The Impact of carbon emissions on market performance: fintech versus non-fintech

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Abstract

This study aimed to examine the impact of Scope 3 carbon emissions on market performance and the moderating effect of financial technology (fintech) on this particular relationship. Empirical data on Scope 3 carbon emissions from 2010 to 2022, which covered both fintech and traditional (non-fintech) financial firms, were collected from Bloomberg. All data were subjected to ordinary least squares (OLS) regression. Generalised method of moments (GMM) was performed to deal with potential endogeneity issues. The significant negative relationship between Scope 3 carbon emissions and market performance in this study implied investors' concerns about the environmental impacts. With the noticeably lower carbon emissions, indicating the adoption of an eco-friendly orientation, fintech financial firms demonstrated positive relationship between their market performance and Scope 3 carbon emissions. Meanwhile, the results revealed otherwise for non-fintech financial firms. It is recommended for future research to consider the qualitative approach, such as structured or semi-structured interviews, to further validate the quantitative results of the current study. This study demonstrated the significant role of fintech financial firms in environmental stewardship, specifically with their markedly lower Scope 3 carbon emissions. Their approaches and practices can benefit ESG implementors in designing and implementing more effective and responsible operational models. Despite the current global challenges, particularly after the COVID-19 pandemic and the growing environmental awareness and concerns, this study commended the sustainable approaches of fintech financial firms, which served as a benchmark for ESG initiatives. This can potentially boost their ESG ratings and market standing. To date, the relationship between Scope 3 carbon emissions and market performance and the moderating role of fintech on this relationship have remained underexplored, which were addressed in the current study.

Keywords Environmental responsibility · Fintech firms · Scope 3 · OLS regression · GMM approach

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1 Introduction

Most prior studies on the relationships of fintech, environmental, social, and governance (ESG) performance, and market performance mainly focused on the direct impact of fintech development on corporate ESG performance and market valuation. The review of recent studies, such as Wang et al. (2022) and Atayah et al. (2024), revealed the lack of findings on the depth of ESG metrics employed, particularly when it comes to the inclusion of Scope 3 carbon emissions, which propelled the current study to explore. Considering the growing importance of greenhouse gas emissions in the sustainable and responsible investment paradigms, this study examined the relationship between Scope 3 carbon emissions and market performance and the moderating effect of fintech on this particular relationship.

Bloomberg ESG data served as a proxy for ESG measurement in prior studies, which somehow overlooked Scope 3 carbon emissions, including the indirect greenhouse gas emissions. This has then led to the lack of comprehensiveness in the evaluation of a firm's environmental impact. Addressing that, the current study's analysis took into account Scope 3 carbon emissions to gain more comprehensive insights on the ESG footprint and its impact on market performance. This quantitative study also rigorously examined the complex relationship between Scope 3 carbon emissions and market performance using the empirical data on Scope 3 carbon emissions from 2010 to 2022 of both fintech and traditional financial firms. Bloomberg was used as the primary source of these data. Ordinary least squares (OLS) regression was employed to validate the baseline model, while the dynamic generalised moments method (GMM) approach was performed to deal with potential endogeneity issues in this study.

Recent studies like Naffa and Fain (2020), Mansouri et al. (2021), Cui (2022), Gupta (2022), Vasiu and Bratu (2022), Azaare et al. (2023), and Suttipun (2023) highlighted the increasing relevance of ESG considerations in financial performance and the innovative potentials of fintech in redefining corporate sustainability practices. Nonetheless, this study served as the first to underscore the role of Scope 3 carbon emissions within the context of fintech and market performance. This study was deemed timely and relevant following the growing global focus on Sustainable Development Goals (SDGs). Theoretically, this study's findings enriched the current literature on fintech and ESG, expanding the narrow focus of existing ESG metrics to a broader, more encompassing, and often significant Scope 3 carbon emissions.

Moreover, this study's findings would substantially benefit policymakers, investors, and stakeholders in the United States, contributing to the country's SDG commitments by promoting a more sustainable financial ecosystem. The application of advanced statistical techniques to isolate the impact of Scope 3 emissions on market performance, controlling for the effects of various confounders, produced a more precise attribution of market responses to a firm's indirect environmental impact. Through the quantification of the impact of Scope 3 carbon emissions, this study's findings highlighted the need for

regulatory frameworks that mandate the disclosure of full-spectrum ESG metrics, encouraging transparency and accountability. This study also presented a benchmark in reporting Scope 3 carbon emissions, establishing a precedent for comprehensive ESG reporting that can potentially become a standard industry practice. Based on this study's findings, firms can formulate and implement effective strategies to minimise Scope 3 carbon emissions in order to boost their market performance and contribute to a more sustainable global ecosystem. Focusing on the sustainable development within the industry, this study also outlined the significant role of fintech in driving innovations for lower Scope 3 carbon emissions. This study's findings on the financial implications of Scope 3 carbon emissions would prompt investors and stakeholders to actively engage in proactive dialogues about sustainability practices, driving broader changes to the industry. Additionally, the introduction of a more nuanced risk assessment tool in this study would benefit investors in making better-informed decisions in regards to the sustainability profiles of fintech firms.

Overall, this paper is organised as follows: Sect. 2 presents the theoretical background and the development of hypotheses; Sect. 3 describes the study's methodology, data, and sample; Sect. 4 discusses and interprets the study's results; Sect. 5 concludes the study's results and findings and presents key implications of the study and recommendations for future research.

2 Theoretical background and hypotheses

Surprisingly, there have been inconclusive empirical evidence on ESG disclosure practices despite the promising prospects and significance of these practices. Furthermore, there have been mixed findings on the positive influence of ESG compliance on market performance in recent studies (Gillian et al., 2021; Tsang et al., 2022).

The positive influence of sustainable practices has been mainly interpreted with respect to legitimacy theory and stakeholder theory. According to the legitimacy theory, firms that engage in proactive environmental initiatives can gain the needed public validation and trust and enhanced reputation (O'Donovan, 2002). Meanwhile, the stakeholder theory highlights the existence of numerous stakeholders, such as the public, governmental agencies, investors, and suppliers, operating within a complex ecosystem (Huang, 2021). Through strong connections and aligned goals and interests with stakeholders' needs and demands, firms can attain long-term operational sustainability (Huang, 2021). With the growing importance of transparent sustainability disclosures in consideration of stakeholders' expectations for higher market performance, the relationship between these two theories has gained growing research interest. Jensen (2002) and Freeman (2010) underscored the critical importance of ensuring such transparency to gain the much-needed trust from stakeholders and subsequently, to boost firm value. From the perspectives of these two prominent theories, Minutolo et al. (2019) revealed the positive relationships of ESG disclosures, firm value, and operational efficiency.

Through the adoption of fintech or collaboration with fintech firms, commercial banks achieve improved market performance, suggesting the symbiotic relationship between traditional banking and fintech (Xu et al., 2022). Focusing on fintech innovations, comparative studies on Islamic and conventional banking systems have demonstrated how fintech firms often outperform traditional banking models, particularly in specific regions like the MENA, highlighting the global market appeal of fintech (Kharrat et al., 2024). Fintech startups in emerging markets have effectively targeted underserved demographics, including the unbanked, through strategic initiatives that promote social inclusion and improve market performance (Atayah et al., 2024). Unlike their traditional counterparts, fintech firms are characterised by their operational efficiency, driven by digital innovation and process optimisation, which is the key contributor to their significant market performance (El Khoury et al., 2022).

Findings on the fintech firms' performance metrics surpassing that of their non-fintech counterparts have been consistently reported in various studies on the market dynamics between fintech firms and traditional (non-fintech) firms. This consistent pattern may be due to the adoption of advanced technologies in fintech firms, such as artificial intelligence, blockchain, and data analytics, which streamline their operations and reduce operational costs, resulting in enhanced customer service (Gil-Corbacho et al., 2023). Furthermore, the adoption of a more customer-centric approach in fintech firms, including personalised service delivery and intuitive digital interfaces, has elevated customer satisfaction and loyalty, boosting their market share and profitability (Kostin, et al., 2022). In addition, firms have the capacity to make use of growth opportunities from the potential challenges encountered through their strategic adaptability in accordance to the constantly changing market trends and regulatory requirements (Kharrat et al., 2024). Despite the increasingly intense competition, the industry continues to demonstrate remarkable success and resilience in securing venture capital and equity investments, particularly in the emerging markets, which have propelled growth and market performance (Kadam & Sethi, 2020). Collaborations between fintech financial firms and traditional banks have created a mutually beneficial environment that makes use of the strengths of both entities, expanding customer bases and enhancing service offerings (Tsanis & Stouraitis, 2022).

Regulatory requirements have also played a pivotal role in fostering innovations within the fintech domain. Policies designed to encourage experimentation have facilitated the rapid development and deployment of fintech solutions, which have further boosted the market success (Mishra, 2023). Moreover, fintech firms have demonstrated their capabilities of penetrating the international markets with scalable digital platforms and innovative payment solutions that transcend geographic boundaries—these firms clearly outperform their traditional counterparts (Sangsavate et al., 2019). The operational models of fintech firms, which integrate both sustainability and social impact, have enhanced their market performance and boosted more investments and patronage from a growing segment of socially conscious consumers and investors (Regina et al., 2021). The traditional banking industry is prompted to take on digital transformation following the emergence of fintech, pushing banks towards innovation and

digitalisation. With all these advancements, the digital orientation of fintech firms has significantly boosted their market standing (Dhiaf et al., 2024).

Despite the critical economic challenges following the COVID-19 pandemic, fintech firms display remarkable resilience—they have successfully maintained their operational continuity and capitalising on the accelerated digital transformation across industries (Toumi et al., 2023). An analysis of market sentiment derived from fintech revealed a positive relationship between public perception and financial performance—this reflects the significance of reputation management in the success of the industry (Sethi & Kadam, 2020).

These prior studies highlighted the competitive advantages of fintech firms over traditional financial institutions, driven by technological innovations, customer-centric approaches, and strategic adaptability in the evolving financial landscape. With that, the following hypothesis was proposed for testing in this study:

H1 With all other factors being equal, fintech financial firms display higher market performance than that of non-fintech financial firms.

Studies on the ESG performance of fintech firms have identified these firms as leading proponents of sustainability. Furthermore, a review of key studies revealed the adoption of an eco-friendly orientation in fintech firms. With digital-first operations, fintech firms undoubtedly display a lower carbon footprint, which then calls for fewer physical infrastructures and yields lower carbon emissions (Miah et al., 2021). Furthermore, the operational efficiency of fintech firms exhibit positive influence on their green total factor productivity (Hu & Li, 2023). Through fintech, the adoption of sustainable practices for lower greenhouse gas emissions is highly plausible across the financial industry (Ashta, 2023).

Muganyi et al. (2021) highlighted the relationships of green finance, fintech, and environmental protection in China and discussed the commitment of the industry to deliver better environmental outcomes. Likewise, Du et al. (2022) emphasised the promising prospects of fintech in improving the ESG performance of firms by addressing internal financing constraints and optimising external fiscal incentives. Meanwhile, Pawlowska et al. (2022) presented significant insights on the significant contributions of fintech in sustainable development and acknowledged how the innovative financial solutions of fintech align with SDGs. Tariq et al. (2022) supported these findings and presented evidence on the positive impact of digital finance and financial inclusion, as characterised by fintech, on environmental sustainability within the Asian context. In a more recent study, Piao et al. (2023) highlighted the environmental commitment of fintech firms in regards to China's green credit development. Focusing on the South Asian region, Zhang et al. (2023) demonstrated the influence of fintech extending beyond the financial markets, promoting broad-based economic sustainability and environmental protection. Moreover, a shift towards sustainable energy consumption patterns following the dynamic impact of fintech on energy consumption further reinforces their positive environmental influence (Afjal

et al., 2023; Xue et al., 2022) presented similar views and postulated how fintech serves as a catalyst in corporate green technology innovations, propelling firms to adopt greener practices.

Based on the findings of these prior studies, it is evident that fintech firms, with their innovative financial and investment solutions, are generally more sustainable and display more favourable ESG profiles than that of their traditional counterparts. Studies have presented solid evidence on the role of fintech firms as environmental stewards, indicating their forefront position in aligning financial services with SDGs. Thus, the following hypothesis was proposed for testing:

H1 When other factors are held constant ("Ceteris paribus"), fintech financial firms display lower greenhouse gas emissions than that of non-fintech financial firms.

There have various arguments on the moderating effect of fintech on the influence of ESG performance on the market performance of firms. However, most studies have postulated the positive impact of integrating fintech in ESG strategies on the market performance of firms.

Many studies have expressed initial concerns on the perceived risks of data security and privacy following the integration of fintech in ESG performance (Toumi et al., 2023). Furthermore, with the advancements of digitalisation, there are higher risks of cyberattacks and data breaches within the domain of financial services, which have weakened the public trust and market performance of participating firms. The need for large data centres to operate fintech services require substantial consumption of energy, which can be an environmental concern (Wang et al., 2023).

Meanwhile, certain studies presented a neutral stance on the relationship between fintech and firms' ESG performance and noted the substantial influence of specific ESG factors under consideration instead (Atayah et al., 2024). For example, enhanced transparency and compliance help fintech firms to enhance the "governance" aspect, but the influence of fintech on the "environmental" and "social" aspects may not be distinct without deliberate policy and strategy alignment.

In most cases, fintech is associated with significant and positive impacts. Innovations like artificial intelligence and blockchain promote more efficient energy consumption and resource management, which further strengthen the participating firms' commitment to environmental stewardship (Dkhili, 2023). Fintech can potentially democratise access to financial services with respect to the social component of ESG, resulting in enhanced societal welfare and financial inclusion. As a result, the participating firms can enhance their market valuation with respect to the growing demand of investors for socially responsible investment opportunities. As for the environmental component of ESG, fintech promotes the reduction of paper-based processes and the need for physical infrastructures, resulting in lower carbon emissions (Siddik et al., 2023).

Furthermore, fintech promotes accountability and transparency, which contribute to the "governance" aspect. Through fintech, the use of advanced

analytics and real-time reporting improves the processes of decision-making, risk management, and regulatory compliance, which contribute to a more robust governance structure for the participating firms (Chams et al., 2021). As a catalyst of sustainable innovations, fintech also boosts the development and adoption of green technologies that open up to new market opportunities and revenue streams. This is particularly relevant for firms that intend to adhere to sustainable practices and achieve competitive advantages in a competitive marketplace (Wang & Yang, 2023).

In view of the above, the relationship between fintech and ESG yields predominantly positive impact on firm performance. The moderating role of fintech with respect to strategic ESG goals is realised given its advantages of promoting sustainable business practices (Wang et al., 2023). The inherent attributes of agility and innovation enable the needed adaptability for fintech firms to deal with the changing demands of investors and regulatory requirements related to sustainability. Firms that successfully take advantage of fintech in their ESG strategies are often associated with enhanced brand reputation, investor confidence, and market competitiveness, which contribute to superior market performance (Atayah et al., 2024). Acknowledging the challenges and neutral impacts involved, the industry sentiment and current literature share a similar notion on the positive connections involving fintech, ESG performance, and market success, which establishes fintech as a significant enabler of sustainable development in the corporate world (Chams et al., 2021; Dkhili, 2023).

Considering the focus of the current study on the direct impact of Scope 3 carbon emissions, one of the sustainability metrics, on market performance and the lack of findings on the moderating effect of fintech on this particular relationship, the following hypothesis was proposed for testing in this study:

H1 With all other factors being equal, fintech moderates the relationship between Scope 3 carbon emissions and market performance

3 Methodology, data, and sample

Addressing the gaps in literature on how fintech and non-fintech financial firms contribute to Scope 3 carbon emissions, market performance, and carbon footprints, this study opted to collect related data within the time frame of 2010 to 2022 from credible indices and databases, including the Nasdaq Financial Technology Index (KFTX) and Bloomberg, to examine the relationship between Scope 3 carbon emissions and market performance and the moderating effect of fintech on this particular relationship. This timeframe was specifically selected due to the emergence of notable advancements in financial technologies and the economic crises following the COVID-19 pandemic. Firms with missing information on Scope 3 carbon emissions and Tobin's Q were excluded from the study. In order to address potential outlier issues, all variables were 1% and 99% winsorized accordingly.

3.1 Dependent variable

Tobin's Q, which represented the market viability of fintech and traditional financial firms in this study, served as the dependent variable and was computed based on Bloomberg Inc.'s established method. Adding to that, this study included Scope 3 carbon emissions, as described by Bloomberg—normalised by each firm's total revenue. With that, the analysis produced the outcomes of the market performance in regards to a firm's indirect environmental impact.

3.2 Independent variables

Focusing on this study's aim of examining how fintech, environmental disclosures pertaining to Scope 3 carbon emissions, and market performance are interrelated, H1 (market performance of fintech versus non-fintech financial firms), H2 (Scope 3 carbon emissions of fintech versus non-fintech financial firms), and H3 (moderating effect of fintech) were proposed for testing in this study. The analysis was intended to provide a more nuanced understanding of the complex dynamics between fintech firms and market performance in terms of Tobin's Q and Scope 3 carbon emissions. The analysis also included interaction variables to unravel the impact of incorporating fintech on the complex relationship between Scope 3 carbon emissions and market performance.

3.3 Firm-level control variables

Several firm-level control variables, such as the presence of a female CEO, the weighted average cost of capital (WACC), firm age, involvement of Big 4 audit firms, business industry classification system (BICS) segments, and ownership structure of firm, were taken into account. The inclusion of these control variables served to improve the robustness of the results (Atayah et al., 2024). Through this approach, the specific impact of each factor and control for potential confounding elements can be distinguished for more accurate interpretations and conclusions.

3.4 Fixed effect control

Over the years, the sustainability disclosures among firms in the United States have shown gradual improvements. Considering that, time-fixed effects were taken into account for unobserved time-variant factors. This was deemed particularly pertinent given the study's timeframe spanning from 2010 to 2022. Focusing on the need for a multifaceted analysis on the complex interactions involved, this study employed a comprehensive approach of using both OLS and dynamic GMM regression methods with rigorous statistical controls to derive credible and robust results for interpretations. This multi-pronged analytical framework produced more nuanced understanding and well-supported conclusions on the

interrelationships of financial performance, sustainability disclosures, and market evaluations.

4 Results and discussion

4.1 Descriptive statistics

The inclusion of outliers contributed to the substantial variability in the overall dataset. In particular, firm age recorded the highest standard deviation, followed by the BICS segments. Interestingly, the values of WACC were predominantly positive. Only about 32% of these firms reported experiencing financial losses in the past 13 years. Based on these observations, it can be assumed that these firms are generally not financially distressed, suggesting their stable financial stance in the market. However, nearly all fintech firms, on average, has 1.39*** recorded higher Tobin's Q than non-fintech financial firms, as shown in Table 1. Fintech firms exhibited lower carbon emissions and better market performance, which supported both H1 and H2.

4.2 Multivariate analyses

4.2.1 Impact of fintech on market performance

This study opted for pooled OLS regression to address issues of estimate bias and multicollinearity, discrete variability, and the temporal relationship between independent and dependent variables. The first model served as the baseline. Any fixed effects were excluded for the case of the second model, whereas the case of the third model ensured no clustering of standard errors and the exclusion of time-fixed effects. Referring to Table 2, based on the results of the case of the first baseline model ($\beta = 1.194, t = 5.259, \alpha = 0.00$, one-tailed), the market performance of fintech financial firms surpassed that of non-fintech financial firms. In other words, H1 was supported.

In particular, fintech financial firms appeared to be valued higher than the non-fintech financial firms during the COVID-19 pandemic. Prior studies reported similar observations and attributed the superior economic growth of fintech firms, as compared to non-fintech firms, to various factors like mergers and acquisitions, governance structures, operational efficiency, and ESG disclosures. Nonetheless, it should be noted that these prior studies focused on the pre-pandemic period (Najaf et al., 2023a), whereas the current study explored the market performance of fintech firms during the pandemic period.

4.2.2 Impact of fintech on scope 3 carbon emissions

This study employed the OLS regression model to examine the Scope 3 carbon emissions of fintech and non-fintech financial firms. Likewise, the first model served

Table 1 Descriptive statistics of the test variables

Variables categories	Variable name	Variable type	Panel A: basic statistics for full sample					Panel B: mean difference: *Fin* vs *non-fin*		
			Obs.	Mean	Std. Dev.	Min	Max	*Fin*	*Non-Fin*	Difference (*t-stat*)
Dependent	*Tobin's Q*	Continuous	979	2.541	2.151	0.945	13.044	3.76	2.36	1.39***
Independent	*Scope 3*	Continuous	841	2.995	2.646	−7.601	10.528	5.16	4.15	(2.53)***
Firm level control	*BICS*	Continuous	979	3.281	2.594	0	13	2.07	3.45	(1.38)***
	WACC	Continuous	979	8.448	2.23	2.526	15.5	8.34	8.46	0.12
	Age	Continuous	979	32.78	27.568	0	115	31.47	32.96	(1.49)
	Big4	Dichotomous	979	0.969	0.172	0	1	0.97	0.96	−0.01
	CEO	Dichotomous	979	0.064	0.246	0	1	0.08	0.06	0.02
	Loss	Dichotomous	979	0.118	0.323	0	1	0.13	0.11	0.02
	Holding	Dichotomous	979	0.398	0.49	0	1	0.43	0.39	0.05

The superscript asterisk *** denote statistical significance at the 1% levels, respectively

Table 2 Regression analysis of fintech on market performance –first hypothese

variable	Market performance		
	Model 1	Model 2	Model 3
	Baseline OLS reg	Without fixed effect.	Without fixed effect and se cluster
Fin	**1.194***	**1.196***	**1.196***
	[5.259]	**[5.239]**	**[6.335]**
CEO	0.280	0.279	0.279
	[0.861]	[0.863]	[1.113]
WACC	0.288***	0.274***	0.274***
	[8.817]	[8.443]	[9.020]
Loss	0.233	0.215	0.215
	[1.153]	[1.068]	[1.072]
Age	0.002	0.002	0.002
	[0.995]	[1.080]	[0.865]
Big4	−0.653**	−0.634*	−0.634*
	[−1.975]	[−1.922]	[−1.682]
BICS	−0.157***	−0.165***	−0.165***
	[−7.373]	[−7.727]	[−6.012]
Holding	0.010	0.022	0.022
	[0.076]	[0.172]	[0.174]
Constant	0.949**	1.115**	1.115**
	[2.125]	[2.520]	[2.375]
SE cluster	Firm	Firm	No
Year fixed effect	Yes	No	No
Obs.	979	979	979
R^2	21.67%	21.20%	21.51%

$$MarketPerformance_{it} = \alpha + \beta_i Fin_{it} + \sum_{i=1}^{n=7} Controls_{it} + \varepsilon_{it} \quad (1)$$

Market Performance$_{it}$ is a continuous variable as a proxy by Tobin's Q of a firm(i) in year (t). *Fin$_{it}$* is a dummy variable where Fin="1" if Fintech firm, and "0" otherwise. The *Controls$_{it}$* is a list of control variables (*CEO, WACC, Loss, Age, Big4, BICS & Holding*). Also, we take into account unknown year fixed effects. We allow for the clustering of error terms at the firm level. The variance inflation factors (VIF) are well below the tolerance level (VIF<5) and the superscript asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

The bold represent the significant coefficients for focused independent variables

as the baseline, while any fixed effects were excluded for the case of the second model. Meanwhile, the third model excluded the clustering of standard errors and time-fixed effects. Referring to Table 3, based on the results of the case of the first baseline model ($\beta = -0.935$, $t = -4.389$, $\alpha = 0.00$, one-tailed), the adoption of an eco-friendly orientation was found more apparent among fintech financial firms, as compared to non-fintech financial firms. With that, H2 was supported, after the adjustment of firm-level control variables.

Table 3 Regression analysis of fintech on carbon emission - second hypothesis

Variables	Scope		
	Model 1	Model 2	Model 3
	Baseline OLS Reg	Without Fixed Effect.	Without Fixed Effect and SE cluster
Fin	**− 0.935***	**− 0.930***	**− 0.930***
	[− 4.389]	**[− 4.367]**	**[− 3.570]**
CEO	0.461	0.477	0.477
	[1.480]	[1.540]	[1.396]
WACC	0.002	0.001	0.001
	[0.049]	[0.022]	[0.020]
Loss	0.334	0.288	0.288
	[1.166]	[1.015]	[1.035]
Age	0.012***	0.012***	0.012***
	[3.413]	[3.457]	[3.828]
Big4	− 0.065	− 0.040	− 0.040
	[− 0.102]	[− 0.064]	[− 0.075]
BICS	0.063	0.060	0.060
	[1.629]	[1.568]	[1.534]
Holding	− 0.018	− 0.011	− 0.011
	[− 0.104]	[− 0.064]	[− 0.063]
Constant	4.454***	4.521***	4.521***
	[5.898]	[6.061]	[6.899]
SE cluster	Firm	Firm	No
Year Fixed effect	Yes	No	No
Obs.	841	841	841
R^2	5.17%	4.94%	4.83%

For testing our second hypothesis, we are following baseline model:

$Scope_{it} = \alpha + \beta_i Fin_{it} + \sum_{i=1}^{n=7} Controls_{it} + \varepsilon_{it}$ (2) $Scope_{it}$ is a continuous variable as a proxy by scope3 emission of a firm(i) in year (t). Fin_{it} is a dummy variable where Fin= "1" if Fintech firm, and "0" otherwise. The $Controls_{it}$ is a list of control variables (*CEO, WACC, Loss, Age, Big4, BICS & Holding*). Also, we take into account unknown year fixed effects. We allow for the clustering of error terms at the firm level. The variance inflation factors (VIF) are well below the tolerance level (VIF<5) and the superscript asterisks ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively

The bold represent the significant coefficients for focused independent variables.

In other words, fintech firms exhibit lower carbon emissions, yielding positive contributions to the environment. This particular observation was deemed particularly noteworthy as no previous studies explored this particular relationship. The significance of
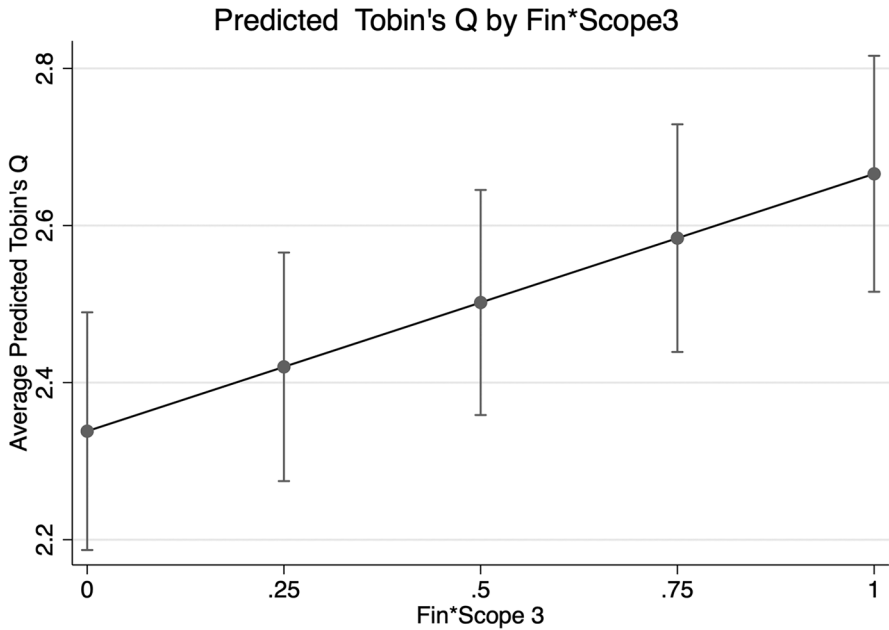
Fig. 1 Margin plots

this aspect becomes increasingly evident given the prominent shift of the global focus towards sustainability.

4.2.3 Moderating effect of fintech on the relationship between scope 3 carbon emissions and market performance

The marginal regression results in Figure 1 revealed a compelling narrative about the relationship between Scope 3 carbon emissions and market performance (Tobin's Q) of fintech financial firms. The x-axis distinctly plotted the interaction term "FinTech*Scope 3 Emission" at margin points of 0, 0.05, 0.5, 0.75, and 1, whereas the y-axis represented the predicted Tobin's Q, which served as a proxy of market performance.

The results clearly showed an upward slope across these specified margins. The average predicted Tobin's Q showed consistent increase from the margin point of 0 to the margin point of 1, suggesting two plausible rationalisations that led to improved market performance (Tobin's Q): fintech financial firms either increased their Scope 3 carbon emissions or displayed better management of their Scope 3 carbon emissions.

In other words, fintech financial firms adopt an eco-friendly orientation and at the same time, possess the capability of translating their sustainable practices into competitive advantages in the marketplace. Firms that effectively manage their indirect emissions are more favourably viewed by investors and stakeholders—they are generally perceived to be more sustainable and forward-looking. Favourable perceptions

Table 4 Results of moderating effect–third hypothesis

Variables	Market performance		
	Model 1	Model 2	Model 3
	Baseline OLS reg.	Without fixed effect.	Without fixed effect and SE cluster
Fintech*scope3	**0.274*****	**0.276*****	**0.276*****
	[4.418]	**[4.429]**	**[6.302]**
(1-Fintech)*scope3	**− 0.003*****	**− 0.000*****	− 0.000
	[− 4.080]	**[− 4.200]**	[− 1.437]
CEO	0.279	0.271	0.271
	[0.833]	[0.812]	[1.018]
WACC	0.309***	0.296***	0.296***
	[8.215]	[7.911]	[8.938]
Loss	0.341	0.328	0.328
	[1.511]	[1.461]	[1.514]
Age	0.004*	0.004*	0.004
	[1.795]	[1.871]	[1.518]
Big4	− 0.691*	− 0.690*	− 0.690*
	[− 1.887]	[− 1.895]	[− 1.670]
BICS	− 0.151***	− 0.158***	− 0.158***
	[− 6.054]	[− 6.344]	[− 5.199]
Holding	− 0.002	0.012	0.012
	[− 0.013]	[0.092]	[0.092]
Constant	0.774	0.926*	0.926*
	[1.564]	[1.891]	[1.815]
SE cluster	Firm	Firm	No
Year Fixed effect	Yes	No	No
Obs.	841	841	841
R^2	24.37%	23.71%	23.79%

For testing our third hypothesis, we are following baseline model:

$Market\,Performance_{it} = \alpha + \beta_i Fin * Scope_{it} + \beta_j(1 - Fin) * Scope_{it} + \sum_{i=1}^{n=7} Controls_{it} + \varepsilon_{it}$ (3)

Where Fin*Scope$_{it}$ is the interaction variable of Fin and Scope 3 emission, and (1−Fin)*Scope$_{it}$ is the interactionof non Fintech firms and Scope3 emission. The Tobin's Q is a proxy for the market performance, remainingall the explanatory variables are the same as Table 4, Eq. 1. ***< 0.01, **< 0.05 and *< 0.1.

The bold represent the significant coefficients for focused independent variables.

can boost the market valuation and performance of such firms. The current study's results clearly demonstrated the symbiotic relationship between fintech firms' environmental considerations and their market standing.

Prior studies demonstrated the negative relationship between carbon emissions and market performance. However, the current study found otherwise. With that, OLS regression was performed to examine the moderating effect of fintech on

the relationship between Scope 3 carbon emissions and market performance. As previously shown in Table 3, fintech financial firms under study were found to be more environmentally conscientious. The same layout of Tables 2 and 3 was applied on the structure of regression results in Table 4.

Taking the case of the first baseline model, the results showed that fintech financial firms made significant efforts of reducing their carbon emissions to improve the environmental quality by 27% ($\beta = 0.274, t = 4.418, \alpha = 0.00$, one-tailed). In the same regard, non-fintech financial firms contributed only 3% ($\beta = 0.003, t = -4.080, \alpha = 0.00$, one-tailed). These results suggested the moderating effect of fintech financial firms' business practices in mitigating carbon emissions, which were further reaffirmed by the outcomes of Model 2 and Model 3.

This study enriched the current literature on how technologically advanced financial institutions like FinTech firms are more attuned to environmental concerns. Fintech financial firms aim to reduce their carbon footprints and at the same time, meet the needs and demands of investors and stakeholders for their approval, particularly investors from the United States who are more in favour of fintech firms over non-fintech firms. This study highlighted the significant roles of tech-savvy financial firms in shaping a more sustainable future. Strategic approaches and strategies of reducing carbon emissions are highly valuable and sought after among investors and shareholders.

4.2.4 Control for endogeneity and robustness test (dynamic GMM)

Arellano and Bond (1991) introduced the GMM approach, which was further developed by Arellano and Bover (1992) and Blundell and Bond (1998). This particular approach was employed in this study to address the possible endogeneity issues and ensuring more precise parameter estimates. Accordingly, the capability of the GMM approach in dealing with endogeneity issues that often confound the multivariate analysis is substantiated. The dynamic system GMM model expressed in Equation (2) was examined. Additionally, this study opted for Blundell and Bond's two-step system GMM model to further tackle endogeneity issues on all three hypotheses. In addition, this study's option of switching from OLS to GMM served as a robustness test.

The obtained results in Table 5 (Models 1–3) were found consistent with this study's initial estimations. Besides that, the results of diagnostic tests confirmed the absence of autocorrelation and validated the appropriateness of the instrumental variables used. Based on the obtained results, it can be concluded that fintech financial firms clearly outperform non-fintech financial firms in terms of Scope 3 carbon emissions and market performance. Moreover, Scope 3 carbon emissions exert positive impact on the market performance of fintech financial firms. In other words, fintech financial firms display better environmental engagements than non-fintech financial firms, which can be attributed to two plausible rationalisations. Firstly, there may be added incentives for fintech financial firms to pro-actively engage in ESG activities. Secondly, fintech financial firms may be inherently more committed to ESG disclosures.

Table 5 Control for endogeneity (System GMM)

Hypothesis	Market performance Model 1	Scope Model 2	Market performance Model 3
	H1	H2	H3
Fin	**1.437***	**− 0.557*****	
	[0.73]	**[0.20]**	
Fintech*scope			**0.331****
			[0.14]
(1-Fintech)*scope			**− 0.004*****
			[0.03]
l.Market performance	0.910***		0.917***
	[0.06]		[0.04]
l.Scope		0.699***	
		[0.07]	
CEO	− 1.202**	− 0.705	− 0.057
	[0.60]	[1.06]	[0.48]
WACC	− 0.006	0.157**	0.017
	[0.04]	[0.07]	[0.04]
Loss	− 0.645**	0.083	− 0.683***
	[0.26]	[0.43]	[0.23]
Age	0.022**	0.035*	0.006
	[0.01]	[0.02]	[0.01]
Big4	1.162*	− 0.248	0.163
	[0.71]	[0.87]	[0.57]
BICS	− 0.119*	0.271**	− 0.048
	[0.07]	[0.11]	[0.06]
Holding	− 0.223	0.335	0.039
	[0.15]	[0.24]	[0.16]
Constant	− 1.007	− 1.490	− 0.077
	[0.90]	[1.10]	[0.76]
Observations	775	657	685
Wald χ2	9540.7	13707.9	1916.1
No. of instruments	91	91	91
No. of groups	132	114	117
Arellano-bond: AR(1)	0.003	0.833	0.001
Arellano-bond: AR(2)	0.000	0.014	0.000
Sargan test (*p*-val)	0.014	0.000	0.000

We estimate the following Models:

For Model 1:

$$MarketPerformance_{it} = \alpha + \beta_i l.MarketPerformance_{it} + \beta_j Fin_{it} + \sum_{i=1}^{n=7} Controls_{it} + \varepsilon_{it}$$

For Model 2:

$$Scope_{it} = \alpha + \beta_i l.Scope_{it} + \beta_j Fin_{it} + \sum_{i=1}^{n=7} Controls_{it} + \varepsilon_{it} \quad (5)$$

For Model 3:

$$MarketPerformance_{it} = \alpha + \beta_i l.MarketPerformance_{it} + \beta_i Fin * Scope_{it} + \beta_j (1 - Fin) * Scope_{it} + \sum_{i=1}^{n=7} Controls_{it} + \varepsilon_{it} \quad (6)$$

5 Conclusion

The effects of ESG factors on firm-related outcomes have gained increasing attention in both scholarly discussions and policy agendas. However, the market performance of fintech firms, particularly in regards to their adherence to reporting Scope 3 carbon emissions, has remained underexplored. The current study enriched this discourse by examining stock performance outcomes linked to environmental emissions based on the data of 979 financial firms from 2010 to 2022. As for model prediction, both OLS and dynamic GMM regression methods were employed to control for both heterogeneity and endogeneity issues.

The study unravelled how Scope 3 carbon emissions can affect both fintech and non-fintech financial firms. The obtained results and findings were deemed pertinent given the growing importance of such disclosures for stakeholders in decision-making, especially investors. The study also observed the positive relationship between Scope 3 carbon emissions and market performance for the case of fintech financial firms given their comparatively lower environmental impact following the adoption of an eco-friendly orientation. However, the same relationship was found negative for the case of non-fintech financial firms. Adding to that, the study proved how fintech financial firms outperform non-fintech financial firms in leveraging Scope 3 carbon emissions for market performance. With respect to the supporting theories, these observations were found consistent across different models and methods.

With that, this study presented several key implications. Firstly, this study demonstrated the need for a sustainable financial system framework to take into account the reporting of carbon emissions. Secondly, this study highlighted the need for a nuanced discussion on why fintech firms capitalise on these ESG criteria. Thirdly, this study underscored the importance of integrating ESG components into fintech firms' strategic plans. Fourthly, the study prompted the need for policymakers to critically consider the quality of ESG disclosures, which are often cited as a point of variance. Besides that, considering the relative infancy of fintech firms, credible environmental disclosures can certainly increase trust among investors. Last but not least, the study presented valuable ESG-related data for prospective investors in making better-informed investment decisions. More importantly, the study highlighted the significance of ESG components in elucidating the financial returns of fintech firms. Therefore, these components should not be overlooked in investment considerations.

Furthermore, it is recommended for future research to explore the role of carbon emissions in determining market performance across different economic sectors. Besides that, the use of a worldwide sample for analysis is recommended

for future research to explore the influence of jurisdictional variations in carbon emission regulations on these relationships.

Declarations

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