



Financial technology and climate risks in the financial market

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ARTICLE INFO

Keywords:

Financial technology
Climate risk
Financial markets
Investment efficiency
Information asymmetry

ABSTRACT

This study explores the role of financial technology (Fintech) in influencing climate risks within financial markets by introducing the Climate Risk Index in Financial Markets (CRIFM), which measures the return differences between green and traditional markets. Through theoretical analysis and empirical research, we find that the development of Fintech significantly increases climate risk in financial markets. The research identifies two main pathways: first, Fintech enhances investment efficiency, directing capital more effectively toward high-return green projects; second, it reduces information asymmetry, increasing transparency and trust in green investments. Our findings suggest that Fintech is essential in helping investors identify and evaluate climate-friendly companies, thereby supporting the growth of green investments. Based on these results, we recommend that governments and regulatory bodies actively promote Fintech innovations and their application in green finance to improve market fairness and transparency, ultimately contributing to sustainable development goals.

1. Introduction

The rapid advancement of financial technology (Fintech) has significantly transformed financial markets (Yang et al., 2025). Fintech has enhanced the efficiency and accessibility of financial services and driven the creation of innovative financial products. By utilizing big data analytics, artificial intelligence, and blockchain technologies, Fintech has strengthened financial institutions' risk management, reduced information gaps, and improved investment efficiency (Murinde et al., 2022). Additionally, Fintech has provided individual investors and small to medium-sized enterprises with advanced financial tools and resources, promoting greater market fairness and transparency (Huang et al., 2023; Zhang et al., 2023). As Fintech continues to evolve, financial services are becoming more intelligent, interconnected, and personalized (Gharbi et al., 2023; Xu et al., 2024). This evolution not only changes how traditional financial institutions operate but also impacts the global economy, presenting new regulatory challenges and policy requirements (Chen & Shen, 2024; Dong & Yu, 2023; Zhang, 2022; Xie and Zhu, 2022).

In parallel, the escalating climate crisis has led investors to differentiate between climate-friendly and non-climate-friendly companies. As the environmental and economic effects of climate change become more evident, investors increasingly incorporate Environmental, Social,

and Governance (ESG) criteria into their investment decisions (Avramov et al., 2022; Chen et al., 2023; Liu et al., 2024; Xue et al., 2023). Companies committed to sustainable development and carbon reduction attract significant investment due to their resilience to risks and potential for long-term growth. These climate-friendly enterprises comply with stricter environmental regulations and utilize innovation and technology to create new market opportunities. In contrast, companies that are not climate-friendly face regulatory pressures, declining investor confidence, and financial risks, resulting in substantial capital withdrawals (Flammer, 2021). Consequently, financial markets are increasingly favoring green investments, fostering the growth of renewable energy, clean technology, and green infrastructure. This shift has changed how investors assess risks and returns, significantly influencing the sustainable development of the global economy.

The intersection of Fintech and the growing preference for climate-friendly investments leads to significant and complex outcomes. Fintech's efficient information processing and distribution capabilities allow investors to identify and evaluate climate-friendly investment opportunities more quickly and accurately. This not only directs capital toward companies with sustainable and environmentally responsible strategies but also encourages the development of diverse green financial products, such as green bonds, carbon credits, and sustainable development funds. Furthermore, Fintech applications, especially in big

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<https://doi.org/10.1016/j.irfa.2025.103920>

Received 28 May 2024; Received in revised form 19 December 2024; Accepted 7 January 2025

Available online 9 January 2025

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data and artificial intelligence, enhance the transparency and reliability of companies' environmental performance (Liu et al., 2025a). Real-time monitoring and analysis of environmental data provide investors with a comprehensive understanding of a company's climate actions and effectiveness, reducing information gaps and lowering investment risks (Liu et al., 2025b). Additionally, blockchain technology in Fintech ensures the authenticity and transparency of environmental information, increasing investor confidence in green investments. Smart contracts can automatically enforce investment terms related to environmental performance, ensuring that funds are aligned with sustainability goals.

Overall, the convergence of Fintech advancements and the trend toward climate-friendly investments is guiding global financial markets toward greater sustainability. This transformation not only changes traditional investment strategies and models but also supports the overall greening of the economic system. Fintech plays a crucial role in global efforts to combat climate change and achieve sustainable development goals by facilitating more informed and responsible investment decisions.

The motivation of this study is to explore the impact of fintech on climate risks in financial markets, particularly in the context of the return differentials between green and brown markets. As fintech rapidly evolves, it improves the efficiency of financial markets in information processing and transactions, while also promoting the growth of green investments by enhancing investment efficiency and reducing information asymmetry. However, this process may also lead to an increase in climate risks in financial markets. The study aims to quantify the influence of fintech on green and brown markets through the development of an innovative Climate Risk Index for Financial Markets (CRIFM), providing a new perspective on climate risk in financial markets.

Previous research on the impact of financial technology (FinTech) on financial markets generally falls into three main categories: the relationship between FinTech and traditional banking, the effects of FinTech on the lending market, and the use of FinTech in information processing and trading within financial markets. Firstly, studies examining the relationship between FinTech and traditional banks reveal both complementary and competitive dynamics. Adbi and Natarajan (2023) investigated FinTech's role in supporting micro-entrepreneurship and found that FinTech services significantly enhance savings among impoverished women, especially when combined with traditional bank accounts. This suggests that FinTech and banks work together to promote financial inclusion. On the other hand, Alyakoob et al. (2021) explored how local bank competition influences online marketplace lending and discovered that increased competition from local banks can limit the benefits borrowers receive from marketplace lending. Additionally, Chu and Wei (2024) found that FinTech lending may reduce credit access for high-quality borrowers, lowering the efficiency of credit allocation and negatively impacting social welfare.

Secondly, research on FinTech's impact on the lending market highlights notable changes in borrowing behavior and the structure of credit markets. Balyuk (2023) utilized data from online peer-to-peer lending platforms to demonstrate that FinTech reduces information barriers, thereby expanding credit access for consumers with limited credit histories. Chen et al. (2022) examined small business loans in China and found that FinTech credit reduces sales volatility and lowers the chances of business bankruptcy or closure, indicating that FinTech contributes to the stability of business operations. Furthermore, Gopal and Schnabl (2022) observed that FinTech lenders increased small business loans after the 2008 financial crisis, offsetting the decline in bank lending. In another study, Gopal, Qiao, Strub and Yang, 2024 showed that enhancing online loan portfolio construction can attract institutional investors, fostering platform growth and expanding the lending market.

Lastly, studies on the application of FinTech in information processing and trading demonstrate significant improvements in market efficiency. Avramov et al. (2023) showed that machine learning-based investment signals can generate profits even in markets with high

arbitrage constraints. Chen et al. (2019) analyzed large-scale patent data and highlighted the substantial value that blockchain and other FinTech innovations bring to the financial sector. In the realm of trading, Zhang and Zhang (2024) found that algorithmic trading combined with initial market mispricing can lead to increased market volatility, potentially causing financial bubbles and crashes. Additionally, Ozik et al. (2021) examined the impact of retail investors using FinTech platforms during the COVID-19 pandemic and discovered that retail trading significantly slowed the rise in stock liquidity.

In summary, FinTech significantly influences financial markets through its interactions with traditional banks, its transformation of the lending market, and its enhancements to information processing and trading efficiency. These studies provide a comprehensive foundation for understanding FinTech's role in the modern financial system. However, the specific effects of FinTech on climate risks within financial markets remain underexplored, which this paper aims to address.

This paper makes several key contributions: (1) It introduces the Climate Risk Index in Financial Markets (CRIFM), which measures yield differences between green and brown markets. This index serves as a quantitative tool for assessing climate change impacts on financial markets and provides investors, policymakers, and financial institutions with an effective mechanism for risk assessment. Investors can better identify and manage climate-related investment risks, policymakers can develop targeted environmental regulations, and financial institutions can optimize their investment portfolios to enhance market sustainability and resilience. (2) Through theoretical analysis and empirical research, the study finds that FinTech development significantly increases climate risk in financial markets. FinTech improves information processing and distribution efficiency, enabling investors to quickly and accurately identify and assess investment opportunities in climate-friendly companies, thereby driving up green investments and associated climate risks. (3) The paper explores how FinTech impacts climate risks through two main channels: improving investment efficiency and reducing information asymmetry. Empirical analysis shows that FinTech enhances investment efficiency by directing capital more effectively toward green projects. Additionally, by reducing information asymmetry, FinTech increases market transparency and trust in green investments, further elevating climate risks.

The structure of this paper is as follows: Section 2 provides a theoretical analysis. Section 3 outlines the empirical design and constructs the relevant indicators. Section 4 presents and discusses the empirical results and robustness tests. Section 5 further validates the two channels. Finally, Section 6 offers conclusions and implications.

2. Theoretical analysis

FinTech improves the information processing and distribution mechanisms in financial markets, thereby increasing the relative returns of green markets compared to brown markets. This direct impact manifests as a market preference for green investments, reflected in the rise of the Climate Risk Index in Financial Markets (CRIFM). However, it is important to note that the yield gap between green and brown markets is complex and dynamic, and influenced by a variety of factors such as macroeconomic conditions, policy changes, investor sentiment, and company performance. While FinTech plays a key role in this relationship, these other factors can also significantly impact the relative returns. In the subsequent analysis, we will control for these external variables, including the overall market conditions, by incorporating factors such as the Shanghai Stock Exchange (SSE) Index to ensure a more accurate assessment of the specific impact of FinTech on CRIFM.

Tobin's Q theory emphasizes that a firm's investment decisions depend on the ratio between its market value and the cost of capital (Lang & Stulz, 1994). The development of FinTech significantly enhances investment efficiency, enabling capital to flow more effectively toward high-yield green projects. Specifically, FinTech enhances investment efficiency through the following means: Firstly, by improving

information processing and analysis capabilities. Utilizing big data and artificial intelligence, FinTech increases the accuracy and speed of investment decisions, thereby optimizing resource allocation. This means that investors can more quickly and accurately identify high-potential green investment projects. Secondly, by reducing transaction costs. Through automated trading and disintermediation, FinTech decreases frictions in the investment process, facilitating smoother capital flows. This allows green projects to more easily secure funding, enhancing their market performance. Under this mechanism, improved investment efficiency increases the relative returns of green markets. Thus, the development of FinTech makes green investments more attractive, driving up the CRIFM.

According to the theory of information asymmetry, asymmetries in market information can lead to adverse selection and moral hazard, thereby diminishing market efficiency (Cui et al., 2018). FinTech mitigates information asymmetry through the following mechanisms: Firstly, by enhancing information transparency. Utilizing blockchain and distributed ledger technologies, FinTech increases the accessibility and transparency of information, enabling investors to more accurately assess investment risks. For instance, investors can more clearly understand the environmental impact and long-term returns of green projects, thereby boosting confidence in these investments. Secondly, by accelerating information transmission. FinTech leverages high-speed networks and smart contract technologies to expedite the transmission of information, reducing delays and errors. This enables investors to obtain and process information more promptly, minimizing investment decision errors caused by information asymmetry. Reducing information asymmetry is particularly crucial for green investments, as they often involve higher uncertainties and long-term returns. The development of FinTech makes information about green projects more transparent, allowing investors to better comprehend and evaluate the potential returns of these projects, thereby enhancing the attractiveness of green investments and subsequently increasing CRIFM.

Next, we will describe this process with a more intuitive model. First is the model framework. We define the variables as follows: R_G represents the return rate of the green market index; R_B represents the return rate of the brown market index; $CRIFM = R_G - R_B$ is the Climate Risk Index in Financial Markets; *Fintech* is the measure of FinTech development level. *CRIFM* indicates the yield difference between the green and brown markets; the greater the difference, the larger the market's divergence in expectations for the prospects of the two types of companies, and the higher the climate risk in financial markets.

Assume R_G and R_B are functions of FinTech development and are also influenced by other market factors (such as macroeconomic conditions, policy changes, etc.). To simplify the model, we assume the influence of these other market factors to be constant.

$$\begin{cases} R_G = \alpha_1 + \beta_1 \text{FinTech} + \epsilon_1 \\ R_B = \alpha_2 + \beta_2 \text{FinTech} + \epsilon_2 \end{cases} \quad (1)$$

where α_1 and α_2 are constants representing the effects of other market factors on green and brown market returns, respectively. β_1 and β_2 represent the impact of FinTech development on green and brown market returns. ϵ_1 and ϵ_2 are random error terms. Therefore,

$$CRIFM = (\alpha_1 - \alpha_2) + (\beta_1 - \beta_2) \text{FinTech} + (\epsilon_1 - \epsilon_2). \quad (2)$$

Let $\alpha = \alpha_1 - \alpha_2$ and $\beta = \beta_1 - \beta_2$, then:

$$CRIFM = \alpha + \beta \text{FinTech} + \epsilon. \quad (3)$$

Secondly, the transmission mechanism. The development of FinTech influences *CRIFM* through two mechanistic factors: enhancing investment efficiency and reducing information asymmetry.

$$R_G = h(IA, IE), R_B = k(IA, IE).$$

For the investment efficiency transmission mechanism, assume investment efficiency *IE* is related to the development of *FinTech*:

$$IE = \gamma_1 + \delta_1 \text{FinTech} + \epsilon, \quad (4)$$

where γ_1 is a constant term, δ_1 is the marginal impact of FinTech on investment efficiency, and ϵ is an error term.

The impact of FinTech on investment efficiency is quite intuitive, with existing research providing evidence that FinTech has a positive effect on investment efficiency (Lv & Xiong, 2022). Regarding the impact of investment efficiency on the Climate Risk Index in Financial Markets (*CRIFM*), the overall investment efficiency in the renewable energy sector is relatively low (Zeng et al., 2018). The positive correlation between investment efficiency and green development is also widely recognized in areas such as policy (Yan et al., 2022), ESG reports (Harymawan et al., 2022), CSR disclosures (2022), and climate change (Yu et al., 2023). Thus, we can infer that improved investment efficiency enhances the propensity for green investments, thereby increasing the *CRIFM*:

$$\frac{\partial R_G}{\partial IE} > \frac{\partial R_B}{\partial IE}.$$

Therefore, the effect of investment efficiency on *CRIFM* (is)

$$\frac{\partial CRIFM}{\partial IE} = \frac{\partial R_G}{\partial IE} - \frac{\partial R_B}{\partial IE} > 0.$$

This implies that when FinTech enhances investment efficiency, *CRIFM* increases, indicating that the advantage of green market returns over brown market returns grows, thereby elevating the climate risk index in financial markets.

Regarding the information asymmetry transmission mechanism, suppose information asymmetry (*IA*) is related to FinTech development:

$$IA = \gamma_2 - \delta_2 \text{FinTech} + \epsilon, \quad (5)$$

where γ_2 is a constant term, δ_2 represents the marginal reduction impact of FinTech on information asymmetry, and ϵ is an error term.

The impact of FinTech on reducing information asymmetry is equally intuitive. According to Christopher Ruof's (2023) treatise "The Information Problem Under Fintech," FinTech firstly accelerates information processing speed and efficiency through automation and datafication. Secondly, the decentralization characteristic of FinTech enables market participants to transact and exchange information directly, reducing information asymmetry caused by intermediaries. Finally, despite increasing market complexity and regulatory challenges, FinTech essentially mitigates traditional information asymmetries among market participants by enhancing the accessibility and processing of information. Several studies have confirmed this (Iyengar et al., 2023; Wen et al., 2023). In green investments, information asymmetry is a significant issue. Investors find it challenging to obtain reliable information about companies' social and environmental standards, and fund managers struggle to provide accurate portfolio information to investors (Rhodes, 2010). Information asymmetry evidently increases the propensity for green investments, thus raising the *CRIFM*:

$$\frac{\partial R_G}{\partial IA} < \frac{\partial R_B}{\partial IA}.$$

Therefore, the effect of information asymmetry on *CRIFM* (is)

$$\frac{\partial CRIFM}{\partial IA} = \frac{\partial R_G}{\partial IA} - \frac{\partial R_B}{\partial IA} < 0.$$

This indicates that when FinTech reduces information asymmetry, *CRIFM* increases, meaning the advantage of green market returns over brown market returns grows, thereby raising the climate risk index in financial markets.

Ultimately, returning to eq. (3), we can conclude that β is positive. FinTech positively impacts *CRIFM* by enhancing investment efficiency and reducing information asymmetry. Improved investment efficiency and reduced information asymmetry result in higher green market

returns relative to brown market returns, thus increasing *CRIFM* and reflecting a greater inclination toward green investments, thereby elevating climate risk in financial markets.

3. Empirical design

3.1. Model construction

This study employs the Time-Varying Parameter Vector Autoregression (TVP-VAR) model to investigate the impact of financial technology (Fintech) on the Climate Risk Index in Financial Markets (CRIFM). The TVP-VAR model is particularly well-suited for this analysis due to its ability to capture the dynamic nature of economic relationships over time (Chan et al., 2020; Gabauer & Gupta, 2018). Unlike traditional models with fixed parameters, the TVP-VAR allows the relationships between variables to evolve, accommodating shifts resulting from economic events, policy changes, or technological advancements. This flexibility is crucial given the rapidly evolving landscape of both Fintech and climate-related policies (Banerjee et al., 2024; Darehshiri et al., 2022).

By using the TVP-VAR model, the study can adapt to real-world fluctuations, providing robust insights that are essential for developing effective risk management and policy strategies within sustainable development. The model incorporates key variables such as financial technology and CRIFM, along with additional factors like energy market risks and green electricity markets in subsequent analyses. This comprehensive approach ensures that the analysis remains relevant and accurate even as external conditions change.

The TVP-VAR model's dynamic features enable it to reveal how the influence of Fintech on climate risk evolves over time and under different economic conditions. This capability is particularly advantageous for understanding the nuanced interactions between financial technology advancements and climate-related financial risks. By capturing these time-varying impacts, the model contributes valuable insights to both the financial technology sector and climate risk management, supporting the formulation of strategies that can adapt to ongoing changes in the economic and regulatory environment.

3.2. Index construction

A key contribution of this study is the development of the Climate Risk Index in Financial Markets (CRIFM), which measures climate-related risk factors reflected in asset prices. This approach draws on the established method in asset pricing research where risk factors are constructed as return spreads between portfolios sorted by particular characteristics (e.g., size, value, or other traits in Fama-French models). Here, we use the return differential between “green” and “brown” market indices to capture a climate-related risk factor. Green firms typically benefit from cleaner technologies, lower emissions, and policy support, while brown firms, tied to fossil fuels and higher emissions, face greater climate transition risks. By focusing on their return spread, we aim to isolate climate-related price signals that are not fully explained by overall market conditions, investor sentiment, or macroeconomic cycles.

We employ the Shanghai Environmental Protection Index as the green market index and the Shanghai Energy Index as the brown market index. Daily closing prices are obtained from the WIND database and converted into monthly data using the last trading day of each month. Monthly returns are computed as:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}, \quad (7)$$

where R_t is the return for month t , P_t is the closing price in month t , and P_{t-1} is the closing price in month $t - 1$. After calculating the monthly returns of both indices, we derive the CRIFM by taking the difference between the green and brown market returns:

$$CRIFM_t = R_{\text{green},t} - R_{\text{brown},t}. \quad (8)$$

Constructing factors from return differentials is a standard technique in asset pricing. By examining the green-minus-brown spread, we treat climate characteristics as an economically meaningful dimension, similar to how size and value factors capture persistent, systematic influences on returns. This relative measure helps filter out broad market effects and highlights changes more directly attributable to climate considerations. For instance, if climate policies tighten or investor awareness of carbon risks increases, green stocks may outperform brown stocks, causing the CRIFM to rise. Conversely, if market conditions temporarily favor traditional energy sectors, brown stocks might outperform, lowering the CRIFM.

A positive CRIFM suggests that green assets outperform brown assets, indicating stronger market support for environmentally aligned firms. A negative CRIFM suggests relative market favor for brown assets. The magnitude of CRIFM reflects how sharply investors differentiate between green and brown companies. Over time, CRIFM can provide insights into the evolving climate risk premium in financial markets, assisting researchers, policymakers, and investors in understanding how climate factors influence valuations.

The official stock index for the fintech industry (Code 399699) was published in June 2017, encompassing over 80 stocks. To extend this stock index to the defined timeframe, we selected 55 stocks that span from January 2012 to April 2024 and recalculated the index using the given weights.

Table 1 presents the descriptive statistics of the two key variables, CRIFM and Fintech. The mean of CRIFM is 0.0063 with a standard deviation of 0.0966, indicating a significant degree of fluctuation in the Climate Risk Index over the entire time period. The minimum value is -0.3029 and the maximum value is 0.2967 , suggesting considerable volatility in climate risk within the market, with notable periods of both high and low risk. The skewness is 0.0747 , close to 0, indicating a slight positive skew in its distribution, while the kurtosis is 1.2166 , suggesting a leptokurtic distribution with a sharper peak and heavier tails compared to a normal distribution. The mean of Fintech is 0.0034 with a standard deviation of 0.0733 , reflecting that the growth of financial technology during the study period was not smooth and exhibited significant volatility. The minimum value is -0.2447 and the maximum value is 0.2090 , indicating substantial fluctuations in the Fintech variable throughout the period. The skewness is -0.3548 , showing a moderate negative skew, and the kurtosis is 0.8581 , indicating a leptokurtic distribution, though less pronounced than that of CRIFM.

After seasonal adjustment, the resulting Climate Risk Index in Financial Markets and the fintech index are illustrated in Fig. 1. By comparing these two datasets, we observe a remarkable consistency in trends between the CRIFM and the fintech index, which partially predicts our findings.

4. Empirical results and discussion

4.1. Impulse response analysis

Fig. 2 presents the impulse response functions derived from the Time-Varying Parameter Vector Autoregression (TVP-VAR) model. The analysis employed several key settings to ensure accuracy and reliability. Initially, all indicators underwent a stationarity test, and the appropriate lag order of two was selected using information criteria. To account for overall market volatility, the SSE index was included as a control variable, ensuring that market fluctuations did not distort the assessment of relationships between the specific variables under study. Additionally, to guarantee the stability and reliability of the results, we performed 10,000 Markov Chain Monte Carlo (MCMC) simulations. This extensive simulation process enhanced the precision of parameter estimates and impulse response functions. Furthermore, we analyzed the

Table 1
Descriptive Statistics of CRIFM and Fintech Variables.

Variable	Mean	Standard Deviation	Minimum	Maximum	Skewness	Kurtosis
CRIFM	0.006315	0.09655	-0.3029	0.2967	0.07465	1.2166
Fintech	0.003351	0.07331	-0.2447	0.2090	-0.3548	0.8581

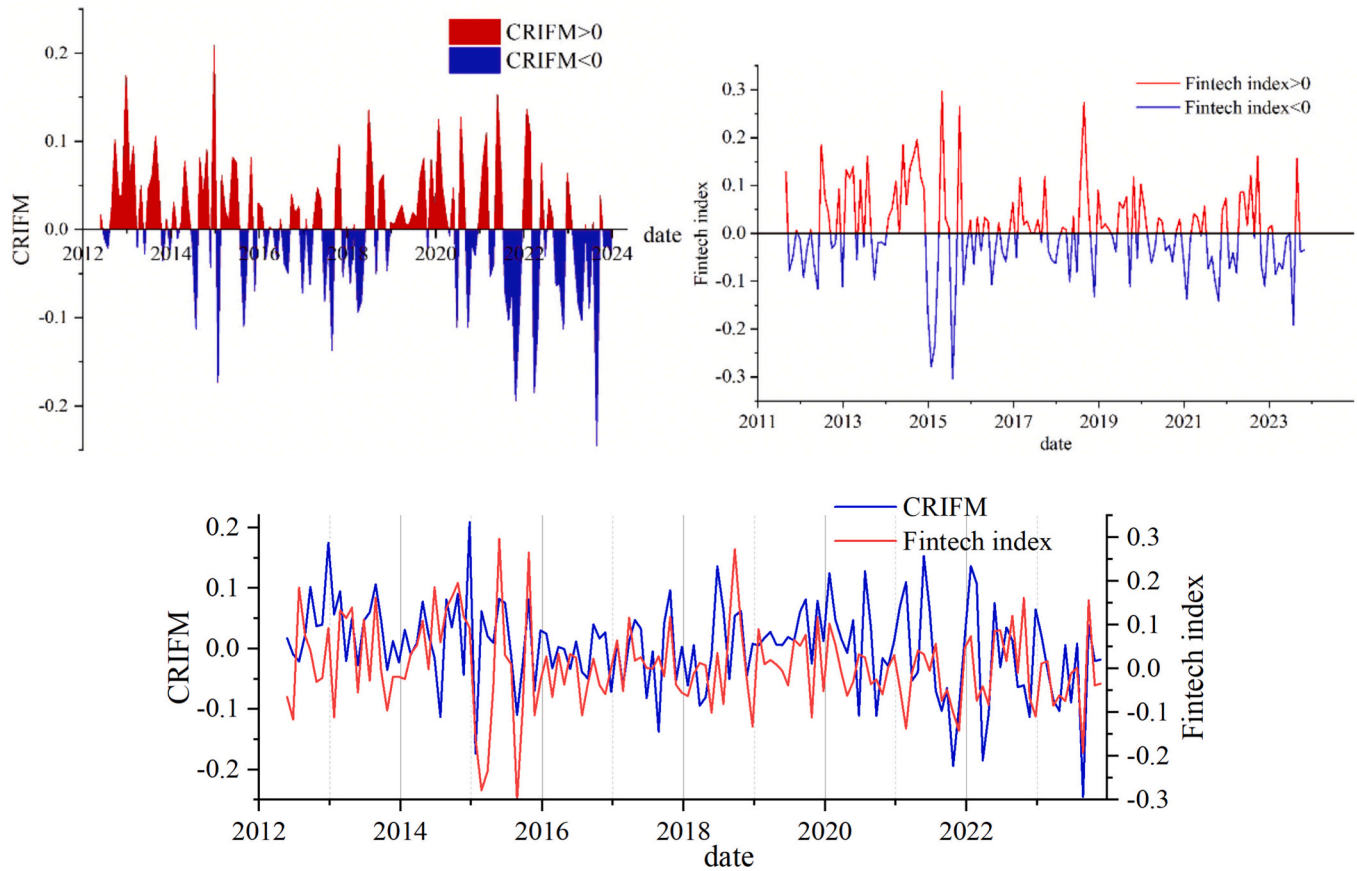


Fig. 1. Trendency of Climate Risk Index in Financial Markets and Fintech Index.

dynamic interactions between variables using one-period, two-period, and three-period lagged impulse responses to capture short-term, mid-term, and long-term effects, respectively. The shocks were observed to dissipate after three periods, indicating that short-term and mid-term effects are more significant. The study period spanned from October 2012 to April 2024.

The middle row of the impulse response graphs reveals that fintech has a substantial positive effect on climate risk in financial markets (CRIFM) both in the short and mid-term. This suggests that advancements in fintech contribute to increased climate risk within financial markets. The positive impact of fintech remains consistent throughout the study period, with the short-term effect showing an upward trend, highlighting the growing influence of fintech. Specifically, a one-unit increase in fintech leads to an approximate 0.0015 rise in climate risk in the short term, indicating that early stages of fintech development significantly affect market risk. Over the mid-term, a one-unit fintech increase results in about a 0.005 rise in climate risk, demonstrating that sustained fintech growth further elevates market risk. These results support the primary conclusion that fintech advancements substantially heighten climate risk in financial markets.

Additionally, several important observations emerge from the analysis. Both fintech development and climate risk in financial markets exhibit significant autocorrelation, meaning that past values of these variables strongly predict their current values. Fintech development

shows a short-term autocorrelation of approximately 0.006, indicating that previous fintech performance significantly influences its current state. Similarly, climate risk in financial markets has short and mid-term autocorrelations ranging from 0.0005 to 0.0015, suggesting that historical fluctuations in climate risk persistently affect its current volatility. Furthermore, fintech development positively impacts the SSE index in the short term. A one-unit increase in fintech leads to an approximately 0.008 rise in the SSE index, highlighting fintech's role in enhancing market confidence and overall performance by optimizing market structure and efficiency. Moreover, climate risk in financial markets also positively influences fintech development. In the mid-term, a one-unit increase in CRIFM boosts fintech development by about 0.005. This indicates a reciprocal relationship where rising climate risks drive fintech innovation and application to address the evolving complexities of the market environment and risk management needs. Table 2 summarizes the primary impulse response effects among the core variables.

4.2. Event-time analysis

To examine how fintech influences climate risk in financial markets at key moments in its development, we focus on three pivotal events: (1) November 2013: Alibaba launches Yu'e Bao. This event marked the introduction of Yu'e Bao, an innovative internet finance product by Ant

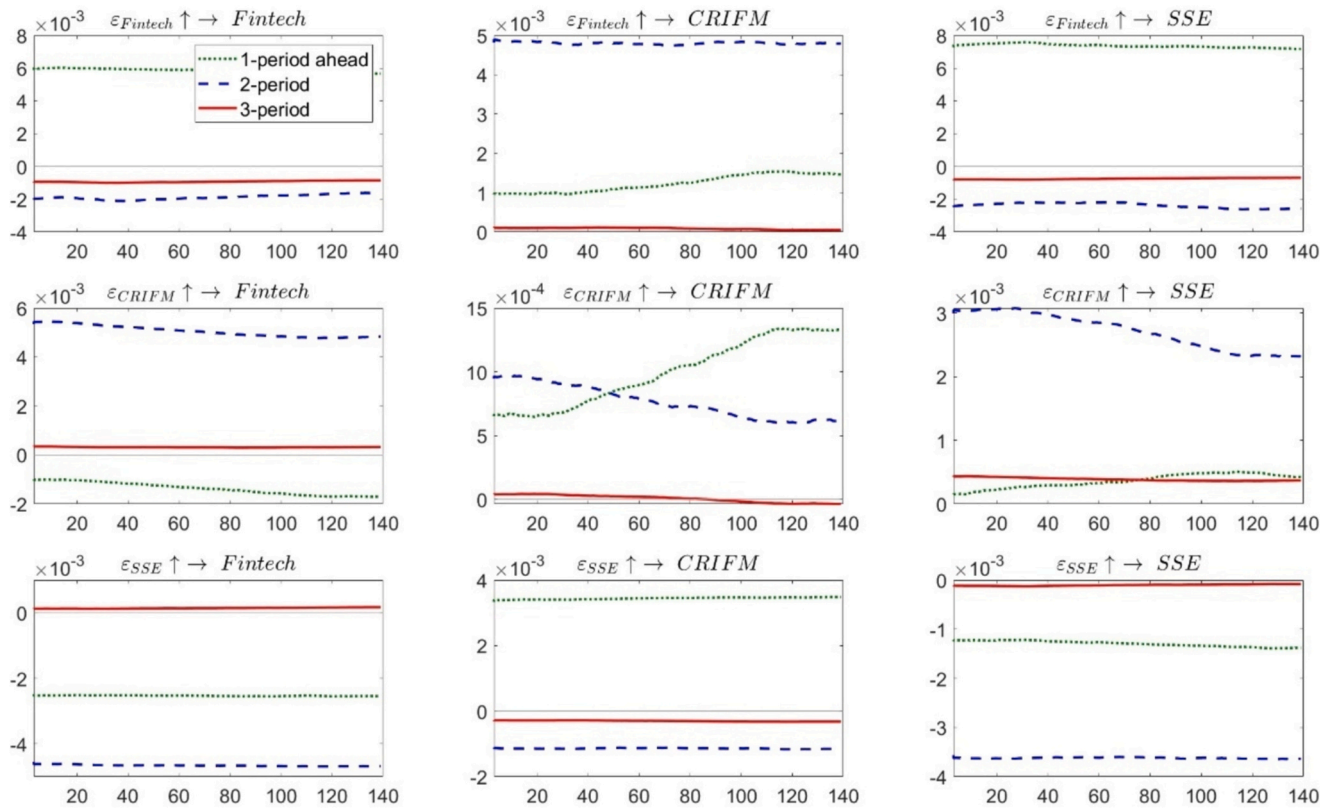


Fig. 2. Baseline Interval Impulse Response Diagram.

Table 2
Impulse Response Statistics.

Variable Impact	Short-Term (1 Period)	Mid-Term (2 Periods)	Long-Term (3 Periods)
<i>Fintech</i> → <i>CRIFM</i>	0.0010–0.0015	0.005	0.000
<i>Fintech</i> → <i>Fintech</i>	0.006	−0.002	−0.001
<i>CRIFM</i> → <i>Fintech</i>	−0.001 ~ −0.002	0.005	0.000
<i>CRIFM</i> → <i>CRIFM</i>	0.0006–0.0013	0.0006–0.0010	0.000

Financial, a subsidiary of Alibaba. It connected traditional money market funds with Alipay accounts, greatly enhancing user investment and financial management capabilities. This marked a significant turning point in the rapid growth of internet finance in China. (2) May 2018: Mastercard adopts blockchain payments. In May 2018, Mastercard announced the integration of blockchain technology into its payment systems, emphasizing the growing recognition of blockchain’s potential to enhance transaction security and efficiency within traditional financial institutions. (3) November 2022: Ethereum completes “The Merge”. In November 2022, Ethereum transitioned from Proof of Work (PoW) to Proof of Stake (PoS), significantly reducing energy consumption and improving blockchain sustainability. These events correspond to periods 14 ($t = 14$), 68 ($t = 68$), and 122 ($t = 122$) in this study.

Fig. 3 presents the event-time impulse response functions based on the Time-Varying Parameter Vector Autoregression (TVP-VAR) model. The analysis shows that fintech’s influence on climate risk in financial markets remains consistent across these key events. In the short term, fintech development increases climate risk by approximately 0.0015. This effect grows to about 0.005 in the second period, indicating that the influence of fintech expands over time. However, after the third period, the impact begins to diminish, suggesting that fintech’s influence on market risk stabilizes in the medium to long term. These findings highlight the consistent and sustained nature of fintech’s effect on

climate risk.

Moreover, Fig. 3 reveals the reciprocal influence of climate risk in financial markets on fintech development. In the early stages of fintech development, rising market risk seems to drive further fintech innovation and adaptation to meet emerging challenges in risk management. However, as fintech matures and becomes more widely adopted, this reciprocal effect diminishes, signaling that fintech development reaches a stable phase, with more rational and effective responses to market risks. The reverse impact of climate risk on fintech also follows a similar pattern, reinforcing the idea that as both variables evolve, their interactions become more stable and less reactive.

4.3. Robustness test: TVP-SV-VAR

To verify the robustness of our baseline results, we applied the TVP-SV-VAR model. This model, an extension of the original Time-Varying Parameter Vector Autoregression (TVP-VAR) model introduced by Cogley and Sargent (2001) and later refined by Primiceri (2005), incorporates stochastic volatility. Unlike the TVP-VAR model, which only captures time-varying relationships between variables, the TVP-SV-VAR model also accounts for changing variances over time. This makes it particularly suitable for data with volatility clustering, such as crude oil futures and spot prices, which may exhibit conditional heteroscedasticity.

Fig. 4 presents the time-varying impact of FinTech on the Climate Risk Index in Financial Markets (CRIFM), based on the TVP-SV-VAR model. The horizontal axis shows the timeline from October 2012 to April 2024, while the vertical axis represents the magnitude of FinTech’s effect on CRIFM. The solid line reflects the average estimated impact, and the dashed lines denote the confidence interval, showing the ± 1 standard deviation range of the estimated impact. From 2013 to 2024, we observe several trends: during the early phase (2013–2015), FinTech had a strong positive effect on CRIFM, indicating that early innovations in FinTech significantly influenced climate risk. In the mid-phase

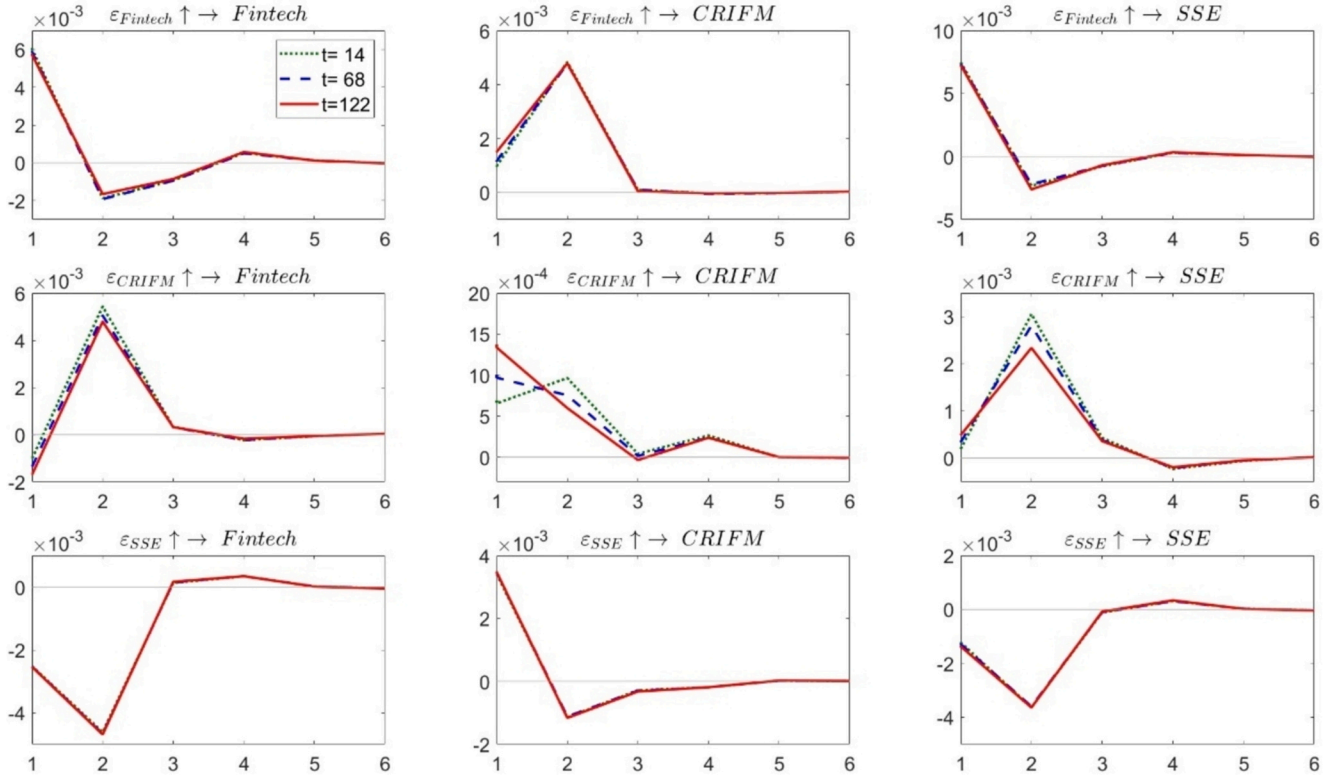


Fig. 3. Baseline Event-Time Impulse Response Diagram.

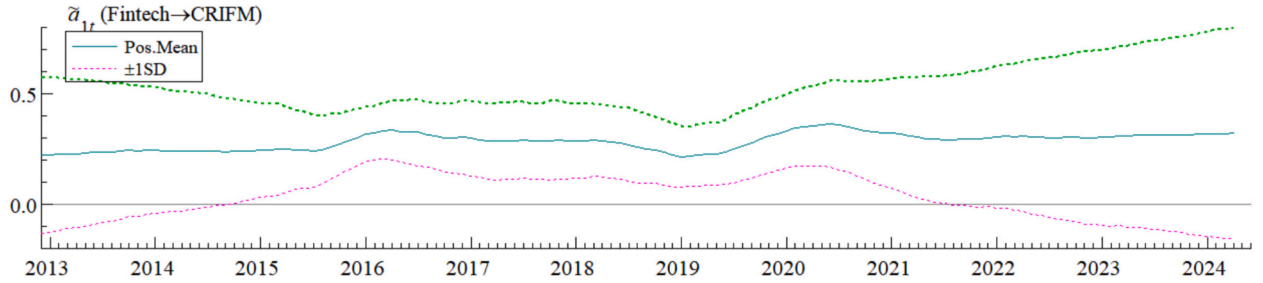


Fig. 4. Time-varying parameter characteristic analysis based on TVP-SV-VAR.

(2015–2020), this impact decreased and stabilized, suggesting that the market adapted to the initial FinTech developments, leading to a more consistent but less pronounced effect. In the later phase (2020–2024), the impact increased again, potentially due to a new wave of FinTech innovations or shifts in market dynamics and regulatory environments, further strengthening FinTech's role in addressing climate risks. The widening confidence interval in the later phase suggests increasing uncertainty, possibly reflecting the diverse and rapid development of FinTech during this period, along with varying market responses to emerging technologies and regulations.

The analysis of Figs. 5 and 6, which depict the interval and point impulse response functions based on the TVP-SV-VAR model, is consistent with the previous results in Figs. 2 and 3. However, under the TVP-SV-VAR model, the positive impact of FinTech on CRIFM is shown to gradually increase over the long term, peaking around 2022. A one-unit shock to FinTech in this model results in approximately a 0.01 increase in CRIFM. Fig. 7's three-dimensional impulse response diagram further illustrates this steadily growing positive impact. These results confirm that, over time, FinTech's influence on climate risk in financial markets becomes more pronounced, highlighting the evolving and increasingly significant role of FinTech in shaping market responses to climate risks.

5. Further analysis

In this section, we test the two channels identified in the theoretical analysis—the investment efficiency channel and the information asymmetry channel—using the same TVP-VAR methodology applied in Section 4.

5.1. Investment efficiency channel

To measure investment efficiency in the stock market, we use the Sharpe Ratio, a widely recognized metric that assesses risk-adjusted returns. The Sharpe Ratio is calculated as follows:

$$\text{Sharpe Ratio} = \frac{\bar{R} - R_f}{\sigma},$$

where $\bar{R}$ represents the average return of the investment portfolio, R_f is the risk-free rate (in this study, the one-year government bond yield is used as a proxy), and σ denotes the standard deviation of the portfolio returns. For this analysis, we collected monthly closing prices of the Shanghai Stock Exchange (SSE) Index and the corresponding one-year government bond yields. We then computed the monthly returns of

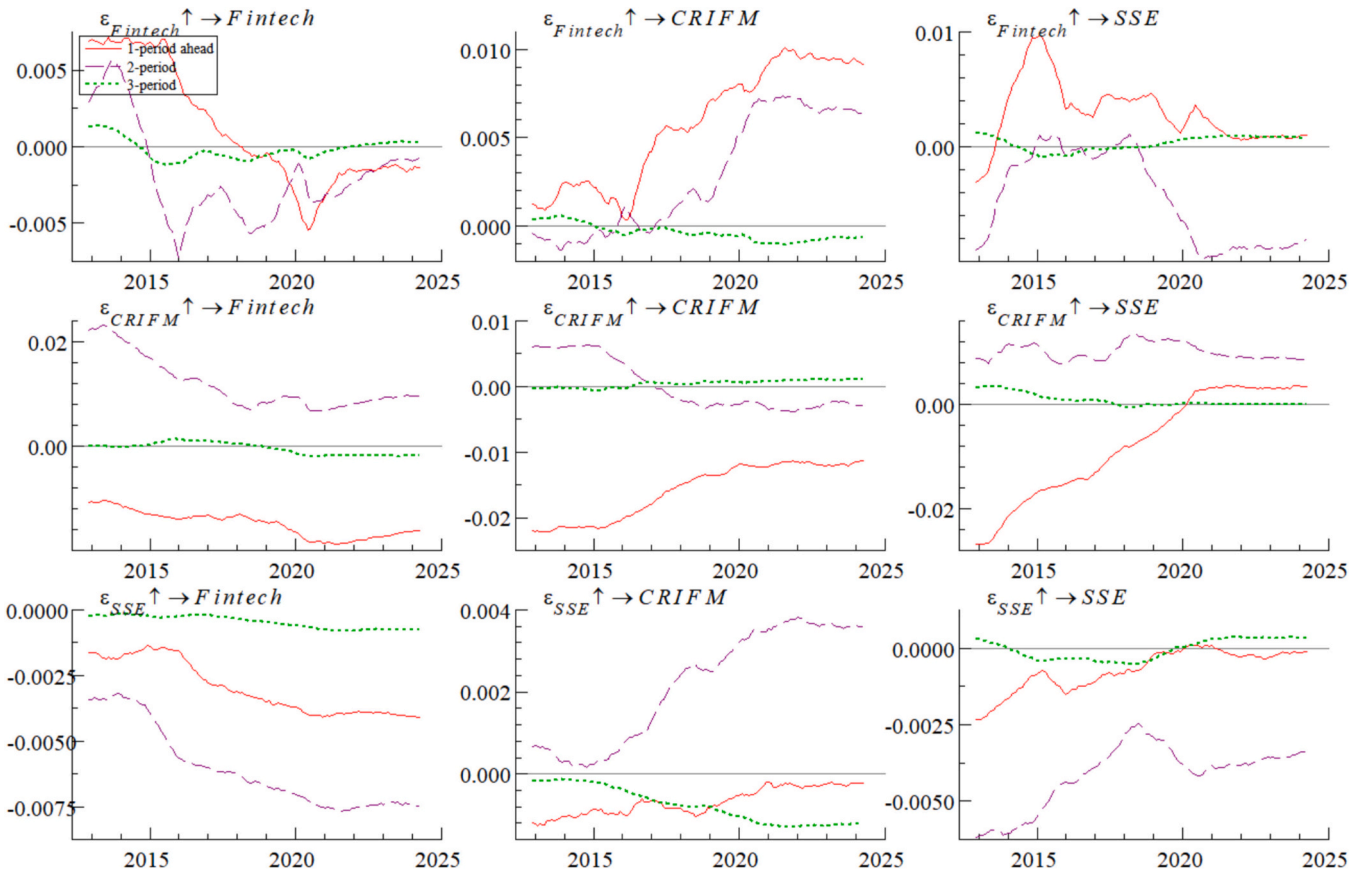


Fig. 5. Interval impulse response diagram based on TVP-SV-VAR.

the SSE Index and calculated the excess returns by comparing them with the monthly risk-free rate. To better capture market volatility, we used a 12-month rolling window to compute the standard deviation of returns, ensuring a dynamic reflection of investment efficiency.

Fig. 8 presents the interval impulse response diagram based on the TVP-VAR model, considering investment efficiency (IE). The first graph in the third column indicates that fintech development significantly improves investment efficiency. In the short term, a one-unit shock to fintech increases investment efficiency by approximately 0.27. In the medium term, the increase is around 0.1, and in the long term, it drops to 0.03. While the effect diminishes over time, it remains significantly positive, demonstrating that fintech development continues to enhance investment efficiency, albeit with a declining impact. The second graph in the third row shows that investment efficiency positively impacts climate risk in financial markets. This effect is evident in the short term and becomes more pronounced over time, with a one-unit increase in investment efficiency raising climate risk by about 0.005 by April 2024. These results confirm the existence of the investment efficiency channel, where fintech development improves investment efficiency, which in turn increases climate risk in financial markets.

Fig. 9 illustrates the event-time impulse response diagram for the investment efficiency channel. The analysis shows that the impact of fintech development on investment efficiency remains stable across the three key events, gradually diminishing from the first period to zero by the fifth period. The impact of investment efficiency on climate risk in financial markets, however, varies across the events. During the launch of Yu'e Bao by Alibaba in November 2013, the effect of investment efficiency on climate risk was slightly negative. By May 2018, when Mastercard announced support for blockchain payments, and by November 2022, when Ethereum completed "The Merge," the impact became clearly positive. These shifts highlight the evolving relationship between investment efficiency and climate risk at different stages of

fintech development.

5.2. Information asymmetry channel

To measure information asymmetry in the stock market, this study uses the Volume Synchronized Probability of Informed Trading (VPIN) metric (Abad et al., 2018; Chu et al., 2023; Zhao & Gao, 2023). VPIN is widely used in finance to capture the degree of informed trading by combining volume and price data, offering insight into the prevalence of informed trades in the market. The formula for VPIN is as follows:

$$VPIN = \frac{1}{n} \sum_{\tau=1}^n \left| \frac{V_{\tau}^B - V_{\tau}^S}{V_{\tau}} \right|$$

where V_{τ}^B and V_{τ}^S represent the buy and sell volumes in the τ trading bucket, respectively, and V_{τ} is the total trading volume for that bucket. The value of n represents the number of trading buckets chosen for analysis.

In this study, we first gathered high-frequency trading data for all A-shares, including minute-by-minute trading volumes and prices. We then divided this data into eight trading buckets with fixed volumes, calculating the buy and sell volumes for each. The VPIN for each bucket was computed and averaged daily to form a daily VPIN indicator. To capture long-term changes in information asymmetry, these daily VPIN values were further converted into monthly averages, allowing us to track the evolution of informed trading in the market.

Fig. 10 presents the interval impulse response diagram based on the TVP-VAR model, considering market information asymmetry (IA). The first graph in the third column shows that fintech development significantly reduces market information asymmetry. This suppression effect is consistent across short, medium, and long terms, with a gradual decline over time. From October 2012 to April 2024, the suppression effect

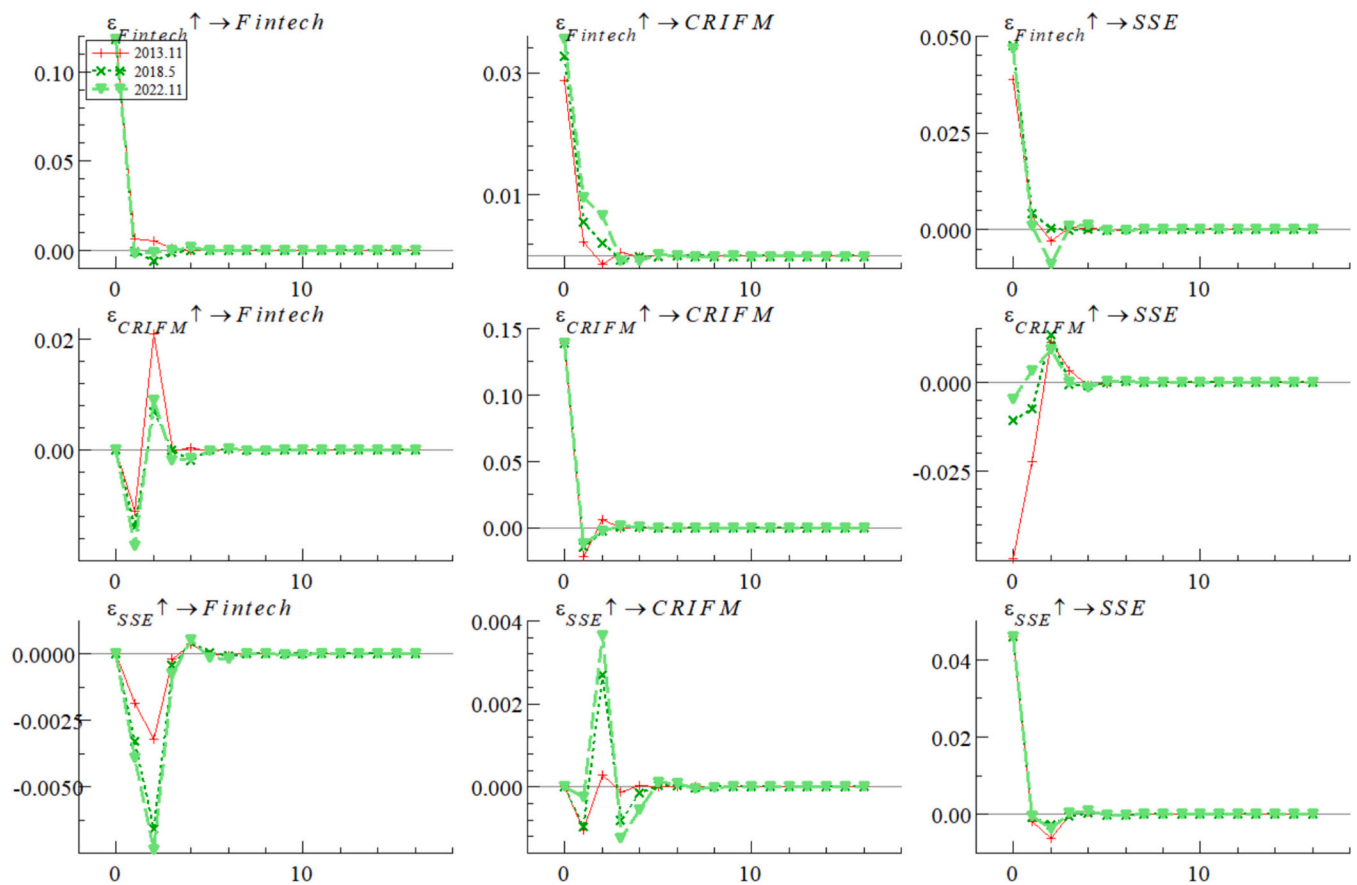


Fig. 6. Point impulse response diagram based on TVP-SV-VAR.

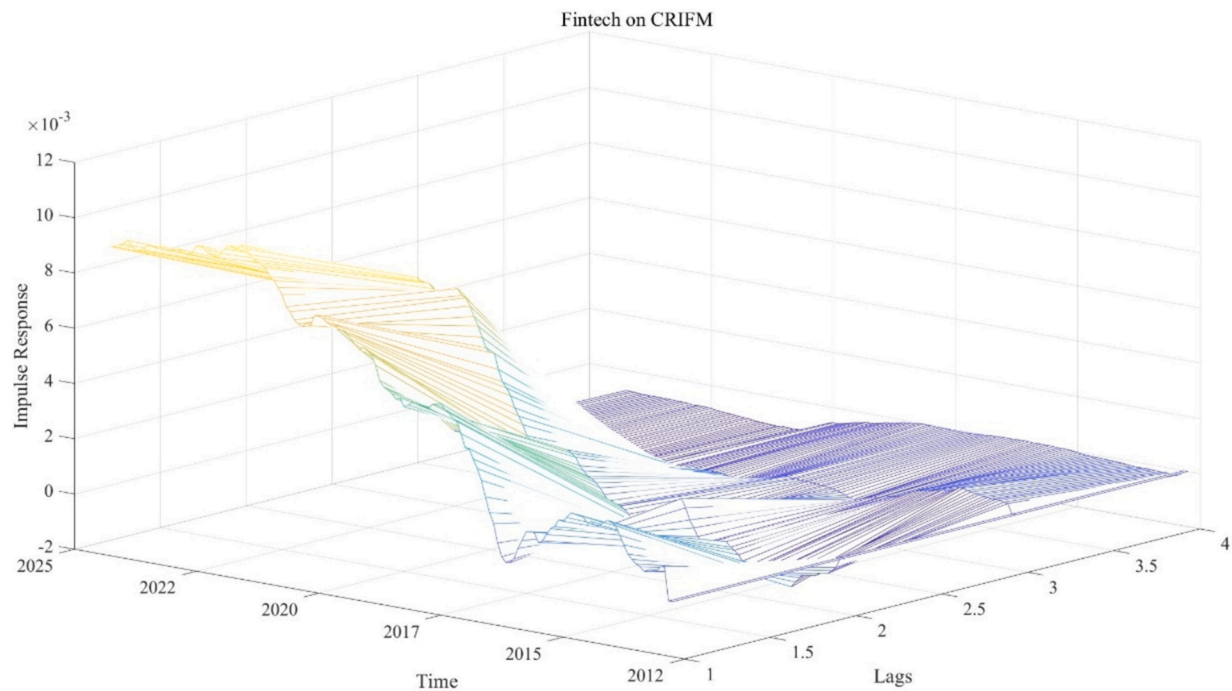


Fig. 7. Three-dimensional impulse response diagram.

decreases from about -0.004 to zero. The second graph in the third row indicates that information asymmetry continuously reduces climate risk in financial markets. In the short term, a one-unit fintech shock reduces

information asymmetry by about -0.006 , with the reduction becoming smaller in the medium and long terms (-0.004 and -0.003 , respectively). Thus, fintech development lessens market information

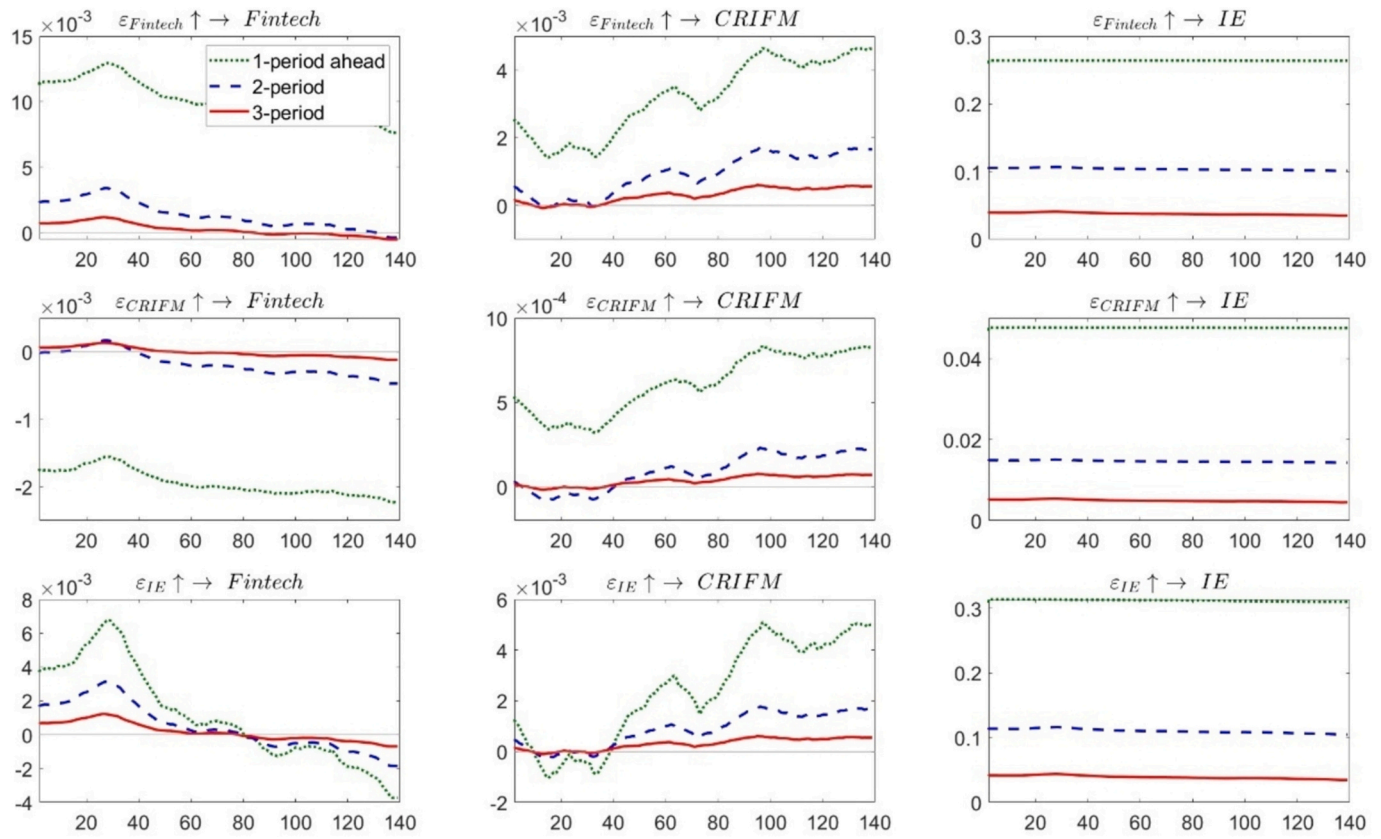


Fig. 8. Impulse Response Diagram for Investment Efficiency Channel.

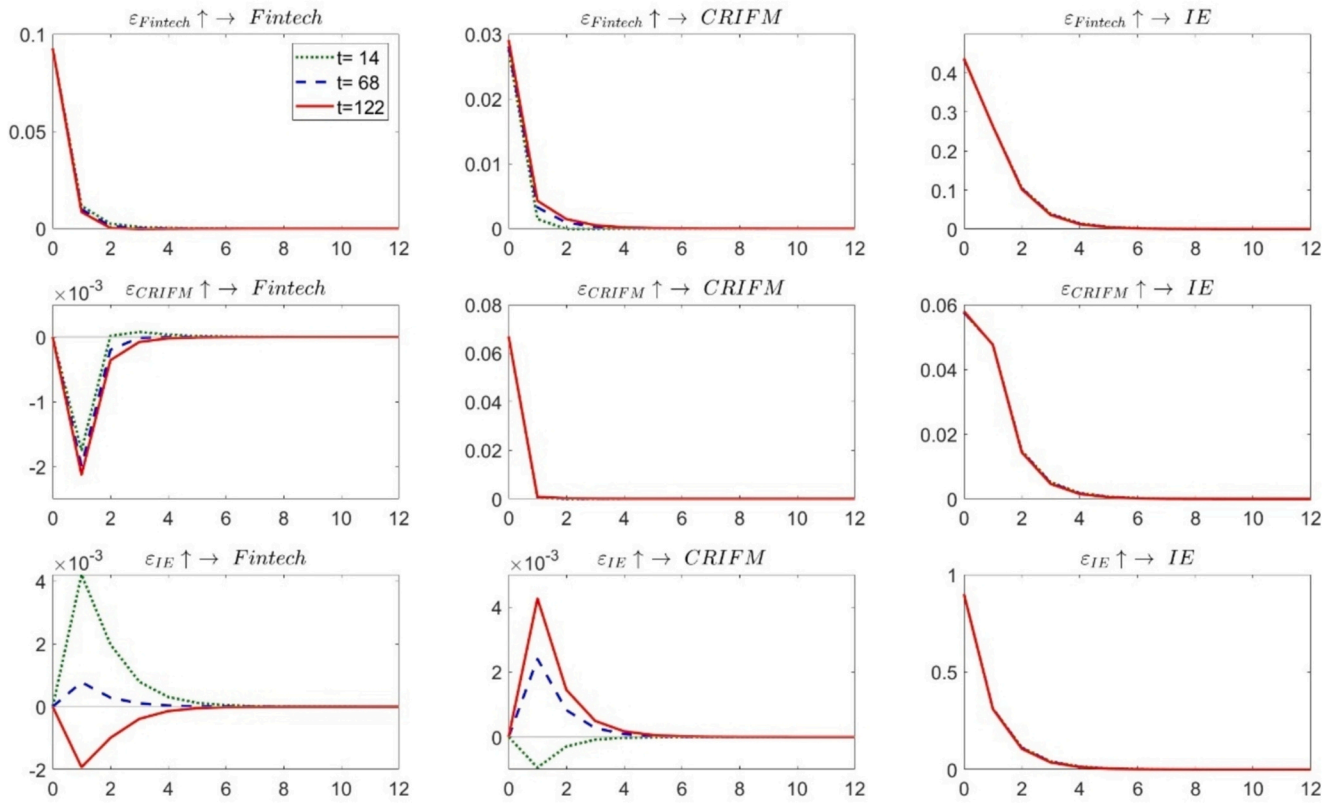


Fig. 9. Event-Time Impulse Response Diagram for Investment Efficiency Channel.

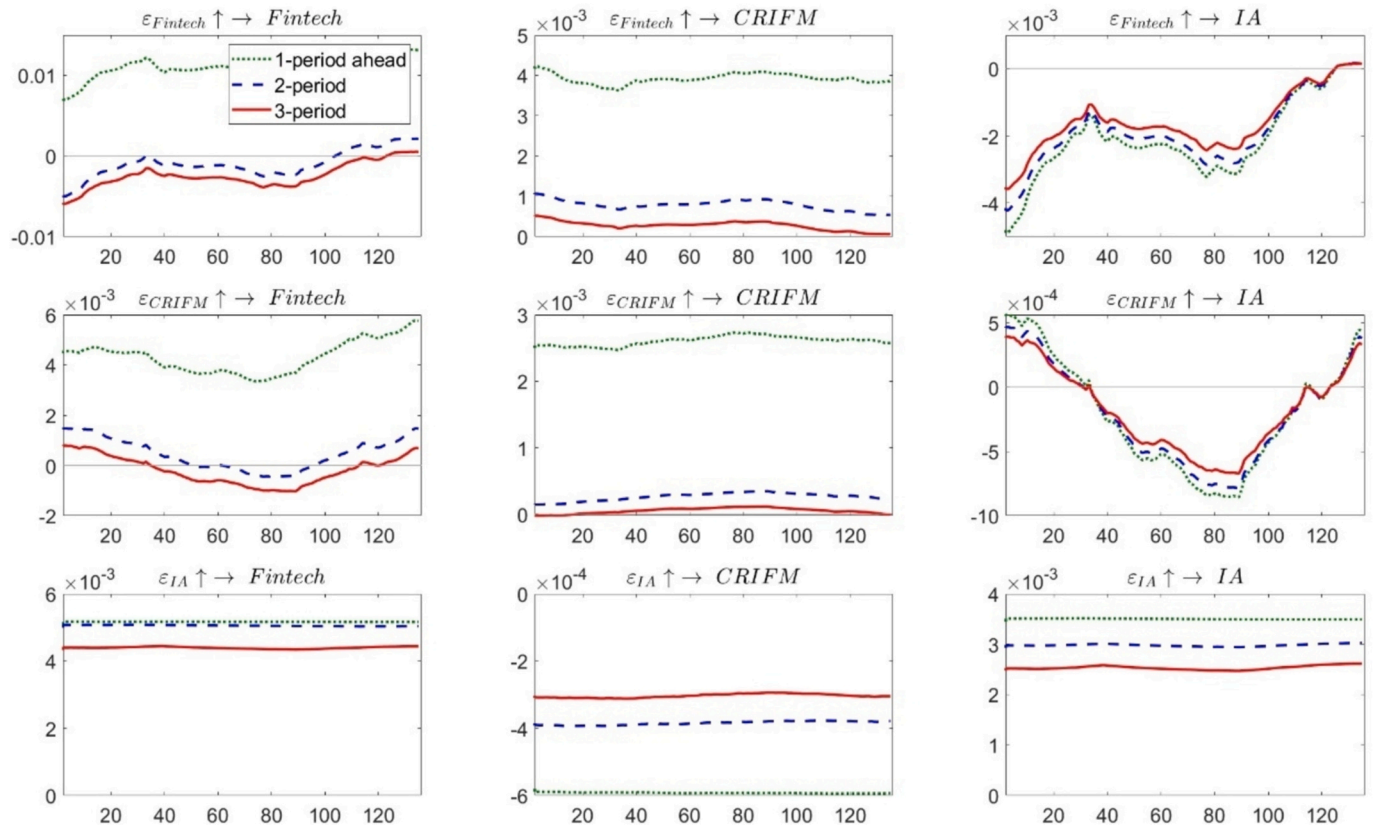


Fig. 10. Interval Impulse Response Diagram for the Information Asymmetry Channel.

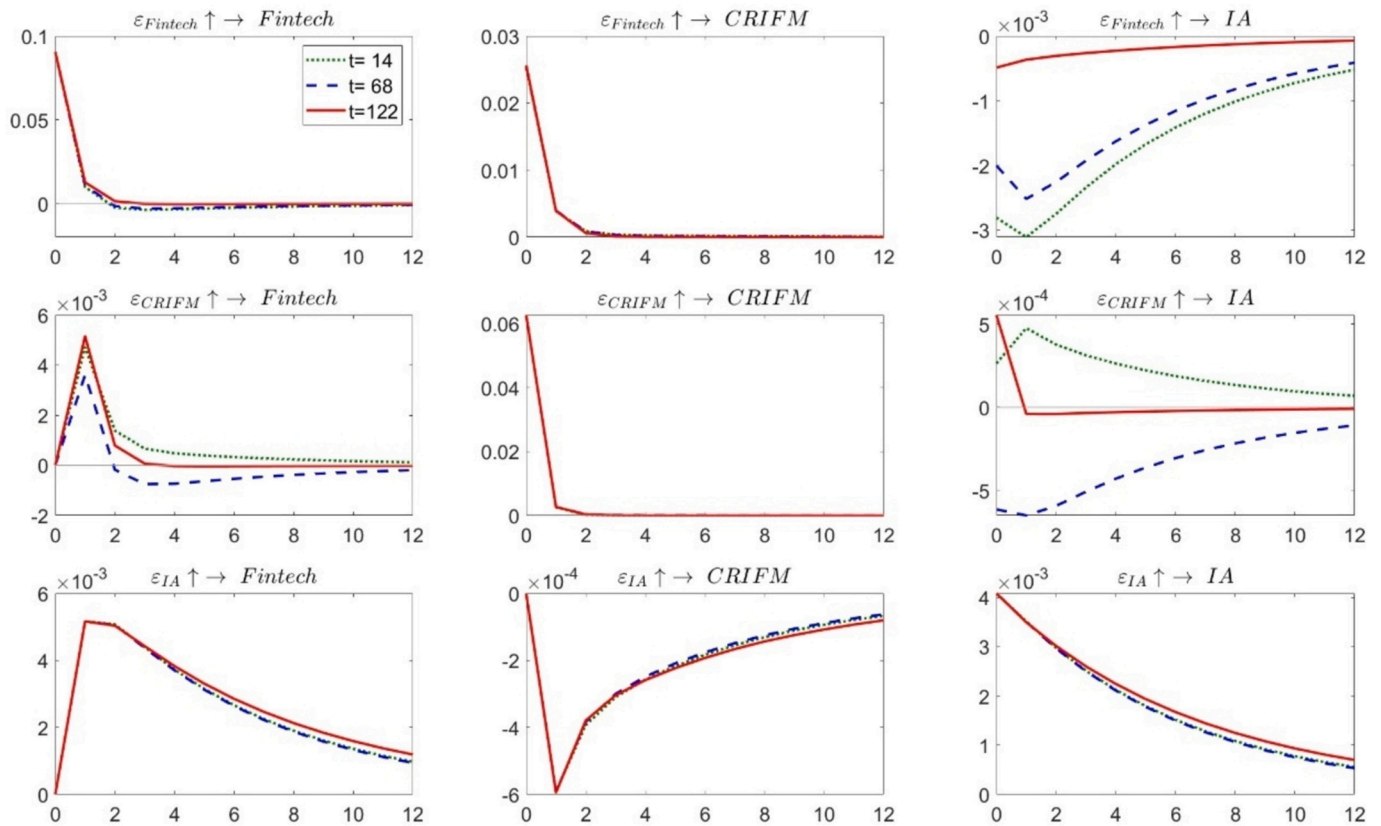


Fig. 11. Event-Time Impulse Response Diagram for the Information Asymmetry Channel.

asymmetry, which, in turn, increases climate risk, confirming the existence of the information asymmetry channel.

Fig. 11 presents the event-time impulse response diagram for the information asymmetry channel. The diagram shows that the impact of fintech development on information asymmetry varies across the three key events. The strongest impact occurred during Alibaba's launch of Yu'e Bao in November 2013 and Mastercard's announcement of support for blockchain payments in May 2018. By November 2022, when Ethereum completed "The Merge," the impact had weakened. The effect of information asymmetry on climate risk in financial markets remained consistent across the events, steadily diminishing from the first period onward.

6. Conclusions and implications

This paper investigates the relationship between fintech and climate risk in financial markets, examining how fintech enhances investment efficiency and reduces information asymmetry, thereby influencing climate risk. The empirical findings show that fintech development significantly raises climate risk levels in financial markets. By improving the efficiency of information processing and distribution, fintech enables investors to more quickly and accurately assess potential investments in climate-friendly projects, leading to a rise in green investments.

Our study identifies two key mechanisms through which fintech impacts climate risk: enhancing investment efficiency and reducing information asymmetry. First, fintech improves investment efficiency, facilitating the flow of capital to high-return green projects, which in turn increases the Climate Risk Index in Financial Markets (CRIFM). Second, fintech reduces information asymmetry by improving market transparency, fostering greater trust in green investments and promoting sustainable investment practices.

These findings lead to several important policy implications. Governments and regulatory authorities should actively support fintech innovations that promote green finance. This can be achieved through financial incentives and policy initiatives that encourage the development of fintech solutions aimed at facilitating green investments. To further address information asymmetry, regulators should introduce more stringent disclosure requirements, ensuring that companies—particularly those in the green sector—provide clear and reliable environmental performance data. Such measures would increase investor confidence in green investments and promote their growth.

As fintech and green finance evolve rapidly, regulatory frameworks must adapt continuously to accommodate new technologies and products. Special attention should be given to the potential effects of fintech on climate risk to ensure the stability and sustainability of financial markets. Given that both climate change and fintech development are global challenges, international cooperation is crucial. Countries should work together in the areas of green finance and fintech, sharing knowledge and best practices to address the challenges of climate change on a global scale.

Funding

This research is supported by the Postdoctoral Fellowship Program of CPSF under Grant Number GZB20240484.

Data availability

Data will be made available on request.

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