positively influences green finance in European banks (Mirza et al., 2023).

H_1: Fintech Adoption has a positive effect on green finance.

1.3. Green Finance Effect on Green Innovation

To promote sustainable growth and restrain environmental degradation, economies must strengthen their policies on green finance and reinforce support for technological advancement. Green financial policies incentivize and regulate investments in environmentally friendly initiatives, while technological innovation enhances the competence and sustainability of manufacturing processes and products. By integrating these strategies, countries can catalyze a shift towards sustainability that benefits both their economies and the environment (Wang, Wang, Feng, & Chang, 2023). Green finance has become a pivotal contributor to environmental expansion, with green innovation playing a central role (Yang, Su, & Yao, 2022). It enables environmental protection and technological advancement through financial resources and incentives, facilitating cleaner production methods and reducing environmental footprints for businesses (Li, Liao, Wang, & Huang, 2018). Many nations recognize green innovation and finance as crucial strategies for achieving enduring climate objectives (Li et al., 2018). However, financing green innovation faces challenges, primarily due to doubts and lengthy R&D processes (Andersen, 2017), requiring substantial capital investments beyond traditional financing channels alone (Hu, Guo, Zhou, & Shi, 2021).

Green finance is vital in promoting investments and loans aimed at environmental sustainability, a priority on the global agenda (Acheampong, Amponsah, & Boateng, 2020). It supports the advancement of green technologies, improves energy efficiency, and reduces carbon dioxide emissions in each production unit (Pan, Uddin, Han, & Pan, 2019). By providing firms with preferential financial support, green finance enables the adoption of clean technologies and advanced production methods, effectively reducing carbon emissions. Consequently, green finance ensures the success of environmental protection efforts by investing in human capital and industrial innovation. The link between green finance and technological innovation is complex. For instance, Andersen (2017) argues that green finance can negatively influence innovation by prompting firms to focus more on tangible assets than on R&D Ran and Zhang (2023) examined the effect of Chinese Green Finance Reform and Innovation trial regions on the green innovation of heavy-contaminating firms using green patent data, finding a negative connection of reforms and green innovation in large, heavily polluted firms, a conclusion echoed by Wang, Feng, Chang, and Wang (2023). Conversely, Yu, Wu, Zhang, Chen, and Zhao (2021) suggest that green finance may stimulate innovation by mitigating R&D risks. Zhou, Zhu, and Luo (2022) showed that FinTech significantly contributes to economic growth and green ventures. Additionally, it reports a positive connotation of green finance with green innovation (Awawdeh, Ananzeh, El-khateeb, & Aljumah, 2022). Thus, it is hypothesized that.

H_2: Green finance has a positive effect on green innovation.

1.4. Green Innovation Effect on Sustainable Performance

Green innovation involves creating or enhancing processes, products, and services to minimize ecological impact (Baeshen et al., 2021). It aids firms in developing green products, expanding product lines, improving quality, boosting reputation, increasing market share, and achieving sustainable growth (Lu, Wang, & Zhang, 2022). Lian, Xu, and Zhu (2022) identified three decisive factors of green innovation: process, product, and organization. Corresponding to Triguero, Moreno-Mondéjar, and Davia (2013) and Xie, Hoang, and Zhu (2022) green innovation combines environmental objectives with process and product innovation, emphasizing efficiency and excellence. Recent literature (Sun et al., 2022) has demonstrated that green innovation assists companies in addressing environmental challenges and promoting ecological sustainability. However, some research indicates that investing

in green innovation can be costly, involving expenses related to training, safety, administration, labor, and research (Gong, Wu, Chen, & Yan, 2020; Lopez, Garcia, & Rodriguez, 2007). Technical challenges, performance issues, and market barriers can make achieving positive returns from green investments more difficult and time-consuming (Gupta & Barua, 2018). Despite these challenges, green innovation is a decisive strategy for sustainable progression (Shahzad, Qu, Rehman, & Zafar, 2022) and gaining a competitive edge (Li et al., 2017). Additionally, green innovation addresses social and ecological issues such as environmental transformation, contamination, and resource scarcity (Chiou, Chan, Lettice, & Chung, 2011). Green process innovation advances business processes, enhancing organizational and environmental performance. The strong link between a firm's sustainable performance and green process innovation has been emphasized (Sarfraz, Hafeez, Abdullah, Ivascu, & Ozturk, 2022). Thus, we hypothesize that.

H_5: Green innovation has a positive effect on sustainable performance.

1.5. Green Finance, FinTech Adoption, and Green Innovation

Prior research investigates the effect of Fintech adoption on the sustainable performance of monetary organizations and examines the intervention of green finance. Findings reveal that fintech adoption enhances sustainable performance through the introduction of green innovation. Additionally, scarce research inspects the intervening role of green finance between fintech adoption and green innovation. However, the study assesses the effect of green banking practices on environmental performance and measures the intervening effect of green finance (Zheng, Siddik, Masukujjaman, Fatema, & Alam, 2021). Findings suggest that green finance strengthens the relationship between green banking practices and environmental performance. Prior literature investigates the influence of green finance on green innovation. Building upon these pauses in prior research, this study considers the intervention of green finance in the context of fintech adoption and green innovation. Consequently, the subsequent investigative hypothesis is proposed:

H_6: Green finance mediates the relationship between FinTech adoption and green innovation.

1.6. Green Innovation, Green Finance and Sustainable Performance

Studies measure the influence of green innovation on environmental performance (Ahmad, Scholz, AlDhaen, Ullah, & Scholz, 2021; Wang et al., 2021). For Example, it revealed that green innovation mediates the influence of CSR on environmental performance (Kraus, Rehman, & García, 2020). The study also examines the influence of green innovation on green finance and sustainable performance in the banking sector. Additionally, it revealed that green finance was a significant intervening variable in various causal relationships. Consequently, another study showed that green innovation mediates the relationship between green finance and sustainable performance. This indicates that green measures such as environmentally friendly technologies, online and mobile banking services, and remote customer provision significantly strengthen the connection between GF and SP, especially during a pandemic. These results suggest that green innovation may influence the interaction between green finance and sustainable performance within firms. Hence, the subsequent research hypothesis was developed.

H_7: Green innovation mediates the effect of green finance on sustainable performance.

1.7. Green Innovation Strategy Moderates the Relationship Between Fintech Adoption and Green Finance

With the connection of technology and sustainability, novel opportunities for promoting environmentally responsible financial practices have emerged. Green innovation strategies that are well-designed are compatible with the principles of green finance. Financial institutions and firms can create products and services that directly contribute to green finance objectives by implementing innovative technologies and applications that decrease ecological impact. This alignment may entice investors interested in environmentally responsible initiatives. Adopting FinTech can improve the accessibility of green finance options (Udeagha & Muchapondwa, 2023).

According to Chen and Liu (2019) positive moderation is demonstrated when employing a differentiation approach related to green product innovation and its relationship with firm performance. However, there is an adverse moderating role between business performance and green process innovation. Additionally, the cost-leadership strategy was negatively impacted by the moderating effect of green product innovation on firm performance. Conversely, it positively influences the link between company performance and green process innovation. The results indicate that an organization's competitive strategy determines how specific green innovations affect performance. The findings offer a clear explanation for the contradictory empirical results observed in previous studies regarding the influence of green innovation on performance outcomes. Furthermore, the study emphasizes the importance of value appropriation derived from green innovation and highlights the necessity of integrating green innovation with business strategy to enhance competitive advantage in the marketplace. Therefore, hypothesis 6 is proposed accordingly.

H_6: Green innovation strategy moderates the effect of FinTech adoption on green finance.

1.8. ESGTL Moderates the Effect of Green Finance on SP

Pursuing sustainable development has led to the convergence of ecologically responsible financial procedures and leadership strategies (Chen et al., 2024). The study by Awan, Dunnan, Jamil, and Gul (2023) indicates that the ability and willingness to contribute to eco-friendly activities significantly impact the overall performance of the environment. Furthermore, it was found that the influence of GHRM practices on environmental performance is mediated by encouraging green innovation. The study's results also showed an influence between green ability and green innovation via the moderating role of ESGTL. However, it is noteworthy that ESGTL unexpectedly weakened the link between green motivation, green opportunity, and green innovation. This is similar to the research done by Kusi, Zhao, and Sukamani (2021) who found insight into the moderating influence of ESGTL. Thus, hypothesis 7 is proposed.

H_7: Green transformational leadership significantly moderates green finance's relationship with sustainable performance.

1.9. ESGTL Moderates the Influence of Green Innovation on SP

Against the backdrop of global imperatives for sustainability, incorporating leadership and innovation principles is gaining importance. This review scrutinizes the central part of ESGTL, moderating between green innovation and sustainable performance, emphasizing the transformative potential of this relationship; according to the research conducted by Chen and Wu (2022) ESGTL and green self-efficacy significantly moderate the role of the aforementioned relationship. The findings show that green HRM practices in businesses raise employees' awareness of environmental issues and, as a result, influence their behavior. These results suggest that ESGTL and green HRM techniques can be used in tandem with one another in green management, and they also validate the pertinence of resource conservation theory to green management. Additionally, Peng, Yin, Hou, Zou, and Nie (2020) measured cue consistency theory-based assumptions supported by Experiments 1a and 1b (A 2x2 between-subject design), which showed that HRM and ESGTL significantly promoted individual green behavior. When high ESGTL and high green human resource management were present, people were more likely to act in a green way. In addition to replicating the results of studies 1a and 1b, study 2, which was built on survey data from 173 leader-employee pairs, also showed that pro-environmental goal clarity modifies green HRM and ESGTL and employee green behavior. Thus, hypothesis 8 is proposed.

H_8: Environment-specific green transformational leadership significantly moderates green innovation's relationship with sustainable performance.

2. METHODOLOGY

The study follows the assumptions of a quantitative, deductive, explanatory, and comparative research approach, which is aligned with a positivist research paradigm (Creswell, 2013). The study surveyed service-sector SMEs in Pakistan and Malaysia to test the hypotheses based on a multi-country analysis, as recommended by Baeshen et al. (2021). The service SME industry managers and owners were selected for sampling because previous studies have measured the environmental performance of manufacturing. Additionally, this study assesses sustainable performance across three dimensions: social, economic, and environmental performance. SMEs, due to extensive competition, operate in a competitive market, and the basis of competition relies on innovation and performance; therefore, they need to follow strategic approaches for the implementation of novel technologies so it is imperative to study the sustainable performance of SMEs in emerging markets. The reason for selecting two countries, Malaysia and Pakistan, as research settings is that both are in the Asia-Pacific region, and it is expected that this region will become the most prominent fintech market with a growth rate of 27%; moreover, it is expected to surpass even the US as the leading fintech sector globally by 2030 (Goyal et al., 2023). Specifically, in this region, various industry-led initiatives have been undertaken to actively promote the adoption of QR code payments as a convenient and affordable method, particularly among MSMEs. Over 68.9% of debit and credit card transactions are digital (FinTech Malaysia & Tranglo, 2023). However, Malaysia is ranked 46th out of 83 nations in the FinTech ranking for adopting digital financial services, whereas Pakistan is not included in this list. Malaysia is ranked 10th in the Asia-Pacific region, and Pakistan is ranked 16th out of 17 countries (Findexable, 2021). Hence, radical efforts are required for both countries to improve their FinTech ranking at both the global and regional levels. Also, scarce studies have been conducted in the Malaysian context to evaluate the influence of SME FinTech adoption on sustainable performance, as previous studies focus on the antecedents of FinTech adoption (Azlul, Ramdhan, & Othman, 2021; Tun-Pin et al., 2019). Also, in Pakistan, studies in the context of FinTech research focus on the antecedents of its adoption (Aamir, Mia, Ahmed, & Prommee, 2023; Misbah Noreen, Ghazali, & Ahmed, 2022). This study makes efforts to address the prevalent differences. Hence, it is imperative to investigate the theoretical framework in the Asia-Pacific region, particularly in a multi-country-based analysis. The study also bridges the theoretical gap linked to the theoretical model through the lens of MMT and AMO theory.

Secondly, SMEs globally serve as the backbone of economies, particularly in Malaysia, with 1.15 million SMEs contributing 97% of all firms and adding 38.2% value to the country's GDP (Reuters Plus, 2023). 50% of SMEs in Malaysia are struggling with the adoption of new norms, and the digital adoption rate is also slow for Malaysian SMEs (Julian, 2022); based on evidence, it is imperative to inspect the effect of FinTech adoption on the sustainable performance of SMEs, which majorly contributes to Malaysia's digital and sustainable economic growth. Meanwhile, SMEs account for 25% of all exports and 40% of Pakistan's GDP. The most significant proportion of the working population in the nation is employed in the SME sector, second only to the agriculture sector. The SME creates 78% of non-agricultural sector jobs (SBP, 2022). Still, concerning digital adoption, it is ranked 16th out of 17 countries in the Asia-Pacific region (Findexable, 2021) So, sustainable performance is challenging and crucial for the growth of a digital and sustainable economy for both countries. The study used a self-directed survey to gather data. To ensure the validity of the questionnaire, service SME managers and four academics from both nations pre-tested the questionnaire. Based on the pilot survey results, the authors made minor changes to the question items in the questionnaire. The SME businesses selected to request permission, and respondents were issued an invitation email before data collection, and a consent form was obtained to ensure the participants' interest.

A self-administered survey questionnaire was utilized to gather information from managers and owners of SMEs in Pakistan and Malaysia. Respondents were approached for data collection via a simple random sampling technique. However, ethical approval was obtained from RMC (MSU, Malaysia; 8th August 2024; Reference code # EA-L1-01-GSM-2024-08-0017), a university ethical board, before data collection. Based on assumptions about multivariate data, concerns regarding normality, estimation methods, the average error of variance, and missing values were considered

to determine the sample size. Furthermore, to determine the appropriate sample size, the study employed a calculation procedure, i.e., sum of elements x 5 = intended sample size (Hair, William, Black, Babin, & Anderson, 2014). Consequently, each construct containing 66 elements, multiplied by 5, results in a sample size of 330 to examine the multivariate data. However, to address non-responses, outliers, and missing data, the sample size was increased by 20%. Therefore, 396 questionnaires were distributed in this study to minimize non-response bias, as suggested by Hair et al. (2014). Data collection was completed in each country between September 2023 and December 2023. A 69.44% response rate was achieved, with 275 surveys received in Pakistan and 282 surveys returned in Malaysia, resulting in a response rate of 71.2%. Following data cleaning, which involved eliminating significant outliers and missing values, 231 responses from Pakistan and 242 responses from Malaysia were used for data analysis. Literature suggests that a sample size of between 200 and 500 respondents is sufficient for analysis using CB-SEM (Rizwan & Mustafa, 2022).

2.1. Constructs and Measures

The FinTech adoption was measured as a single-order construct with six items, and the pilot study results yielded a Cronbach's α value of 0.889. Payment methods are considered when measuring FinTech adoption in this study (Siddik et al., 2023). The green finance scale was adapted from and measured with four dimensions: economic (ECO 4 items), social (SOCial 4 items), environmental performance (ENViro = 4 items), and sources of green financing (SGFing = 4 items). Hence, the green finance construct is measured as a high-order construct scale, which assesses Cronbach's values of 0.923, 0.886, 0.845, and 0.945 for each component. A higher-order concept, derived from Kemp (2008) was considered in relation to green innovation. Environmental technology (five items), environmental organizational innovation (three items), manufacturing and innovation providing ecological benefits (four items), and green system innovations (two items) comprised the four elements of green innovation. Additionally, Cronbach's α values for each component were evaluated by green innovation, and they were 0.887, 0.848, 0.926, and 0.824, respectively. Besides achieving a Cronbach's Alpha score of 0.94, the five-item measure created by Graves and Sarkis (2018) was used to measure ESGTL as a first-order construct. Sustainable performance was measured with three components: ECOper (6 items), ENViro (7 items), and SOCial (5 items), adapted from Shoaib, Nawal, Zámečník, Korsakienė, and Rehman (2022). Lastly, the Green innovation strategy is measured as a single-order construct adapted from Dooley and Fryxell (1999) based on the strategic decision quality. It measures the quality of the green innovation strategy, encompassing facets such as ecological consistency, internal consistency, adaptability, the success of the green innovation strategy, and the degree of risk. Hence, a total of six items were used (see Appendix 1). Furthermore, the green innovation strategy assessed Cronbach's α of 0.868. The constructs were measured using a five-point Likert scale, where 1 indicated "strongly disagree" and 5 indicated "strongly agree." A rigorous statistical analytic tool called AMOS 25, often utilized for CFA and SEM, was used for structural equation modeling (CB-SEM).

2.2. Data Analysis

The demographic construct showed that 82.3% of owners and managers are male and work in SME firms in Pakistan. In contrast, 52.9% of the individuals are male and 47.1% are female, working as owners and managers for Malaysian SMEs. In Pakistan, 61.5% of the population was under the age of 40, and 48.8% of owners and managers in Malaysian SMEs were also under 40 years old. In Pakistan, 76.2% of the population holds a bachelor's degree or higher, while 53.3% hold a master's degree or higher. Moreover, 71.9% of owners and managers in Pakistan have 15 or fewer years of experience. In Malaysia, 73.2% of individuals have 15 years or fewer of professional experience. Hence, trends showed that females participate more in Malaysian SME firms than in Pakistan.

2.3. Construct Validity and Reliability

A good fit can be defined as follows: $p < 0.005$, RMSEA up to 0.08, CFI, TLI, and NFI indices > 0.90. Pakistan SME firms confirm the CFA and generate *(Chi-square/df = 1.893; χ^2 = 229.118/ df = 121), P-value = 0.001, RMSEA = 0.057, CFI = 0.973, TLI = 0.971, and NFI = 0.967*. The measurement model for this investigation generally indicated a satisfactory fit (Hair et al., 2014). Whereas data collected from Malaysian SME firms was used to conduct CFA and generate *(Chi-square/df = 1.892; χ^2 = 247.923/ df = 131), P-value 0.001, RMSEA = 0.059, CFI = 0.963, TLI = 0.961, and NFI = 0.957*, the measurement model for this investigation generally indicated a satisfactory fit (Hair et al., 2014). Items of various constructs and dimensions achieve a verge of 0.60; the factor loadings and AVE for each construct are also above a verge level of 0.50, and further, the composite reliability for each construct is also above the threshold level of 0.60, as suggested by Fornell and Larcker (1981), see Table 1.

Table 1. Convergent Validity.

Construct	Pakistan		Malaysia	
	Average variance extracted > 0.50	Composite reliability> 0.60	Average variance extracted > 0.50	Composite reliability> 0.60
Fintech adoption	0.752	0.948	0.787	0.957
Environmental-specific Transformational leadership	0.724	0.929	0.766	0.942
Green finance	0.780	0.934	0.732	0.916
Green innovation strategy	0.734	0.943	0.722	0.939
Green innovation	0.765	0.942	0.723	0.929
Sustainable performance	0.740	0.934	0.710	0.924

The assessed discriminant values were less than 0.85 and indicated that there was no redundancy among the items of the measurement model, thereby confirming discriminant validity (Kline, 2017). The bold and diagonal values are greater than the values below, and no value exceeds the correlation coefficients greater than the square root of the AVE; therefore, there is no multicollinearity among the constructs, and they achieve discriminant validity, see Table 2.

Table 2. Discriminant validity.

SME Firms from Pakistan (Owner & Manager)							
Construct	**VIF**	**FA**	**GF**	**GI**	**SP**	**GIS**	**ESGTL**
Fintech	1.213	**0.86**					
Green finance	1.234	0.44	**0.89**				
Green innovation	1.334	0.62	0.43	**0.83**			
Sustainable performance	1.311	0.45	0.42	0.54	**0.85**		
Green innovation strategy	1.101	0.34	0.31	0.49	0.39	**0.89**	
ESGTL	1.105	0.21	0.21	0.42	0.51	0.47	**0.87**
SME Firms from Malaysia (Owner & Manager)							
Construct	**VIF**	**FA**	**GF**	**GI**	**SP**	**GIS**	**ESGTL**
Fintech	1.131	**0.88**					
Green finance	1.121	0.34	**0.89**				
Green innovation	1.133	0.51	0.37	**0.86**			
Sustainable performance	1.342	0.39	0.23	0.41	**0.87**		
Green innovation strategy	1.229	0.57	0.33	0.32	0.38	**0.86**	
ESGTL	1.545	0.51	0.51	0.24	0.49	0.41	**0.86**

2.4. Causal Path Investigation Via CB-SEM

The effect of independent and mediating variables was assessed via multivariate data analysis. The causal path analysis supports the direct and indirect effects of fintech adoption on sustainable performance via serial mediation of green finance and green innovation.

Table 3. Causal Path Analysis and Coefficients.

	SME Firms from Pakistan					
	Causal Path	**β**	**S.E.**	**C.R.**	**p-Value**	**Result**
H1a:	FinTech→ Green Finance	0.291	0.093	3.234	0.001	Supported
H2a:	Green Finance → Green Innovation	0.401	0.241	7.678	0.000	Supported
H3a:	Green Innovation → Sustainable Performance	0.521	0.358	9.123	0.000	Supported
	SME Firms from Malaysia					
	Causal Path	**β**	**S.E.**	**C.R.**	**p-Value**	**Result**
H1b:	FinTech→ Green Finance	0.491	0.091	5.134	0.000	Supported
H2b:	Green Finance → Green Innovation	0.613	0.249	11.324	0.000	Supported
H3b:	Green Innovation → Sustainable Performance	0.534	0.347	12.131	0.000	Supported

The results for both countries are found to be significant. Fintech adoption has a significant positive effect on green innovation in Pakistan ($\beta = 0.291$, SE = 0.093, p = 0.001). However, the results are more significant in the case of SMEs from Malaysia ($\beta = 0.491$, SE = 0.091, p = 0.000). Moreover, the effect of green finance on green innovation is significantly positive ($\beta = 0.401$, SE = 0.241, p = 0.000). The effect is highly significant in Malaysia ($\beta = 0.613$, SE = 0.249, p = 0.000). Lastly, green innovation has a positive influence on the sustainable performance of SMEs in both Pakistan (β = 0.521, SE = 0.358, p = 0.001) and Malaysia (β = 0.534, SE = 0.347, p = 0.001), as shown in Table 3.

2.5. Mediation Analysis

It was found that green finance is a significant mediator between Fintech adoption and green innovation (β = 0.289, SE = 0.061, p = 0.002), with the lower bound valued at 0.319 and the upper bound at 0.819; hence, "0" did not prevail, which is why the indirect effect was significant along with the direct effect. Therefore, H4a was accepted, indicating a partial mediating relationship. Secondly, green innovation fully mediates the link between green finance and sustainable performance because the direct influence is insignificant. In comparison, the indirect effect was significant ($\beta = 0.321$, SE = 0.077, p = 0.001) because "0" did not fall between the upper and lower bounds of 0.289-0.534. Thus, H5a was accepted. For the mediation analysis of SMEs from Malaysia, findings also showed that green finance significantly mediates the connection between Fintech adoption and green innovation ($\beta = 0.398$, SE = 0.079, p = 0.002), with "0" not falling between the lower and upper bounds of 0.239-0.388, indicating a significant indirect effect along with the direct effect. Consequently, H4b was accepted, explaining a partial mediating relationship. Additionally, green innovation fully mediates the connection between green finance and sustainable performance because the direct impact is insignificant. In comparison, the indirect effect was significant ($\beta = 0.391$, SE = 0.227, p = 0.001) because "0" did not fall between the upper and lower bounds of 0.459-0.811. Therefore, H5b was accepted.

2.6. Moderation Analysis

2.6.1. Moderation Analysis for SMEs from Pakistan

Under the lens of moderation analysis suggested by Hayes (2013) the moderating role of green innovation strategy and ESGTL was measured. SPSS 26 was used, along with a process macro procedure, with a sample size of 10,000 at a 95% confidence interval level. A separate moderation analysis was conducted for SME firms' managers and owners from Pakistan and Malaysia.

Table 4. Results of the Moderation Test SME Firms from Pakistan.

Causal structural paths	β	S.E	t-value	CI 95%	Results
GIS x FinTech → Green Finance	0.214	0.091	4.343	0.211, 0.439	H6a: Supported
ETL x Green Finance → Green Innovation	0.245	0.101	4.076	0.241, 0.532	H7a: Supported
ETL x Green Innovation → Sustainable Performance	0.267	0.076	4.431	0.286, 0.647	H8a: Supported
GIS(H) x FinTech → Green Finance	0.526	0.078	7.522	0.351, 0.587	Supported
GIS(L) x FinTech → Green Finance	0.221	0.776	0.331	1.221, 2.763	Not Supported
ETL(H) x Green Finance → Green Innovation	0.566	0.112	8.119	0.221, 0.598	Supported
ETL(L) x Green Finance → Green Innovation	0.211	0.910	0.299	1.511, 2.031	Not Supported
ETL(H) x Green Innovation → Sustainable Performance	0.371	0.110	5.421	0.211, 0.401	Supported
ETL(L) x Green Innovation → Sustainable Performance	0.346	0.783	0.313	1.201, 2.151	Not Supported

Note: H represents high & L represents Low, *** $p < 0.001$.

According to Table 4, the results revealed that the causal link between Fintech adoption and green finance was moderated by the green innovation strategy; hence, the *H6a* green innovation approach (β *GIS x FTA* GF = 0.214, t = 4.343 (0.211, 0.439), $p < 0.001$) indicates clear support for *H7a*. Secondly, ESGTL moderates the relationship between green finance and green innovation (β *ETL x GF* GI = 0.245, t = 4.076 (0.241, 0.532), $p < 0.001$), thus supporting *H7a*. Lastly, ESGTL moderates the connection between green innovation and sustainable performance (β *ETL x GI* SP = 0.267, t = 4.431 (0.286, 0.647), $p < 0.001$), thus supporting *H8a*.

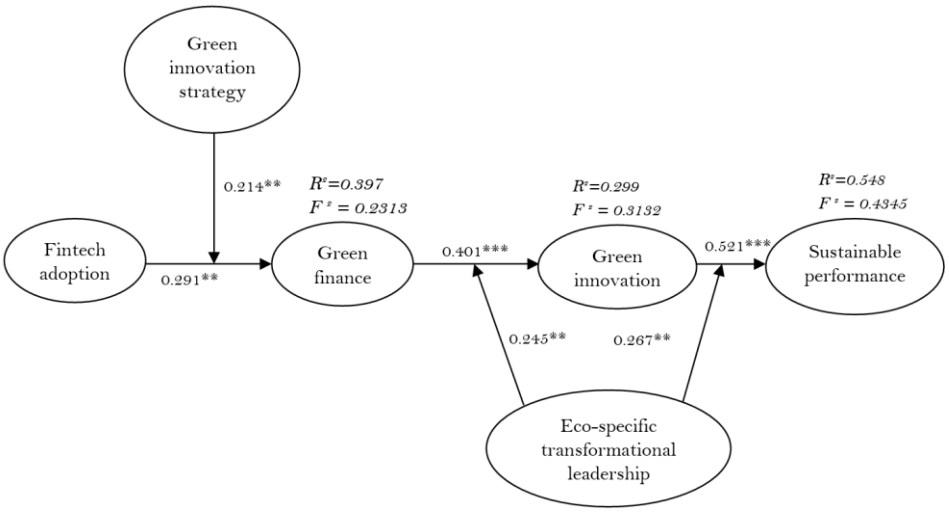

Figure 1. Confirmation of the hypothetical relationship of parent social media firms.
Note: **,*** indicates significance at 5% and 1%.

The findings showed that FinTech is responsible for 39.7% of the variation in green finance. This was determined by calculating the predictive power (R2) of the total variance induced in the dependent variable due to changes in the independent variables. Furthermore, FinTech adoption and green financing account for 29.9% of the change in green innovation. Additionally, FinTech adoption, green finance, and green innovation in the dependent variable create a 54.8% change in sustainable performance, as suggested by Hair et al. (2014). To determine the effect size, the study

employed (Cohen, 1988) methodology. According to Cohen (1988) the small, medium, and large threshold values of f_2 should be 0.02, 0.15, and 0.35, respectively, to indicate the relative abundance of an object in the population. Therefore, the current research approach for Pakistani SME business respondents suggests that green finance (f_2 = 0.2313), green innovation (f_2 = 0.3132), and sustainable performance (f_2 = 0.2342) have large effect sizes. Furthermore, turnover intention has a significant effect size (f_2 = 0.4345), see Figure 1.

The additional data set is divided into high and low groups based on the method proposed by Aiken and West (1991). Here, we examine the moderating influence of FinTech on green financing at different levels. When the green innovation strategy is at a low level (β = 0.221, S.E = 0.776, t-value = 0.331, (1.221, 2.763), p-value = 0.001), FinTech has a positive influence on green finance. Conversely, at a high level of green innovation strategy (β = 0.526, S.E = 0.078, t-value = 7.522, (0.351, 0.587), p-value = 0.000), the influence of FinTech on green finance is more pronounced. Additionally, an analysis was conducted on the moderating effect of green innovation on green finance at different levels of ETL. When ETL is high (β = 0.566, S.E = 0.112, t-value = 8.119, (0.221, 0.598), p-value = 0.000), green financing positively impacts green innovation. In contrast, at a low level of ETL (β = -0.249, S.E = 0.910, t-value = 0.299, (1.511, 2.031), p-value = 0.002), the impact is less favorable. Furthermore, the moderating influence of sustainable performance on green innovation was evaluated at both high and low levels of ETL. When ETL is high (β = 0.371, S.E = 0.110, t-value = 5.421, (0.211, 0.401), p-value = 0.000), green innovation has a positive effect on sustainable performance. When ETL is low (β = 0.346, S.E = 0.783, t-value = 0.313, (1.201, 2.151), p-value = 0.001), the effect remains positive but less significant See Table 4 and Figure 2.

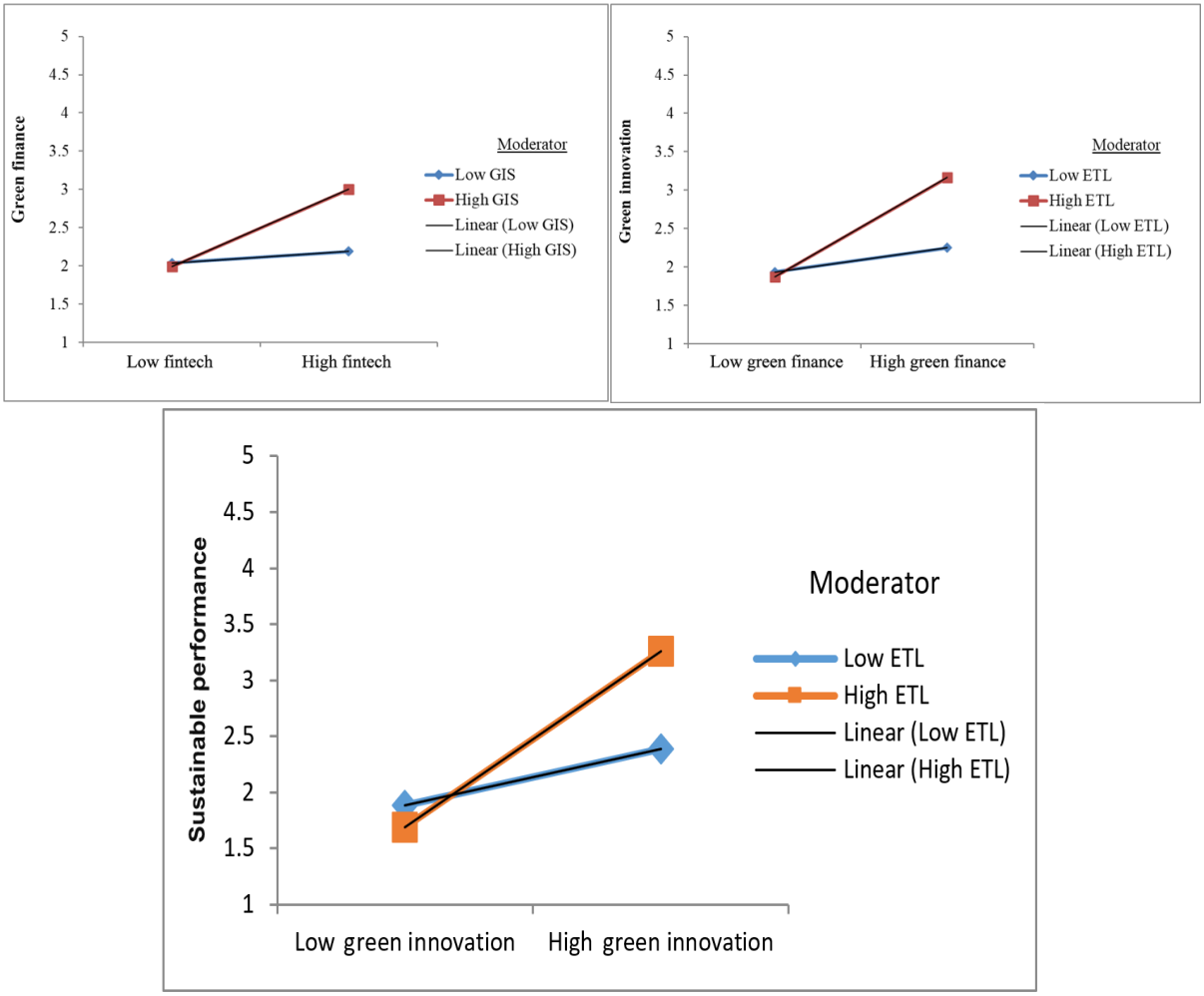

Figure 2. Moderation analysis of green innovation strategy and ESGTL.

2.6.2. Moderation Analysis for SMEs from Malaysia

The relationship between Fintech Adoption and green finance is moderated by the firm's green innovation strategy, supporting *H6a*. Specifically, the green innovation approach (βGIS x FTA → GF = 0.299, t = 4.119, 95% CI [0.201, 0.534], p < 0.001) indicates a significant moderation effect. Additionally, the connection between green finance and green innovation is moderated by ESGTL, supporting *H7a*. The interaction term (βETL x GF → GI = 0.267, t = 4.071, 95% CI [0.269, 0.531], p < 0.001) demonstrates a significant moderation effect. Lastly, the causal path from green innovation to sustainable performance is significantly moderated by ESGTL, supporting *H8a*. The interaction (βETL x GI → SP = 0.232, t = 5.076, 95% CI [0.286, 0.647], p < 0.001) confirms this moderation effect, indicating that ESGTL plays a crucial role in enhancing the impact of green innovation on sustainable performance.

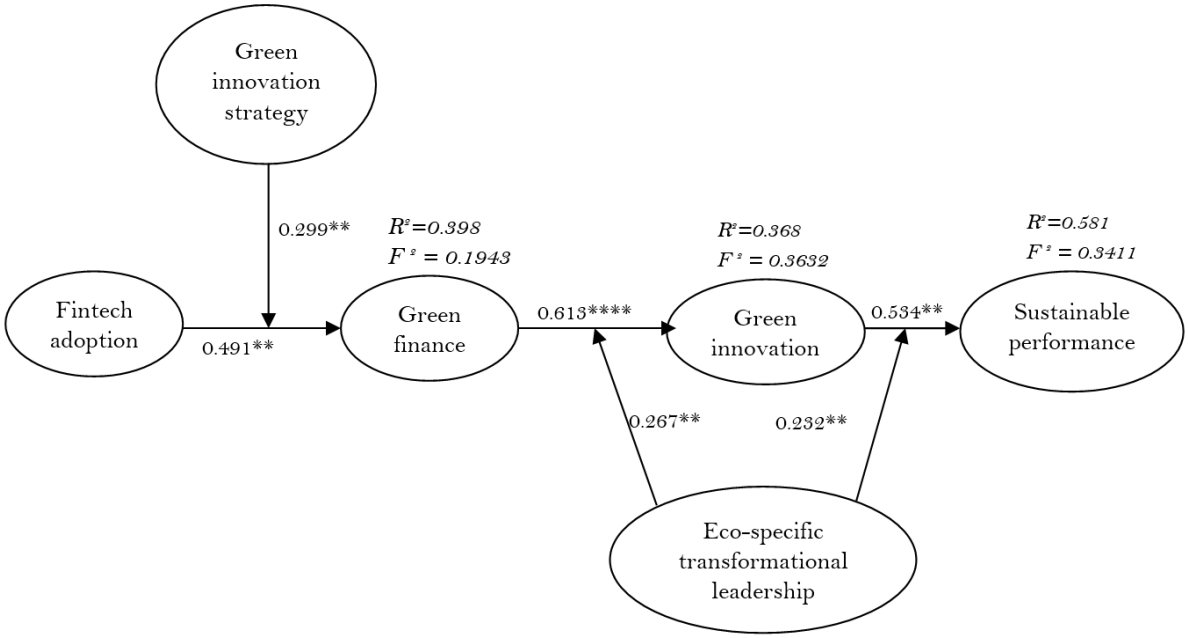

Figure 3. Confirmation of the hypothetical relationship of onshore business process outsourcing firms.
Note: **,*** indicates significance at 5% and 1%.

The predictive capacity (R2) of the total variance caused in the dependent variable due to changes in the independent factors was identified. The results showed that a change of 39.8% in green finance is induced by FinTech adoption. Furthermore, FinTech and green finance contribute to a 36.8% change in green innovation among SME firms in Malaysia. Additionally, FinTech, green finance, and green innovation account for 58.1% of the change in sustainable performance, which is considered acceptable as recommended by Hair et al. (2014). Cohen's approach Cohen (1988) was also utilized in the study to determine the degree of the effect. Cohen (1988) states that the small, medium, and large threshold values of f_2 should be 0.02 for small, 0.15 for medium, and 0.35 for large values. These figures show the object's population prevalence. Therefore, the current study methodology for parent social media SME firms from Malaysia revealed that green finance (f_2 = 0.1943) has a medium effect size, green innovation (f_2 = 0.3632) and sustainable performance (f_2 = 0.3411) have substantial effect sizes. See Figure 3.

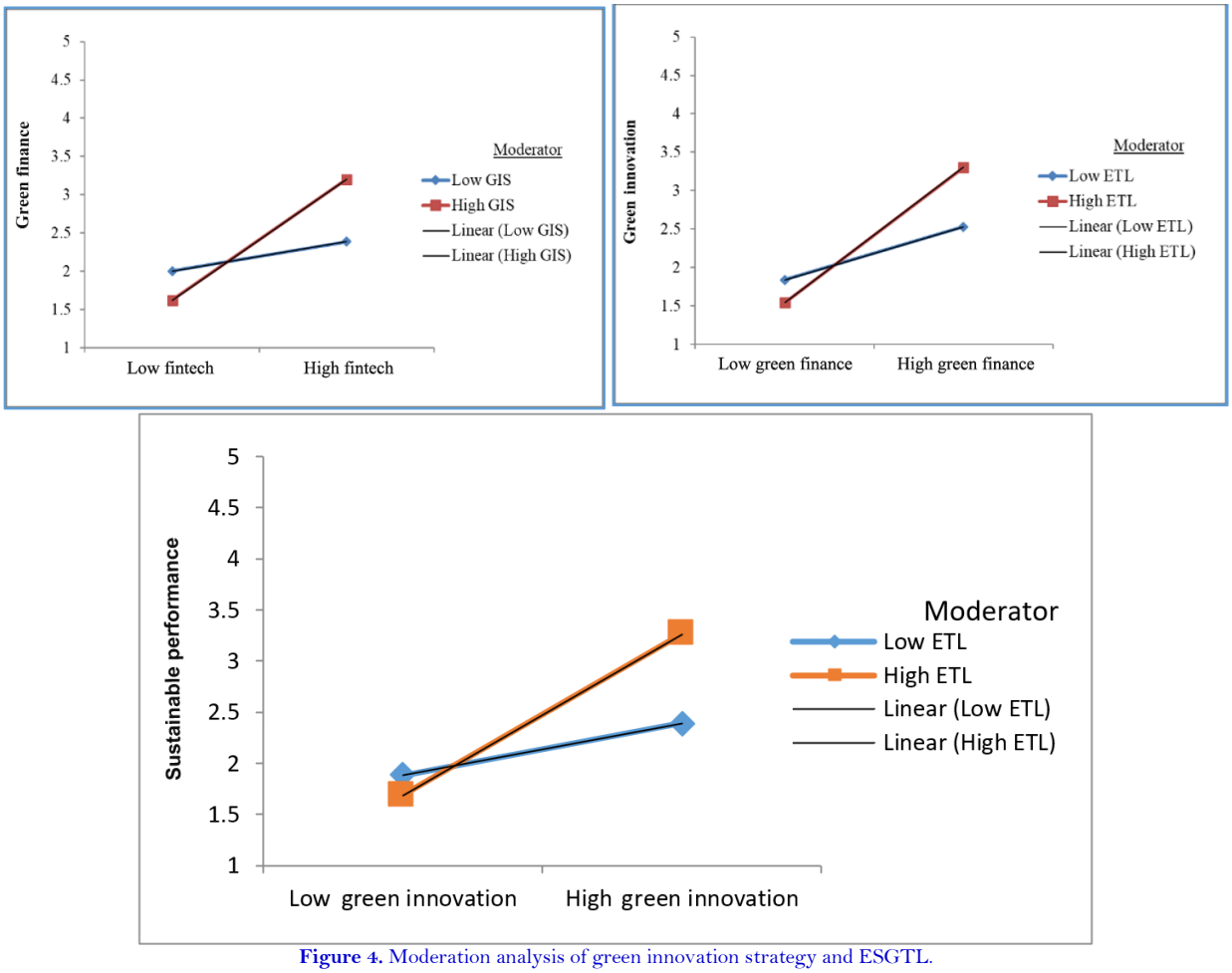

Figure 4. Moderation analysis of green innovation strategy and ESGTL.

According to Aiken and West (1991) the data set was divided into high and low groups using a centre mean technique. Here, we first examine the high and low levels of the moderating influence of FinTech in the context of green financing. In comparison to green innovation strategy at a low level (β = 0.098, S.E = 0.231, t-value = 1.656, (1.113, 2.312), p-value > 0.05), FinTech had a positive influence on green finance when green innovation strategy was at a high level (β = 0.361, S.E = 0.031, t-value = 5.323, (0.219, 0.448), p-value = 0.000). Secondly, an analysis was conducted on the high and low levels of moderating influence that green innovation has on green finance. When ETL was at a high level (β= -0.321, S.E = 0.114, t-value = 4.411, (0.219, 0.431), p-value = 0.001), green financing had a favorable impact on green innovation compared to when ETL was at a low (β= 0.078, S.E = 0.431, t-value = 0.398, (1.113, 2.564), p-value > 0.05). Thirdly, the moderating influence on green innovation with sustainable performance was evaluated at both high and low levels. When ETL had a high level (β= 0.231, S.E = 0.111, t-value = 5.223, (0.232, 0.532), p-value = 0.000), green innovation had a favorable impact on sustainable performance compared to ETL at a low level (β= 0.039, S.E = 0.911, t-value = 1.421, (1.411, 2.998), p-value > 0.05), See Figure 4.

3. FINDINGS AND DISCUSSIONS

The empirical results confirmed that fintech adoption has a positive influence on green finance, supporting hypotheses H1a and H1b. This result supports the findings of Mirza et al. (2023). Fintech can help make green finance more accessible to a wider range of borrowers, including SMEs. For example, fintech platforms can use big data and artificial intelligence (AI) to assess creditworthiness and reduce risk, making it easier for borrowers to qualify for green loans. Further, these results support the idea that fintech can help to reduce the cost of green finance by automating tasks and streamlining processes. For example, fintech platforms can efficiently originate, underwrite,

and service green loans (Muganyi, Yan, & Sun, 2021). As expected, the findings revealed the significant effect of green finance on green innovation, supporting H2a and H1b. This indicates that green finance endorses green innovation in Malaysia and Pakistan. It argued that green finance can stimulate innovation by reducing the risks of R&D (Yu et al., 2021). Previous findings revealed the significant effect of green finance on green innovation (Awawdeh et al., 2022). Findings revealed that green finance could enable investments and loans for environmental sustainability, support green technologies, advance energy productivity, and decrease carbon emissions per unit. Therefore, your result aligns with the existing literature and adds to our knowledge of the role of green finance in fostering green innovation. The findings examined the significant link between green innovation and sustainable performance, thus supporting H3a and H1b. It reinforces the outcomes of preceding research (Awawdeh et al., 2022; Kraus et al., 2020; Wang et al., 2021). This consistency across multiple studies strengthens the validity of the claim that global innovation positively impacts sustainable performance. The empirical results support H4a and H4b by indicating a significant intervention of green finance between fintech adoption and green innovation. Corresponding to the findings, Malaysian and Pakistani businesses are adopting fintech, which boosts their green finance and fosters green innovation. Previous research has demonstrated the influence of green finance on green innovation (Acheampong et al., 2020; Yu et al., 2021). Rarely have studies addressed the mediating influence of green finance and green innovation. One possible explanation could be that fintech adoption in Pakistan and Malaysia increases firms' green finance. This suggests that fintech adoption is linked to greater availability and utilization of green financial services. It seems that fintech platforms effectively connect businesses with green financial solutions, making it easier for companies to invest in environmentally friendly initiatives. Another significant research finding is that it measures the intervening impact of green innovation on the link between green finance and sustainable performance, supported by hypotheses H5a and H5b. Empirical data indicate that green finance can improve sustainable performance, which in turn can mitigate green innovation. These outcomes are consistent with research by Qin, Aziz, Hussan, Qadeer, and Sarwar (2024) which suggested that governments in countries with earlier stages of green finance should make more substantial efforts to direct the development of green innovation, such as increasing communal allocations or tax inducements. In both Pakistan and Malaysia, the existing level of green finance appears to stimulate and support green innovation naturally. This suggests that businesses and governments in Pakistan and Malaysia can further focus on fostering green finance to enhance their green innovation efforts. Authorities should endeavor to minimize ecologically harmful waste and promote ecological innovation, as these measures can increase environmental performance. Green innovation has a significant link with sustainable performance in nations with lower ranks of green innovation. Accordingly, the causal link between green finance and sustainable performance was mediated by green innovation (Ahmad et al., 2021).

Green innovation successfully moderates the effect of Fintech adoption on green finance because green innovation is crucial in ensuring that an organization's overarching strategy aligns with environmentally sustainable practices. This involves strategically aligning financial technology (FinTech) projects with green finance goals and using technology to advance the productivity and efficiency of environmentally friendly fiscal operations. In addition, it promotes the advancement of novel monetary products and services that prioritize the principles of sustainability, where FinTech platforms can be strategically developed to facilitate and provide these pioneering, environmentally friendly financial solutions to a broader demographic, hence enhancing the accessibility of sustainable alternatives (Liu, Zhang, & Kuang, 2023). Moreover, the subject pertains to implementing risk management strategies to mitigate environmental hazards in financial operations. Monetary expertise (FinTech) is crucial in enhancing transparency in financial transactions. By offering stakeholders access to real-time data and analytics, FinTech solutions enable them to effectively evaluate and mitigate risks related to green finance developments (Nenavath & Mishra, 2023). ESGTL significantly moderates the influence of green finance on green innovation and green innovation's effect on the sustainable performance of SME firms in Pakistan and Malaysia. This scenario is that environment-specific Green Transformational Leadership (ESGTL) can inspire and encourage individuals within an organization to adopt and

actively engage in environmentally friendly practices. ESGTL promotes sustainable financial practices, including supporting investments and economic choices linked with long-term ecological and societal objectives (Bhatti et al., 2023). ESGTL cultivates an environment that promotes the generation of novel ideas and invents green financial goods and services, fostering a culture of innovation. Promoting innovation by ESGTL facilitates the development of financial solutions that endorse sustainable investments and foster favorable environmental consequences (Özgül & Zehir, 2023). Moreover, Environmental-specific Green Transformational Leadership (ESGTL) places significant emphasis on implementing ethical and sustainable decision-making procedures, focusing on ensuring that the values upheld align with the objectives of green finance. The success of green finance efforts relies on incorporating ethical decision-making, and ESGTL guarantees the prioritization of sustainable factors in financial decision-making processes (Awan et al., 2023).

3.1. Theoretical Implications

Companies must continuously improve their ESGTL within HRM and implement cutting-edge financial technologies to enhance their sustainability performance in response to growing environmental concerns. There are various theoretical ramifications for this discovery. Firstly, this work broadens the discussion of two critical theories: it examines the assumptions from the perspectives of both AMO and modern monetary theory. The MMT asserts that electronic money is related to the money supply and the flow rate of funds. A further sub-part of MMT is RBV, which proposes that firms might establish and uphold a competitive edge by building and applying evaluated resources and capabilities (Mercurius & Sorongan, 2020; Wernerfelt, 1995). Our findings revealed that businesses may improve sustainable performance by adopting new financial technologies. Our evidence supports the AMO hypothesis, which conditions staff to have more capability, incentive, and opportunity to search for green funding and drive green innovation for the company's sustainable performance when they use the green innovation strategy and ESGTL. Second, our research offers a framework for further research on environmental management, particularly for studies that examine how FinTech adoption, green financing, green innovation strategy, ESGTL, and GI relate to the services industry. It also provides a pragmatic indication of the subsidiary effects of FinTech via green finance and green innovation to enhance the sustainable performance of firms.

We add to the existing debate on green finance and green innovation by examining the sequential mediating influence of green finance and green innovation on Fintech adoption and sustainable performance, as well as the moderating influence of green innovation strategy and ESGTL as moderators. Previous studies have predominantly focused on green innovation due to 4.0 technology implementation (Liu & Chen, 2022) and as an enterprise enabler (Kraus et al., 2022). We also examine the sequential interaction of green finance and innovation between Fintech adoption and sustainable performance. Our study concentrates on the role of green finance and green innovation as a sequential intervention between Fintech adoption and sustainable performance. The results suggest that service SMEs can innovate green goods and processes by implementing Fintech. Thirdly, the linkage of Fintech adoption with the environmental performance of financial institutions was debated in various studies (Irimia-Diéguez, Velicia-Martín, & Aguayo-Camacho, 2023). Scarce studies examine the effect of Fintech on SMEs' firm environmental performance.

3.2. Practical Implications

In practical terms, the results show that service SMEs' attainment of sustainable performance depends on their routine operations incorporating Fintech, green finance, green innovation, and sustainable performance. The study's conclusions offer practical managerial recommendations to legislators and managers of SMEs in the service sector. These include encouraging management to have pro-environmental attitudes, implementing a green and innovative culture within the company, embracing the newest and most cutting-edge technology, and funding eco-friendly projects to prevent environmental deterioration. The governments of Malaysia and Pakistan can also promote green

finance and green innovation by creating a reward system for small and medium-sized businesses (SMEs) that use cutting-edge eco-friendly technologies like blockchain, AI, internet banking, and phone banking, as well as by prioritizing investments in environmentally friendly projects like clean energy, pollution reduction, and carbon-neutral industry. Furthermore, laws and regulations should prioritize localizing fintech according to national goals and capabilities. The national government needs to comprehend these notions and integrate them with regional and nationwide monetary areas because different nations have different capacities for implementing and preparing fintech practices. Regulations may be created and carried out more flexibly with a clear direction and set of rules, which increases the likelihood that fintech will be effectively implemented in the service sector SMEs and helps countries achieve sustainability objectives. However, the administration prioritizes all stakeholders' acceptance and involvement in adopting financial technology to maximize the benefits of high-tech inventions and limit adverse environmental repercussions. Pakistan, in particular, needs to create national strategies for adopting Fintech as an emerging economy and back these plans with laws that encourage their implementation. Since companies are responsible for participating in expanding inventions and creating an effective commercial prototype by government objectives, they play a critical role in adopting fintech. Businesses should strongly emphasize coordinating industrial strategy and innovation with the goals and initiatives of other stakeholders.

3.3. Limitations and Future Recommendations

Our study's findings should only be considered as evidence; the link between FinTech adoption, green financing, green innovation, ESGTL, green innovation strategy, and SME enterprises' sustainable performance should only be further investigated. However, more research should be conducted on various green innovation strategies, such as management, processes, and product innovation. Even though this study investigates the possible effects of FinTech, further investigation is needed to specify a more detailed understanding of the various facets of FinTech, green innovation, and ESGTL. The study's use of multi-country analysis focused on SME firms in emerging nations. Nevertheless, it is essential to investigate other emerging and developed economies and enterprises' adoption patterns and technological capabilities, such as multi-regional comparison analysis or multi-country comparisons between developed and underdeveloped nations. Future studies may investigate these factors regarding green innovation, ESGTL, and sustainable performance in various situations. Furthermore, the performance dimension did not investigate whether the examined firms participate in sustainability strategies and agendas to show their devotion to legal regulations or assurance of eco-friendly sustainability performance. Future studies should focus on different catalysts, expediters, and inducers for long-term performance.

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Institutional Review Board Statement: The Ethical Committee of the Research Management Committee (RMC), Management and Science University, Malaysia has granted approval for this study on 08 August 2024 (Ref. No. EA-L1-01-GSM-2024-08-0017).
Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.
Data Availability Statement: Upon a reasonable request, the supporting data of this study can be provided by the corresponding author.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

REFERENCES

Aamir, H., Mia, M. S., Ahmed, F., & Prommee, P. (2023). A moderated mediation analysis on fintech adoption, social influence, competitiveness and financial performance of commercial banks in Pakistan. *Banks and Bank Systems, 18*(4), 226-240. https://doi.org/10.21511/bbs.18(4).2023.19

Abbasi, K. R., Hussain, K., Radulescu, M., & Ozturk, I. (2021). Does natural resources depletion and economic growth achieve the carbon neutrality target of the UK? A way forward towards sustainable development. *Resources Policy*, *74*, 102341. https://doi.org/10.1016/j.resourpol.2021.102341

Acheampong, A. O., Amponsah, M., & Boateng, E. (2020). Does financial development mitigate carbon emissions? Evidence from heterogeneous financial economies. *Energy Economics*, *88*, 104768. https://doi.org/10.1016/j.eneco.2020.104768

Adaba, G. B., Ayoung, D. A., & Abbott, P. (2019). Exploring the contribution of mobile money to well-being from a capability perspective. *The Electronic Journal of Information Systems in Developing Countries*, *85*(4), e12079. https://doi.org/10.1002/isd2.12079

Afzal, A., Rasoulinezhad, E., & Malik, Z. (2022). Green finance and sustainable development in Europe. *Economic Research-Ekonomska Istraživanja*, *35*(1), 5150-5163. https://doi.org/10.1080/1331677X.2021.2024081

Ahmad, N., Scholz, M., AlDhaen, E., Ullah, Z., & Scholz, P. (2021). Improving firm's economic and environmental performance through the sustainable and innovative environment: Evidence from an emerging economy. *Frontiers in Psychology*, *12*, 651394. https://doi.org/10.3389/fpsyg.2021.651394

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Thousand Oaks, CA: Sage Publications.

Akomea-Frimpong, I., Adeabah, D., Ofosu, D., & Tenakwah, E. J. (2022). A review of studies on green finance of banks, research gaps and future directions. *Journal of Sustainable Finance & Investment*, *12*(4), 1241-1264. https://doi.org/10.1080/20430795.2020.1870202

Amidjaya, P. G., & Widagdo, A. K. (2020). Sustainability reporting in Indonesian listed banks: Do corporate governance, ownership structure and digital banking matter? *Journal of Applied Accounting Research*, *21*(2), 231-247. https://doi.org/10.1108/JAAR-09-2018-0149

Andersen, D. C. (2017). Do credit constraints favor dirty production? Theory and plant-level evidence. *Journal of Environmental Economics and Management*, *84*, 189-208. https://doi.org/10.1016/j.jeem.2017.04.002

Awan, F. H., Dunnan, L., Jamil, K., & Gul, R. F. (2023). Stimulating environmental performance via green human resource management, green transformational leadership, and green innovation: A mediation-moderation model. *Environmental Science and Pollution Research*, *30*(2), 2958-2976. https://doi.org/10.1007/s11356-022-22424-y

Awawdeh, A. E., Ananzeh, M., El-khateeb, A. I., & Aljumah, A. (2022). Role of green financing and corporate social responsibility (CSR) in technological innovation and corporate environmental performance: A COVID-19 perspective. *China Finance Review International*, *12*(2), 297-316. https://doi.org/10.1108/CFRI-03-2021-0048

Azlul, Z. K., Ramdhan, N. A., & Othman, N. (2021). The nexus between FinTech adoption and financial development in Malaysia: An overview. *Global Business & Management Research*, *13*(4), 123–135.

Baeshen, Y., Soomro, Y. A., & Bhutto, M. Y. (2021). Determinants of green innovation to achieve sustainable business performance: Evidence from SMEs. *Frontiers in Psychology*, *12*, 767968. https://doi.org/10.3389/fpsyg.2021.767968

Bhatti, A., Ur Rehman, S., Mirza, F., Nguyen, N., Samad, S., & Kamal, I. (2023). Green intellectual capital, green transformational leadership, and sustainable performance: A moderated mediation model. *World Journal of Science, Technology and Sustainable Development*, *19*(2), 1-18.

Bos-Nehles, A. C., Van Riemsdijk, M. J., & Kees Looise, J. (2013). Employee perceptions of line management performance: Applying the AMO theory to explain the effectiveness of line managers' HRM implementation. *Human Resource Management*, *52*(6), 861-877. https://doi.org/10.1002/hrm.21578

Brühl, V. (2022). Green financial products in the EU—A critical review of the Status Quo. *Intereconomics*, *57*(4), 252-259. https://doi.org/10.1007/s10272-022-1057-2

Charilaos, M. (2023). FinTech finance and social-environmental performance around the world. *Finance Research Letters*, *56*, 104107. https://doi.org/10.1016/j.frl.2023.104107

Chen, J., & Liu, L. (2019). Profiting from green innovation: The moderating effect of competitive strategy. *Sustainability*, *11*(1), 15. https://doi.org/10.3390/su11010015

Chen, S.-L., Su, Y.-S., Tufail, B., Lam, V. T., Phan, T. T. H., & Ngo, T. Q. (2024). Retraction Note: The moderating role of leadership on the relationship between green supply chain management, technological advancement, and knowledge management in sustainable performance. *Environmental Science and Pollution Research, 31*, 58649. https://doi.org/10.1007/s11356-024-35088-7

Chen, T., & Wu, Z. (2022). How to facilitate employees' green behavior? The joint role of green human resource management practice and green transformational leadership. *Frontiers in Psychology, 13*, 906869. https://doi.org/10.3389/fpsyg.2022.906869

Chiou, T.-Y., Chan, H. K., Lettice, F., & Chung, S. H. (2011). The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan. *Transportation Research Part E: Logistics and Transportation Review, 47*(6), 822-836. https://doi.org/10.1016/j.tre.2011.05.016

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Creswell, J. W. (2013). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). London: SAGE Publications, Inc.

Croutzet, A., & Dabbous, A. (2021). Do FinTech trigger renewable energy use? Evidence from OECD countries. *Renewable Energy, 179*, 1608-1617. https://doi.org/10.1016/j.renene.2021.07.144

Dooley, R. S., & Fryxell, G. E. (1999). Attaining decision quality and commitment from dissent: The moderating effects of loyalty and competence in strategic decision-making teams. *Academy of Management Journal, 42*(4), 389-402.

Dwivedi, P., Alabdooli, J. I., & Dwivedi, R. (2021). Role of FinTech adoption for competitiveness and performance of the bank: A study of banking industry in UAE. *International Journal of Global Business and Competitiveness, 16*(2), 130-138. https://doi.org/10.1007/s42943-021-00033-9

Ferdaous, D., & Rahman, M. N. (2021). Banking goes digital: Unearthing the adoption of fintech by Bangladeshi households. *Journal of Innovation in Business Studies, 1*(1), 7-42.

Fernandes, C. I., Ferreira, J. J. M., & Raposo, M. L. (2013). Drivers to firm innovation and their effects on performance: An international comparison. *International Entrepreneurship and Management Journal, 9*(4), 557-580. https://doi.org/10.1007/s11365-013-0263-6

Findexable. (2021). *Global fintech rankings report bridging the gap*. United Kingdom: Findexable Limited.

FinTech Malaysia & Tranglo. (2023). *Malaysia FinTech report*. Malaysia: Fintech New Network.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39-50.

Gong, R., Wu, Y.-Q., Chen, F.-W., & Yan, T.-H. (2020). Labor costs, market environment and green technological innovation: Evidence from high-pollution firms. *International Journal of Environmental Research and Public Health, 17*(2), 522. https://doi.org/10.3390/ijerph17020522

Goyal, D., Varma, R., Rada, F., Pande, A., Jauregui, J., Corelli, P., . . . Suri, S. (2023). *Reimagining the future of finance: Global FinTech report*. Boston: Boston Consulting Group & QED Investors.

Graves, L. M., & Sarkis, J. (2018). The role of employees' leadership perceptions, values, and motivation in employees' provenvironmental behaviors. *Journal of Cleaner Production, 196*, 576-587. https://doi.org/10.1016/j.jclepro.2018.06.013

Griffith, R., & Austin, S. F. (2004). *Electronic money and monetary policy*. Paper presented at the Southwestern Economic Proceedings.

Gupta, H., & Barua, M. K. (2018). A framework to overcome barriers to green innovation in SMEs using BWM and Fuzzy TOPSIS. *Science of the Total Environment, 633*, 122-139. https://doi.org/10.1016/j.scitotenv.2018.03.173

Haddock-Millar, J., Sanyal, C., & Müller-Camen, M. (2016). Green human resource management: A comparative qualitative case study of a United States multinational corporation. *The International Journal of Human Resource Management, 27*(2), 192-211. https://doi.org/10.1080/09585192.2015.1052087

Hair, J. F., William, C., Black, B. J., Babin, R. E., & Anderson. (2014). *Multivariate data analysis*. Edinburgh Gate, Harlow: Pearson New International Edition.

Hayes, A. F. (2013). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach.* New York: Guilford Press.

Hu, B., Guo, H., Zhou, P., & Shi, Z.-L. (2021). Characteristics of SARS-CoV-2 and COVID-19. *Nature Reviews Microbiology, 19*(3), 141-154. https://doi.org/10.1038/s41579-020-00459-7

Irimia-Diéguez, A., Velicia-Martín, F., & Aguayo-Camacho, M. (2023). Predicting FinTech innovation adoption: The mediator role of social norms and attitudes. *Financial Innovation, 9*(1), 36. https://doi.org/10.1186/s40854-022-00434-6

Julian, N. (2022). *Slow digital adoption among Malaysia SME's.* Retrieved from https://www.linkedin.com/pulse/smes-make-up-985-percent-all-businesses-malaysia-contributing-neo

Karusala, N., Holeman, I., & Anderson, R. (2019). Engaging identity, assets, and constraints in designing for resilience. *Proceedings of the ACM on Human-Computer Interaction, 3*(CSCW), 1-23. https://doi.org/10.1145/3359315

Kemfert, C., & Schmalz, S. (2019). Sustainable finance: Political challenges of development and implementation of framework conditions. *Green Finance, 1*(3), 237-248. https://doi.org/10.3934/GF.2019.3.237

Kemp, R. (2008). *Measuring eco-innovation.* USA: United Nations University.

Kline, R. (2017). Some clarifications and recommendations on fit indices. *Structural Equation Modeling: A Multidisciplinary Journal, 24*(3), 1–4.

Kraus, S., Durst, S., Ferreira, J. J., Veiga, P., Kailer, N., & Weinmann, A. (2022). Digital transformation in business and management research: An overview of the current status quo. *International Journal of Information Management, 63*, 102466. https://doi.org/10.1016/j.ijinfomgt.2021.102466

Kraus, S., Rehman, S. U., & García, F. J. S. (2020). Corporate social responsibility and environmental performance: The mediating role of environmental strategy and green innovation. *Technological Forecasting and Social Change, 160*, 120262. https://doi.org/10.1016/j.techfore.2020.120262

Kusi, M., Zhao, F., & Sukamani, D. (2021). Impact of perceived organizational support and green transformational leadership on sustainable organizational performance: A SEM approach. *Business Process Management Journal, 27*(5), 1373-1390. https://doi.org/10.1108/BPMJ-09-2020-0419

Li, D., Zheng, M., Cao, C., Chen, X., Ren, S., & Huang, M. (2017). The impact of legitimacy pressure and corporate profitability on green innovation: Evidence from China top 100. *Journal of Cleaner Production, 141*, 41-49. https://doi.org/10.1016/j.jclepro.2016.08.123

Li, X., Ozturk, I., Majeed, M. T., Hafeez, M., & Ullah, S. (2022). Considering the asymmetric effect of financial deepening on environmental quality in BRICS economies: Policy options for the green economy. *Journal of Cleaner Production, 331*, 129909. https://doi.org/10.1016/j.jclepro.2021.129909

Li, Z., Liao, G., Wang, Z., & Huang, Z. (2018). Green loan and subsidy for promoting clean production innovation. *Journal of Cleaner Production, 187*, 421-431. https://doi.org/10.1016/j.jclepro.2018.03.066

Lian, G., Xu, A., & Zhu, Y. (2022). Substantive green innovation or symbolic green innovation? The impact of ER on enterprise green innovation based on the dual moderating effects. *Journal of Innovation & Knowledge, 7*(3), 100203. https://doi.org/10.1016/j.jik.2022.100203

Liu, J., Zhang, Y., & Kuang, J. (2023). Fintech development and green innovation: Evidence from China. *Energy Policy, 183*, 113827. https://doi.org/10.1016/j.enpol.2023.113827

Liu, N., Liu, C., Xia, Y., Ren, Y., & Liang, J. (2020). Examining the coordination between green finance and green economy aiming for sustainable development: A case study of China. *Sustainability, 12*(9), 3717. https://doi.org/10.3390/su12093717

Liu, Y., & Chen, L. (2022). The impact of digital finance on green innovation: Resource effect and information effect. *Environmental Science and Pollution Research, 29*(57), 86771-86795. https://doi.org/10.1007/s11356-022-21802-w

Liu, Y., Liu, J., Xia, H., Zhang, X., Fontes-Garfias, C. R., Swanson, K. A., . . . Shi, P.-Y. (2021). Neutralizing activity of BNT162b2-elicited serum. *The New England Journal of Medicine, 384*(15), 1466-1468. https://doi.org/10.1056/NEJMc2102017

Lopez, M. V., Garcia, A., & Rodriguez, L. (2007). Sustainable development and corporate performance: A study based on the Dow Jones sustainability index. *Journal of Business Ethics, 75*, 285–300. https://doi.org/10.1007/s10551-006-9253-8

Lu, Y., Wang, L., & Zhang, Y. (2022). Does digital financial inclusion matter for firms' ESG disclosure? Evidence from China. *Frontiers in Environmental Science,, 10*, 1029975. https://doi.org/10.3389/fenvs.2022.1029975

Macchiavello, E., & Siri, M. (2022). Sustainable finance and fintech: Can technology contribute to achieving environmental goals? A preliminary assessment of 'green fintech'and 'sustainable digital finance'. *European Company and Financial Law Review, 19*(1), 128-174. https://doi.org/10.1515/ecfr-2022-0005

Masud, H., Ahmad, M. S., Cho, K. W., & Fakhr, Z. (2019). Parenting styles and aggression among young adolescents: A systematic review of literature. *Community Mental Health Journal, 55*(6), 1015-1030. https://doi.org/10.1007/s10597-019-00400-0

Melville, N., Kraemer, K., & Gurbaxani, V. (2004). Review: Information technology and organizational performance: An integrative model of IT business value. *MIS Quarterly, 28*(2), 283-322. https://doi.org/10.2307/25148636

Mercurius, B. L., & Sorongan, F. A. (2020). Role of FinTech mechanism to technological innovation: A conceptual framework. *International Journal of Innovative Science and Research Technology, 5*(5), 1-6.

Mirza, N., Umar, M., Afzal, A., & Firdousi, S. F. (2023). The role of fintech in promoting green finance, and profitability: Evidence from the banking sector in the euro zone. *Economic Analysis and Policy, 78*, 33-40. https://doi.org/10.1016/j.eap.2023.02.001

Misbah Noreen, M., Ghazali, Z., & Ahmed, F. (2022). Role of government policies to fintech adoption and financial inclusion: A study in Pakistan. *Universal Journal of Accounting and Finance, 10*(1), 37-46. https://doi.org/10.13189/ujaf.2022.100105

Muganyi, T., Yan, L., & Sun, H.-P. (2021). Green finance, fintech and environmental protection: Evidence from China. *Environmental Science and Ecotechnology, 7*, 100107. https://doi.org/10.1016/j.ese.2021.100107

Najaf, K., Subramaniam, R. K., & Atayah, O. F. (2022). Understanding the implications of FinTech Peer-to-Peer (P2P) lending during the COVID-19 pandemic. *Journal of Sustainable Finance & Investment, 12*(1), 87-102. https://doi.org/10.1080/20430795.2021.1917225

Nassiry, D. (2018). *The role of FinTech in unlocking green finance: Policy insights for developing countries*. ADBI Working Paper No. 883.

Nenavath, S., & Mishra, S. (2023). Impact of green finance and fintech on sustainable economic growth: Empirical evidence from India. *Heliyon, 9*(5), e16301. https://doi.org/10.1016/j.heliyon.2023.e16301

Northouse, P. G. (2015). *Leadership: Theory and practice* (7th ed.). Thousand Oaks, CA: SAGE Publications.

Özgül, B., & Zehir, C. (2023). How managers' green transformational leadership affects a firm's environmental strategy, green innovation, and performance: The moderating impact of differentiation strategy. *Sustainability, 15*(4), 3597. https://doi.org/10.3390/su15043597

Pan, X., Uddin, M. K., Han, C., & Pan, X. (2019). Dynamics of financial development, trade openness, technological innovation and energy intensity: Evidence from Bangladesh. *Energy, 171*, 456-464. https://doi.org/10.1016/j.energy.2018.12.200

Pease, W., & Rowe, M. (2005). Diffusion of innovation-The Adoption of electronic commerce by small and medium enterprises (SMES)-A comparative analysis. *Australasian Journal of Information Systems, 13*(1), 287–294.

Peng, J., Yin, K., Hou, N., Zou, Y., & Nie, Q. (2020). How to facilitate employee green behavior: The joint role of green transformational leadership and green human resource management practice. *Acta Psychologica Sinica, 52*(9), 1105-1120. https://doi.org/10.3724/SP.J.1041.2020.01105

Pizzi, S., Corbo, L., & Caputo, A. (2021). Fintech and SMEs sustainable business models: Reflections and considerations for a circular economy. *Journal of Cleaner Production, 281*, 125217. https://doi.org/10.1016/j.jclepro.2020.125217

Porter, M. E., & Millar, V. E. (1985). How information gives you competitive advantage. *Harvard Business Review, 63*(4), 149–160.

Qin, L., Aziz, G., Hussan, M. W., Qadeer, A., & Sarwar, S. (2024). Empirical evidence of fintech and green environment: Using the green finance as a mediating variable. *International Review of Economics & Finance, 89*, 33-49. https://doi.org/10.1016/j.iref.2023.07.056

Ran, C., & Zhang, Y. (2023). Does green finance stimulate green innovation of heavy-polluting enterprises? Evidence from green finance pilot zones in China. *Environmental Science and Pollution Research, 30*(21), 60678-60693. https://doi.org/10.1007/s11356-023-26758-z

Reuters Plus. (2023). *Access all areas – European SMEs and Malaysia*. Retrieved from https://www.reuters.com/plus/access-all-areas-european-smes-andMalaysia

Rizwan, A., & Mustafa, F. (2022). Fintech attaining sustainable development: An investor perspective of crowdfunding platforms in a developing country. *Sustainability, 14*(12), 7114. https://doi.org/10.3390/su14127114

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York: Free Press.

Ryu, H.-S. (2018). What makes users willing or hesitant to use Fintech?: The moderating effect of user type. *Industrial Management & Data Systems, 118*(3), 541-569. https://doi.org/10.1108/IMDS-07-2017-0325

Sachs, J. D., Schmidt-Traub, G., Mazzucato, M., Messner, D., Nakicenovic, N., & Rockström, J. (2019). Six transformations to achieve the sustainable development goals. *Nature Sustainability, 2*(9), 805-814. https://doi.org/10.1038/s41893-019-0352-9

Sarfraz, M., Hafeez, H., Abdullah, M. I., Ivascu, L., & Ozturk, I. (2022). The effects of the COVID-19 pandemic on healthcare workers' psychological and mental health: The moderating role of felt obligation. *Work, 71*(3), 539-550. https://doi.org/10.3233/WOR-211073

SBP. (2022). *Challenge fund for SMEs. State Bank of Pakistan*. Retrieved from https://www.sbp.org.pk/smefd/circulars/2022/C4-Annex-A.pdf

Shahzad, M., Qu, Y., Rehman, S. U., & Zafar, A. U. (2022). Adoption of green innovation technology to accelerate sustainable development among manufacturing industry. *Journal of Innovation & Knowledge, 7*(4), 100231. https://doi.org/10.1016/j.jik.2022.100231

Shoaib, M., Nawal, A., Zámečník, R., Korsakienė, R., & Rehman, A. U. (2022). Go green! Measuring the factors that influence sustainable performance. *Journal of Cleaner Production, 366*, 132959. https://doi.org/10.1016/j.jclepro.2022.132959

Siddik, A. B., Yong, L., & Rahman, M. N. (2023). The role of Fintech in circular economy practices to improve sustainability performance: A two-staged SEM-ANN approach. *Environmental Science and Pollution Research, 30*(49), 107465-107486. https://doi.org/10.1007/s11356-023-25576-7

Sun, X., El Askary, A., Meo, M. S., Zafar, N. U. A., & Hussain, B. (2022). Green transformational leadership and environmental performance in small and medium enterprises. *Economic Research-Ekonomska Istraživanja, 35*(1), 5273-5291. https://doi.org/10.1080/1331677X.2021.2025127

Triguero, A., Moreno-Mondéjar, L., & Davia, M. A. (2013). Drivers of different types of eco-innovation in European SMEs. *Ecological Economics, 92*, 25-33. https://doi.org/10.1016/j.ecolecon.2013.04.009

Tun-Pin, C., Keng-Soon, W. C., Yen-San, Y., Pui-Yee, C., Hong-Leong, J. T., & Shwu-Shing, N. (2019). An adoption of fintech service in Malaysia. *South East Asia Journal of Contemporary Business, 18*(5), 134-147.

Udeagha, M. C., & Muchapondwa, E. (2023). Green finance, fintech, and environmental sustainability: Fresh policy insights from the BRICS nations. *International Journal of Sustainable Development & World Ecology, 30*(6), 633-649. https://doi.org/10.1080/13504509.2023.2183526

Van Tulder, R., Rodrigues, S. B., Mirza, H., & Sexsmith, K. (2021). The UN's sustainable development goals: can multinational enterprises lead the decade of action? *Journal of International Business Policy, 4*(1), 1-21. https://doi.org/10.1057/s42214-020-00095-1

Varga, D. (2017). Fintech, the new era of financial services. *Vezetéstudomány-Budapest Management Review, 48*(11), 22-32. https://doi.org/10.14267/VEZTUD.2017.11.03

Wang, H., Khan, M. A. S., Anwar, F., Shahzad, F., Adu, D., & Murad, M. (2021). Green innovation practices and its impacts on environmental and organizational performance. *Frontiers in Psychology, 11*, 553625. https://doi.org/10.3389/fpsyg.2020.553625

Wang, Q.-J., Wang, H.-J., Feng, G.-F., & Chang, C.-P. (2023). Impact of digital transformation on performance of environment, social, and governance: Empirical evidence from China. *Business Ethics, the Environment & Responsibility, 32*(4), 1373–1388. https://doi.org/10.1111/beer.12573

Wernerfelt, B. (1995). The resource-based view of the firm: Ten years after. *Strategic Management Journal*, *16*(3), 171-174. https://doi.org/10.1002/smj.4250160303

Xie, X., Hoang, T. T., & Zhu, Q. (2022). Green process innovation and financial performance: The role of green social capital and customers' tacit green needs. *Journal of Innovation & Knowledge*, *7*(1), 100165. https://doi.org/10.1016/j.jik.2022.100165

Yang, Y., Su, X., & Yao, S. (2022). Can green finance promote green innovation? The moderating effect of environmental regulation. *Environmental Science and Pollution Research*, *29*(49), 74540-74553. https://doi.org/10.1007/s11356-022-21118-9

Yu, C.-H., Wu, X., Zhang, D., Chen, S., & Zhao, J. (2021). Demand for green finance: Resolving financing constraints on green innovation in China. *Energy Policy*, *153*, 112255. https://doi.org/10.1016/j.enpol.2021.112255

Zhang, D. (2023). Can digital finance empowerment reduce extreme ESG hypocrisy resistance to improve green innovation? *Energy Economics*, *125*, 106756. https://doi.org/10.1016/j.eneco.2023.106756

Zheng, G.-W., Siddik, A. B., Masukujjaman, M., Fatema, N., & Alam, S. S. (2021). Green finance development in Bangladesh: The role of private commercial banks (PCBs). *Sustainability*, *13*(2), 795. https://doi.org/10.3390/su13020795

Zhou, G., Zhu, J., & Luo, S. (2022). The impact of fintech innovation on green growth in China: Mediating effect of green finance. *Ecological Economics*, *193*, 107308. https://doi.org/10.1016/j.ecolecon.2021.107308

Zhou, X., Li, N., Luo, Y., Liu, Y., Miao, F., Chen, T., . . . Hu, R. (2018). Emergence of African swine fever in China, 2018. *Transboundary and Emerging Diseases*, *65*(6), 1482-1484. https://doi.org/10.1111/tbed.12989

Appendix 1.

FinTech adoption (FA)	**Environmental-specific green transformational leadership (ESGTL)**
We use fintech at our firms regularly.	I inspire subordinates with environmental plans.
We use fintech for our merchant payments.	I provide subordinates with a clear environmental vision.
We use fintech to pay employees' salaries.	I encourage subordinates to work on an environmental plan.
We use fintech for government payments.	I encourage employees to attain environmental goals.
We use fintech for our microfinance and crowdfunding.	I consider the environmental beliefs of my subordinates.
We use fintech for our loan payments.	
Green Finance	Green Innovation
The social dimension of green finance	Environmental Technology
We follow the provision of better customer satisfaction.	Our firms use pollution control technologies such as wastewater treatment.
We always try to establish the trust of stakeholders.	Our firm uses technology to treat pollution released into the environment.
We have brought stakeholders to engage with our firm's plans.	Our firm uses cleaner process technologies that are more resource-efficient.
We bring the provision of more employee benefits.	Our firm uses waste management equipment.
The economic dimension of green finance	Our firm uses green energy technologies.
We strive to create a more competitive advantage for our firm.	Environmental firm innovation
We strive to generate more revenue.	Our firm follows pollution prevention schemes.
We strive to save on investment and other costs.	Our firm follows environmental management and audit systems.
We strive to reduce overall risk for our firm.	Our firm follows chain management to cooperate with firms to close the material loops and avoid environmental damage across the value chain.
The environmental dimension of green finance	Manufacturing and innovation provide ecological benefits.
We reduce carbon emissions from firms' activities.	Our firm focuses on environmentally improved products such as eco-houses and buildings.

We try to control the production of waste and emissions.	Our firm's focus on green financial products, such as eco-lease or climate mortgages, is to expand business units.
Our firm is concerned about waste recycling.	Our firm hires environmental services experts for environmental consultation.
Our firm is concerned about waste management.	Our firm promotes services among employees that are less polluting and resource-intensive, like sharing transportation.
Sources of green financing	**Green system innovations**
Our firm generates investment from green finance products.	Our firm focuses on developing alternative production systems that are eco-friendly for existing systems.
We try to avoid the generation of domestic public finance due to a lack of a green vision.	Our firm focuses on developing alternative consumption systems that are eco-friendly for existing systems.
We generate international public finance when a source has a green vision.	Green Innovation
We generate private-sector finance from sources that have green-financed products.	
Our innovation strategy is aligned with the market environment.	
Our innovation strategy and policy environment are aligned.	
Our innovation strategy is aligned with internal resources and capabilities.	
Our Innovation strategy is adapted to other firms' decisions.	
Our Innovation strategy is compatible with the organizational structure of the enterprise.	
Our Innovation strategy promotes the achievement of innovation goals.	
Sustainable Performance	
Economic performance	**Environmental performance**
Our firm's profit growth is generally due to reduced energy consumption and materials.	Our firm lowers the discharge of toxic chemicals into the air and water.
Our firm reduces the cost of energy usage.	Our firm's enhancement of the environmental state
Our firm reduces processing fees and waste disposal.	Our firm reduces the frequency of environmental mishaps.
Our firm's average growth in market share over the past two years has increased.	Our firm's direct and indirect toxic emissions have been reduced.
Our firm's average profit and growth over the past two years have increased.	Our firm is increasing the purchase rate of environmentally friendly goods.
Our firm's average growth in market share over the past two years has increased.	Increase the volume of recycled materials and reduce waste.
Social performance	Increase the activities that protect our natural environment, such as the presence of green areas in the organization.
Our firm increases attention to the rules for the health and safety of employees.	
Our firm improves community health, safety, and infection control.	
Our firm reduces the impact of waste on the community.	
Our firm is improving the quality of service provided and is committed to the code of ethics.	
Our firm is developing economic activities in the community and providing more job opportunities.	