Unleashing Fintech's Potential:

A Catalyst for Green Bonds Issuance

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Abstract

Financial technology, also known as Fintech, is transforming our daily life and revolutionizing the financial industry. Yet at present, consensus regarding the effect of Fintech on the green bonds market is lacking. With novel data from China, this study documents robust evidence showing that Fintech development can significantly boost green bonds issuance. Further analysis suggests that this promotion effect occurs by empowering intermediary institutions and increasing social environmental awareness. Additionally, we investigate the heterogeneous effect and find that the positive relation is more pronounced for bonds without high ratings and whose proceeds are not used for refinancing. This effect is also stronger for non-stated-owned issuers and in cities connected with High-Speed Railways network or located in the eastern region of China. The results call for the attention from policymakers and security managers to take further notice of Fintech utilization in green finance products.

Keywords: *Fintech; Green bonds; Intermediary environment; Environmental awareness*

JEL Classification: G23, G24, G15

1. Introduction

Among the various financial instruments, green bonds are emerging as a fast-growing type of fixed-income security, and the proceeds are committed to finance climate change solutions and other green projects (Tang and Zhang, 2020). The market volume of green bonds has reached over half a trillion dollars (USD 517.4 bn) in 2021, according to Climate Bonds Market Intelligence. However, the green bond market still holds substantial potential for growth, largely due to the future necessity for a carbon-neutral society and the inadequate supply of green bonds in recent years (Sangiorgi and Schopohl, 2023). The primary reason for the insufficient supply of green bonds is the complexity involved in their issuance and the high costs associated with verifying the environmental impact of the projects they fund. In addition, the returns and quality of green bonds are uncertain for investors due to the lack of historical references and limited financial information of underlying projects. Furthermore, monitoring and regulations of these emerging assets can be similarly difficult (Flammer, 2021). For these reasons, green bonds face various challenges in issuance.

Facing these obstacles, in order to expand the green bond market, it's crucial to gain a deeper understanding of the factors that encourage and assist organizations to offer green bonds. The majority of existing research on the determinants of green bond issuance predominantly focuses on firm attributes (Dutordoir et al., 2023) or issuer motivations (Flammer, 2021, Sangiorgi and Schopohl, 2023). However, there is a dearth of literature that documents the role of the regional factors in the issuance of green bonds. A deeper understanding of how regional characteristics drive green bonds is crucial since it can directly inform policymakers about future regulation strategies. In this paper, we manage to fill the research gap by asking that beyond corporate attributes and investor attitudes, would the advancement of Fintech in a region can also facilitate

the issuance of green bonds, which formulates our first research question: (1) *What is the effect of Fintech on green bonds issuance?*

We focus on regional Fintech development as it can be closely connected with green bonds. Fintech, also known as financial technology, is revolutionizing the financial industry with its innovative solutions and cutting-edge technologies (Ding et al., 2022). The Fintech sector has witnessed a rapid growth over the past few years, as evidenced by its huge amount of investment, high rate of returns globally, and governments around the world prioritizing the development of this sector (Jiao et al., 2021). Thus, Fintech is transforming our daily life. People can go shopping without their wallets and pay by smartphone or use Kickstarter to raise money for their business. The innovation in financial services can also promote financial development by encouraging risk sharing, advocating market competition, improving allocation efficiency, and creating excessive credit supply (Allen et al., 1994; Grinblatt and Longstaff, 2000; Houston et al., 2010; Brunnermeier 2009), further exerting an effect on financial instruments. With innovative platforms and cutting-edge technologies, the development of Fintech globally may offer solutions to the challenges faced by green bonds. Recently, governments have already promoted green bonds issuance using Fintech. For example, in February 2023, the Hong Kong SAR Government tokenized green bonds using blockchain technology, which is the first tokenization attempt for green bonds worldwide, and commented on the potential enhancement of the "efficiency, transparency and security of green bonds transactions"[1]. However, in literature, there is currently a lack of consensus regarding the effect of Fintech on green bonds issuance (Qin et al., 2022).

Regional Fintech development may have three potential effects on green bonds. First, Fintech may accelerate green bonds issuance by empowering financial institutions. As mentioned

[1] Source: Hong Kong Monetary Authority
https://www.hkma.gov.hk/eng/news-and-media/press-releases/2023/02/20230216-3/

above, green bonds issuance and development present various challenges. By introducing innovative digital solutions, financial institutions can streamline and expedite the bonds issuance, facilitate data sharing, reduce the potential for fraud, and enhance trust with the advent of blockchain and smart contracts (Shin et al., 2020; Monrat et al., 2019; Cong et al., 2022). Additionally, with the support of Fintech, financial intermediaries can tap into a wider pool of investors to accelerate the investment matchmaking. Therefore, Fintech advancement in a region has empowered financial institutions to increase the green bonds' issuance transparency and efficiency but decrease its risks, and thus increasing actual issuance (Quddus, 2020; Dorfleitner and Braun, 2019). Second, Fintech may also play a vital role in increasing investors' environmental awareness, thus promoting green bonds issuance. Fintech platforms now provide investors with user-friendly interfaces, educational resources, and effect measurement tools, enabling them to easily align their financial objectives with environmental goals. These advancements of regional Fintech development have expanded channels for cultivating environmental awareness, extending its effect throughout society via everyday usage of its applications. This heightened environmental awareness is expected to drive an increase in expenditure and demand for green projects (Eyraud et al., 2013; Liao et al., 2018), which benefits green bonds issuance. However, Fintech infrastructures may also prevent new green bond issuance by raising the transparency of unmatured ESG portfolios (Dorfleitner and Braun, 2019), followed by the divestment of several financial products due to environmental regulatory risks (Heinkel et al., 2001), which in turn prevent new green bonds issuance. In conclusion, to enrich our understanding of the channels through which Fintech can affect green bonds issuance, we pose our second research question: (2) *How does Fintech affect green bonds issuance through possible channels?*

To empirically unveil these puzzles, we combine the data of China city-level Fintech index and green bonds issuance. China is at the forefront of the financial technology (Goldstein et al., 2019; Guo et al., 2023) and can therefore provide detailed Fintech data that other countries currently lack. China also plays a vital role in the global goals of sustainability and carbon emissions reduction[2]. Moreover, green bonds are especially prevalent in China (Flammer, 2021), which thereby provides us with a good opportunity to investigate the relationship between Fintech and green bonds development. We begin our empirical analysis by showing that Fintech development exerts a positive effect on green bonds issuance. To address potential omitted variable concerns, following Qin et al. (2022) and Ding et al. (2022), we adopt an instrumental variable (IV) for Fintech development with the distance between Hangzhou[3] and the city of green bonds issuance. We also employed a staggered Difference-in-Difference (DiD) model that utilizes a strand of Fintech-boosting policies as an exogenous shock to support the causal relationship between the regional Fintech development and green bond issuance. The Heckman two stage model is applied to alleviate the underlying selection bias. The estimation results are consistent with our main findings. We then examine the underlying mechanisms through which Fintech helps to promote green bonds issuance. Results show that from the supply side, Fintech can empower financial institutions to promote the issuance of green bonds. From the demand side, Fintech can enhance social environmental awareness, and thus increase green bonds issuance. Finally, we also carry out cross-section partition tests and find that the positive effect is more pronounced for bonds without high credit ratings and whose proceeds are not used for refinancing. This effect is also

[2] See "Climate change: China's green power surge offers hope on warming," BBC, June 29, 2023 https://www.bbc.com/news/science-environment-66043485

[3] The Fintech center in China and the headquarters of Alibaba.

more pronounced for issuers that are not state-owned and for cities linked to the High-Speed Railways (HSR) network, and those located in the eastern region of China.

This study presents contributions to two strands of literature. First, we contribute to the literature on how Fintech is related to green projects. Existing literature generally focuses on the positive effects of Fintech on sustainability-oriented ventures (Calic and Mosakowski, 2016; Vismara, 2019; Ding et al., 2022), green education programs (Savelyeva and Park, 2022; Yin et al., 2019), and land restoration (Zhang et al., 2021). For example, Calic and Mosakowski (2016) find that ventures with sustainability orientation are more likely to be funded in crowdfunding campaigns. Zhang et al. (2021) posit that Ant Forest, an application made by Fintech giant Alibaba, can effectively contribute to land restoration in China. By empirically testing a sample from China, this study extends the discussion of Fintech to green bonds. This extension is rather important because green bonds are a new investment instrument with dramatically increasing sales in recent years (Pham and Huynh, 2020). For issuers, green bonds may expand the investor base with a lower cost of capital and longer term. For investors, green bonds help their ESG performance improvement (Tang and Zhang, 2020).

This study also contributes to the burgeoning literature on green bonds. The rapid growth of the green bonds market has left behind the research on its determinants and consequences (Wang et al., 2020). Current research has mainly focused on the motivation or the determinants of issuing green bonds (e.g., Flammer, 2021; Dutordoir et al., 2023; Sangiorgi and Schopohl, 2023), the green bonds pricing (e.g., Larcker and Watts, 2020; Flammer, 2021; Tang and Zhang, 2020), and the impact of green bonds on the issuers (Tang and Zhang, 2020; Flammer, 2021), and there is no literature attribute the offering to regional development factors. We shed light on the regional development factors by analyzing how regional Fintech innovation could help in green bonds

issuance process, therefore accelerating the issuance of green bonds, and in which situation, the effect is more pronounced.

Finally, our findings offer important implications to those nations that are pursuing their environmental goals. The progress in Fintech can provide a valuable solution to the challenges associated with financing environmental initiatives. Nations now have the opportunity to harness Fintech innovations to successfully attain their environmental targets.

In the following section, we first discuss the uniqueness of green bonds and related literature in Section 2 and then analyze how Fintech development would affect green bonds issuance and propose three hypotheses in Section 3. Next, we describe our variable constructions and analysis results in Section 4 and 5. Finally, we conclude and discuss the results and managerial implications in Section 6.

2. The Uniqueness of Green Bonds and Related Literature

Recent years have shown a growing interest in sustainable finance, and green bonds have emerged as a powerful tool to fund environmentally friendly projects (Flammer, 2020; Fatica and Panzica, 2021). Different from conventional bonds and other securities, green bonds are special in the following aspects: use of proceeds, process for project evaluation and selection, management of proceeds, and reporting.

The fundamental aspect of a green bond is the utilization of the bond's proceeds for environmentally friendly projects. Then it might seem puzzling why companies choose to issue green bonds instead of conventional bonds, despite the restricted application of the proceeds. Contemporary research has proposed three potential explanations. The first one is the signaling argument, suggesting that green bonds could act as a credible signal of the company's

environmental dedication, as investors often lack adequate information regarding a company's environmental commitment (e.g., Lyon and Maxwell, 2011; Lyon and Montgomery, 2015). Dutordoir et al. (2023) show that companies with greater reputational benefits from being perceived as environmentally friendly and those with a heightened emphasis on eco-innovation are more likely to issue green bonds. Flammer (2021) provides evidence that investors react favorably to the announcement of green bond issuance. The survey data in Sangiorgi and Schopohl (2023) further corroborates the signaling strength of green bonds. Secondly, the issuance of green bonds could be perceived as a form of greenwashing—a practice where companies make unfounded or deceptive assertions about their environmental commitment. In this context, companies might issue green bonds to project an image of environmental responsibility, without implementing substantial actions.

The third potential motivation to issue green bonds is the green pricing premium (cost of capital argument). This suggests that if investors in green bonds are prepared to sacrifice financial returns for societal benefits, companies may issue green bonds to obtain cheaper financing. Karpf and Mandel's (2017) research on municipal green bond pricing indicates that these bonds are priced at a discount of approximately eight basis points. Studies conducted by Zerbib (2019), Baker et al. (2018), and Bachelet et al. (2019), which are based on different bond samples, all report a price premium for green bonds. Larcker and Watts (2020), however, found no pricing difference between green bonds and their plain vanilla counterparts when a strict matching procedure was applied. This finding is supported by Flammer (2021) and Tang and Zhang (2020), who also found no significant premium for their corporate green bond samples. Fatica et al. (2021) demonstrate that whether a premium exists or not depends on issuer types.

As for the process for project evaluation and selection, The Green Bond Principles (GBP) issued by The International Capital Market Association (ICMA) suggests issuers to clearly communicate to investors about the environmental sustainability objectives, the process by which the issuer determines how the projects fit within the eligible green projects categories, and the related eligibility criteria. Currently, however, different countries, international organizations and institutions have different certification standards when it comes to the specific identification of green bonds, although the connotation and extension of green bonds are similar among different countries or regions. The differences in standards raise transaction costs in terms of assessment and compliance. To ensure that green bond issuance and all related documentation align with market expectations, some issuers seek third-party guidance during the issuance process. External review providers are typically appointed by issuers to assess the alignment of their green bonds with the GBP (Flammer, 2021; Sangiorgi and Schopohl, 2023). Some regions or institutions, such as the Association of Southeast Asian Nations (ASEAN), European Union (EU), and Climate Bonds Initiative (CBS), have mandatory external review requirements, while others, like China, adopt a voluntary and encouraging approach. As reported by Sangiorgi and Schopohl (2023), the majority of issuers utilized external parties when issuing green bonds, with only a minority of 16% stating that they managed the issuance process entirely internally. Flammer (2021) demonstrates that investors react more positively to issuance announcements when the green bonds are certified by third parties.

Management of proceeds and reporting are also crucial for green bonds, particularly in light of the recent rise in greenwashing concerns. The EU has recently enhanced regulations to address greenwashing, such as the Sustainable Finance Disclosure Regulation, which came into effect in March 2021. This regulation mandates the disclosure of ESG-related information by

financial market participants, thereby increasing the transparency of green investment products and preventing greenwashing. However, in other regions, the proceeds management and reporting systems of green bonds are far from perfect, and greenwashing is still a major concern of investors. For example, according to the Climate Bonds Initiative (CBI) report, a total of 5.6 billion yuan (USD$792 million) of Chinese green bonds issued in 2019 were with insufficient disclosure on how the funds raised were used[4].

Despite the challenges and issues associated with issuing green bonds and the green bond market, the overall impact of green bonds is positive. Flammer (2021) and Tang and Zhang (2020) demonstrate that the stock price of corporate issuers responds positively to the announcement of a green issuance, suggesting that equity investors perceive green bond issuances as value-enhancing. Baker et al. (2018), Flammer (2021), and Tang and Zhang (2020) show that following the issuance of green bonds, corporate issuers experience an increase in institutional ownership of their stocks, particularly by long-term and green investors as well as domestically located institutional investors. This suggests that green bonds can attract new investors and diversify the issuer's investor base. Furthermore, green bonds can significantly aid firms in their environmental policies and performance (Flammer, 2021).

3. Hypothesis Development

3.1. Fintech and Green Bonds Issuance

With all the uniqueness of green bonds discussed above, we can see that one of the major challenges in green bonds issuance has been the complexity and cost associated with verifying the

[4] Climate Bonds Initiative. (2020). China's green bond issuance and investment opportunity report 2020. Available online: https://www.climatebonds.net/files/reports/cbi_gfo_china_05b.pdf.

environmental effect of projects, and the uncertainty in bond quality and profitability. Furthermore, the monitoring and regulations of these emerging assets present difficulties.

Fintech development offers solutions to these challenges. For instance, blockchain infrastructures, with a decentralized immutable ledger and smart contracts, can enhance transparency and traceability throughout the entire lifecycle of a green bond. These technologies enable the recording of project data, certifications, and effect metrics, easily allowing investors to assess the environmental performance of underlying projects (Dorfleitner and Braun, 2019). This transparency helps build trust among investors, attracting an increased pool of capital into the green bonds market. Moreover, the automation capabilities of Fintech platforms can streamline the green bonds issuance (Quddus, 2020). Traditionally, issuing a bond involves numerous intermediaries, extensive paperwork, and time-consuming manual processes, especially for green bonds, with the special project evaluation and selection process, there are more paperwork and time-consuming manual processes. Fintech platforms can digitize and automate these processes, reducing administrative burdens and transaction costs. By simplifying the issuance, Fintech can allow for increased access of green bonds to a broader range of issuers, including smaller organizations and local governments, who may have been deterred by its high costs. Furthermore, Fintech can enhance the transparency, traceability, and automation, and thus allowing for easier regulations and supervision and creating a more reliable ecosystem of green finance (González Páramo, 2017). Together, these functions of Fintech can lead to a large supply of green bonds by issuers.

Market development not only relies on the supply side but also on the demand side. Fintech development can also broaden the investor base for green bonds by enhancing environmental awareness (Dietz et al., 2016). Fintech platforms enable retail investors to participate in green bond investments, democratizing access to sustainable finance. By engaging a wider audience, Fintech

can mobilize additional capital for green projects and create an inclusive and resilient financial ecosystem. Fintech can also improve the liquidity of green bonds by facilitating the efficient matching of investors and sellers, thereby enhancing price discovery and market efficiency.

In summary, the integration of Fintech into the green bonds market holds immense potential to accelerate the issuance of these financial instruments. On the supply side, by leveraging technologies such as blockchain, automation, and digital platforms, Fintech can enhance transparency, streamline processes, and improve the intermediary institutions. On the demand side, these advancements can increase the overall environmental awareness, broaden investor participation, and facilitate the transition to a greener and more sustainable economy. Therefore, we formulate Hypothesis 1 as follows:

H1: Fintech development can significantly accelerate the issuance of green bonds.

3.2. Fintech and Green Bonds Supply

The first hypothesis formulates a general relationship between Fintech development and green bonds issuance. To find further empirical evidence of why Fintech can accelerate green bonds issuance from the supply and demand sides, we separately formulate hypotheses based on these two possible channels.

First, on the supply side, financial intermediaries are essential participants in the bonds market. Intermediary institutions such as banks, insurance companies, and investment firms play a crucial role in facilitating transactions, managing risks, and providing green bonds services to individuals and businesses (Buchak et al., 2018; Erel and Liebersohn, 2022). The development of Fintech has empowered intermediary institutions in the financial industry. Innovative Fintech

applications provide efficient and seamless digital solutions, promoting transparency and trust while facilitating effective matchmaking for environmentally friendly projects with investors who are specifically interested in supporting sustainable initiatives.

Shenzhen, China, is one of the pioneer cities in Fintech development. In 2016, Shenzhen has already proposed a comprehensive green financial service system, integrating green financial institutions, products, markets, and intermediary services. The city also established the Green Finance Professional Committee to assist in implementing the "Green Ticket" initiative, serving small and medium-sized green businesses. The proposal came to reality in 2019, when Shenzhen launched the world's first financial service platform linking green bond with the green real economy, in collaboration with the United Nations Environment Program, and as a member of FC4S[5]. This platform, based in Shenzhen, further solidified the city's role in accelerating intermediary development related to green bonds through Fintech.

In this case, the Green Finance Professional Committee and the newly built financial service platform act as the intermediaries linking green finance with the green real economy. They play a crucial role in connecting investors with green businesses and facilitating the issuance and trading of green bonds. Fintech empowers these intermediaries in several ways. Firstly, it provides them with the necessary tools and infrastructure to efficiently manage and process green bond transactions. This includes digital platforms that allow for transparent and streamlined issuance and trading of green bonds. Secondly, Fintech enables these intermediaries to reach a wider audience of investors. Through digital platforms, information about green bonds can be easily disseminated to potential investors, increasing the accessibility of green bonds.

[5] Financial Centers for Sustainability (FC4S) is a global network of 40 financial centers, working together to achieve the objectives set by the 2030 Agenda and the Paris Agreement. See https://www.fc4s.org/about-us/

As mentioned in the above example, one of the key effects of Fintech-empowered financial intermediaries is the increased efficiency and speed of green bond issuance. Financial intermediaries can significantly reduce the steps involved in the above process by introducing more efficient and streamlined digital solutions (Cai, 2018). Traditionally, issuing bonds involves numerous intermediaries, extensive paperwork, and manual processes, which can be time-consuming, costly, and prone to errors. However, financial intermediaries adopting Fintech allow for the feasibility and practicality of digitizing bond issuance documentation and automating various processes, such as legal documentation, verification, and compliance checks (Malamas et al., 2020). This feasibility can reduce the time and effort required to prepare and process the necessary paperwork, leading to a faster and more streamlined bond issuance (Li et al., 2022). In addition, financial intermediaries can leverage cloud-based document management systems to securely store and organize bond issuance files (Hill, 2018; Kumar, 2014). Cloud platforms provide easy access to authorized parties, facilitate collaboration among multiple stakeholders, and ensure document version control. These capabilities eliminate the need for physical document storage and enhance document sharing and accessibility. Fintech is also poised to significantly reduce the potential for fraud, enhance trust, and significantly improve the intermediary environment through its innovative technologies. For example, with the advent of blockchain and smart contracts, Fintech solutions can ensure increased transparency, immutability, and traceability of financial transactions, thereby reducing the probability of fraud to the minimum (Shin et al., 2020; Monrat et al., 2019; Cong et al., 2022). Additionally, digital identity verification systems offered by Fintech platforms enable robust "Know Your Customer" procedures, allowing for easier authentication of individual identities and mitigation of risks associated with money laundering and terrorism financing (Soni and Duggal, 2014). This scenario

fosters trust and encourages the supply of financial instruments such as green bonds by reducing the perception of risks associated with fraudulent or manipulative practices.

Fintech's data analytics capabilities can also facilitate investment matchmaking (He et al., 2023). Fintech-empowered financial intermediaries can leverage data analytics and artificial intelligence (AI) technologies to improve bond issuance (Davradakis and Santos, 2019). Data analytics can help identify market trends, investor preferences, and pricing insights, thereby enabling investment banks to optimize bond offerings. The recognition of climate change as a pressing global issue has driven the need for sustainable and environmentally friendly solutions (Dwivedi et al., 2022). Governments encourage businesses and investors to embrace sustainable projects. Therefore, consumer demand for environmentally friendly products and services is growing. We expect that Fintech-empowered financial intermediaries are well-positioned to stay informed about the growing green trend and meet the increasing demand for green bonds from their clients. Furthermore, Fintech-empowered financial intermediaries can have access to a broader pool of investors through digital marketplaces such as mobile apps and expand the reach of potential investors, which incentivize financial intermediaries to provide more products (Cumming et al., 2022). Considering this supply channel, we formulate Hypothesis 2 as follows:

H2: Fintech can increase green bonds issuance by empowering market intermediaries.

3.3. Fintech and Green Bonds Demand

Second, on the demand side, environmental awareness shows a significant rise among investors and society as a whole. Fintech can promote environmental awareness of the entire society, thereby increasing their attention and expenditures to green projects. Individuals and institutions are

increasingly prioritizing sustainable investments to address pressing environmental challenges. Many Fintech platforms now offer user-friendly interfaces, educational resources, and effect measurement tools that allow investors to align their financial objectives and environmental goals. For example, Ant Forest was introduced in August 2016 by Ant Financial Services Group — which is a subsidiary of Alibaba, China's largest online shopping company — with the primary objective of motivating users of Alipay, Alibaba's mobile payment platform, to actively reduce their carbon footprint. Ant Forest combines elements of the Internet, finance, and a low-carbon lifestyle, offering a gamified application that serves as a personal carbon account and facilitates participation in public benefit activities. With the help of Fintech development, the channels for cultivating environmental awareness have further expanded to the extent of improving the environmental awareness of the whole society through the daily use of Fintech applications. The increased environmental awareness results in higher environmental expenditure and demand for green projects (Eyraud et al., 2013; Liao et al., 2018), thereby acting as a mediator to increase the demand of issuance of green bonds. Following such mediation of the demand side, we formulate Hypothesis 3 below:

H3: Fintech magnifies the green bonds issuance by promoting social environment awareness.

As a result, the enhanced market mediation on the supply side coupled with the increasing environmental awareness on the demand side lead to the acceleration of green bonds issuance in the Fintech sector. This positive trend not only promotes sustainable finance but also drives the transition to a more environmentally conscious and socially responsible economy.

4. Data and Measures

The sample data begins in 2016, which is the year that the first green bond in China was issued. China city-level Fintech index is from the Institute of Digital Finance at Peking University and Ant Group. Many studies use the same index to measure Fintech development (e.g., Ding et al., 2022; Luo et al., 2022). The aggregate Fintech index is the weighted average of three sub-indices, namely, breadth of coverage, depth of usage, and level of digitalization. Breadth of coverage includes the number of Alipay account per 10,000 people, the average number of bank cards linked to each Alipay account, and the proportion of Alipay linking bank card users. Depth of usage is measured by Alipay users' participation in payment, money fund, lending, insurance, investment, and credit scoring businesses. The level of digitalization is calculated by the number/amount of digital payments, average lending interest rate, and use of credit[6].

The green bonds data are derived from the China Stock Market & Accounting Research (CSMAR) database and consist of different types of green bonds, including corporate, government-related, and asset-backed securities and financial bonds. Green bonds information also includes the city of issuance and can be matched to other city-level variables. The city-level controls are collected from the China Statistical Yearbook. We combine the datasets into a bond-city-year level panel. Table 1 presents the summary statistics of our final sample with 2,153 bond-city-year observations for 337 cities. All continuous variables are winsorized at the 1% and 99% levels. Among all the cities where our sample firms are located, the average level of financial technology development is measured as 236.60 by the Peking University Digital Financial Inclusion Index of China (PKU-DFIIC). We include bond-level and city-level control variables in our empirical setting. Bond-level control variables include: the terms of the loan of bonds in years,

[6] A more detailed introduction of the index indicators is shown in Appendix A2. For more details of the index calculation, please refer to https://en.idf.pku.edu.cn/docs/20190610145822397835.pdf.

bonds' credit levels, and the approved scale of issued green bonds (in RMB Yuan) by financial authorities; city-level control variables include the Gross Domestic Product per capita (in RMB Yuan) of cities, the population of cities, the total loan balance of financial institutions (in RMB Yuan) of cities, the administrative area (in square kilometers) of cities, and the number of words related to "Green Development" in the annual reports of the government of cities. Definitions of all variables are shown in Appendix Table A1. Table 2 shows the correlations among all the variables. We can see that the correlation between the Fintech index and the green bond issuance is significantly positive, suggesting the positive relation between the Fintech index and the green bond issuance.

[Insert Table 1 Here]

[Insert Table 2 Here]

5. Methodology and Empirical Results

5.1. Baseline Analysis

We first use an OLS regression to document the relationship between the Fintech index and the green bonds issuance. The model is as follows:

$$Log(Issue\_scale)_{i,c,t} = a_0 + \alpha_1 Fintech\_index_{c,t} + a_2\, Bond\_Level\_Controls_{i,t} + a_3 City\_Level\_Controls_{c,t} + FE(Year, City) + \varepsilon_{i,c,t}. \quad (1)$$

Our sample comprises bond-city-year level data, where *i* refers to bond, *c* refers to city, and *t* refers to year. In the model, *Log(Issue_scale)* is the natural logarithm of the green bonds issued in RMB yuan, and *Fintech_index* is the Peking University Digital Financial Inclusion Index of

China (PKU-DFIIC) where a high number indicates a high level of digital financial development. Control variables at the bond and city levels, as exhibited in Table 1, are included in the model. FE denotes year and city fixed effects. Our coefficient of interest is α_1.

Table 3 shows the results of the regression. In Column (1), we find a positive coefficient and statistically significant effect of the Fintech development on the issuance scale of green bonds. To test if the effect is attributed to city- and year-specific characteristics, given that Fintech index tends to cluster significantly within specific cities, we include different fixed effects. The results are presented from Columns (2) to (4). The positive and statistically significant coefficients remain, indicating that Fintech growth facilitates the issuance of green bonds among Chinese cities. This effect is also economically significant: a one-standard-deviation increase in Fintech index leads to a 0.714 billion RMB ($\approx$ 98.04 million USD) increase in the issue scale of green bonds[7].

[Insert Table 3 Here]

5.2. Endogeneity

Although a city-level green bond issuance is unlikely to also influence the Fintech development within the same year, potential endogeneity occurs in another two ways. First, Fintech and green bonds may be simultaneously influenced by omitted factors, which can widely range from socio-demographic and individual consciousness that are difficult to measure quantitatively. Second, the Fintech index also presents a potential measurement error. To address the potential endogeneity issue, we follow the settings of Qin et al. (2022) and Ding et al. (2022) that use the distance to

[7] When the Fintech index increases by a standard deviation, which is 34.08, issue scale (in RMB) increases on average by [exp(0.03 × 34.08) − 1] × 0.42 billion (mean value of issue scale), which is 0.714 billion RMB (≈ 98.04 million USD). Considering that more than half of cities do not issue green bonds (issue scale is zero), which lowers the mean value of the issue scale, the magnitude of the effect of Fintech index is considerable reasonable.

Hangzhou City as an instrument variable. Hangzhou is the center of Fintech in China and has a great effect on Fintech development. The distance to this city is highly related to the Fintech development level and is not likely to directly affect the green bond issuance or indirectly through other channels, thus being exogenous in our study. We use a two-stage least square method in Table 4, and the results are consistent with the baseline regression in Table 3 after instrumentation.

We also apply the Heckman two-stage regression to alleviate the concerns of the self-selection bias, which means the issuance scale of green bonds is conditional only on cities that have issued such bonds. Table 4 shows the results, which still have a strong and statistically significant association between Fintech development and green bonds issuance.

[Insert Table 4 Here]

The instrumental Variable (IV) and Heckman two-stage models aim to address concerns related to omitted variables and selection bias, respectively. Both methodologies rely on a Fintech index as a crucial factor. To complement these established methods, we also utilize the staggered adoption of city-level Fintech development policies as exogenous shocks, impacting regional Fintech development and, consequently, influencing green bond issuance. Since 2018, a number of major cities across Mainland China, such as Beijing, Shanghai, Shenzhen, Guangzhou, Chongqing, Chengdu, Hangzhou etc., have introduced supporting policies for financial technology. These policies include various preferential measures such as investment attraction, financing, talent subsidies, financial support, research incentives, and special investment funds to attract high-quality financial technology enterprises, research institutions, and top talents, promoting,

encouraging, and supporting the development of financial technology[8]. The results are presented in Table 5 Column (1). The primary independent variable, *Treat_Post*, takes the value of one if the city has implemented a Fintech policy in the respective year and thereafter, and zero otherwise. Notably, the coefficient of *Treat_Post* is positive and statistically significant at the 5% level which supports our notion that Fintech development can drive green bond issuance. Recognizing the current discussion on heterogeneity in treatment effects within staggered DiD models, following Zhou et al. (2023) and Butts and Gardner (2021), we have incorporated a two-stage DiD model to verify the robustness of our findings and also assess the validity of the parallel trend assumption. Detailed results are presented in Table 5 Column (2) and (3), and the accompanying Figure 1 illustrates the absence of a pre-trend before the implementation of the policies.

[Insert Table 5 Here]

[Insert Figure 1 Here]

5.3. Mediating Factors

The previous section tests the causal relationship between Fintech development and green bonds issuance. Now we further illustrate why Fintech can accelerate green bonds issuance, such as in our hypotheses. Enhanced intermediary environment and increased social environmental awareness can serve as two possible channels through which green bonds issuance increases with Fintech development. Accordingly, we further examine the mediating effects of enhanced intermediary environment and increased social environmental awareness by utilizing the Sobel test (Sobel, 1982, 1987). The regression models of the mediation tests are as follows:

[8] Source: Chinese Fintech Ecosystem White Paper (2020)
http://www.caict.ac.cn/kxyj/qwfb/bps/202211/t20221117_411575.htm

$$\begin{cases} IntEnv_{c,t}(EnvAwa_{c,t}) = \beta_0 + \beta_1 Fintech\_index_{c,t} + \beta_2\ Bond\_Controls_{i,t} + \beta_3 City\_Controls_{c,t} + \varepsilon_{i,c,t} \\ Log(Issue\_scale)_{i,c,t} = \gamma_0 + \gamma_1 Fintech\_index_{c,t} + \gamma_2 IntEnv_{c,t}\left(EnvAwa_{c,t}\right) + \gamma_3\ Bond\_Controls_{i,t} \\ \qquad\qquad + \gamma_4 City\_Controls_{c,t} + \varepsilon_{i,c,t} \end{cases} \quad (2)$$

where *Intermediary Environment* (*IntEnv*) and *Environmental Awareness* (*EnvAwa*) are the two mediating variables; γ_1 is the direct effect coefficient of Fintech development on green bonds issuance, controlling for the mediator variables; and $\beta_1 \times \gamma_2$ is the mediating effect of the two mediators between Fintech development and green bonds issuance. We use the "Development of Intermediary Environment" sub-index extracted from the "Marketization Index for China's Provinces" (Fan et al., 2001) to carry out a mediation analysis on the channel of enhanced market intermediaries. This index provides province-year measurements spanning from 2016 to 2020, where a high value signifies the advanced development of market intermediaries. Table 6 Panel A shows the results, which reveal a significantly positive mediation effect with the Sobel test's Z statistics significant at a 5% level. Thus, the progress of Fintech contributes to the enhancement of market intermediaries, which subsequently facilitates the issuance of green bonds. These results support the supply-side mechanism that illustrates how Fintech advancements expedite the adoption of green bonds.

Additionally, in our conceptual analysis, environmental awareness can serve as another possible channel through which Fintech promotes green bonds issuance. We count the total number of environmental-related words appearing in city government work reports to proxy for the environmental awareness of a city. China is a strong political society on which the government work report has a significant effect. The government encourages public engagement and empowers citizens to voice their concerns, suggestions, and expectations, thereby influencing

public decision making. The high number of environmental-related words in the work report indicates high citizens' concerns on the environment, which reflects environmental awareness in the city. Table 6 Panel B shows the results. In line with our prediction, the coefficient $\beta_1 \times \gamma_2$, which indicates the total mediation effect of environmental awareness is positive and the Z statistics of Sobel test is significant at 5% level. The mediation results show that Fintech development can contribute to environmental awareness and in turn, positively affect green bonds issuance. The results support the demand side channel where environmental awareness mediates the relationship between Fintech development and green bonds issuance.

[Insert Table 6 Here]

5.4 Heterogeneous Effects

Our tests show that Fintech development enhances green bonds issuance. As such, a related question is how this effect varies in different situations. We answer this question by carrying out heterogeneous tests in this section. First, in terms of green bonds issuance, we argue that the enhancement effect is more pronounced for bonds with low rather than high ratings. In China, bond-rating agencies have been criticized for being unable to provide high-quality ratings (Livingston et al., 2018). Investors face difficulties in obtaining enough information about bonds from rating agencies, especially for those without high ratings. Fintech can improve the development of market intermediary institutions, through which the public can obtain more information about bonds. Given that investors can already receive relatively adequate information for high-rating bonds, we argue that this incremental effect is larger for bonds without high ratings. In addition, Fintech itself can also provide more information about bonds in different

platforms with varying technologies (Buchak et al., 2018; Erel and Liebersohn, 2022). Bonds without high ratings are hard to advertise or draw attention from investors through traditional channels, and thus Fintech can be used to provide more information to investors. Therefore, we conjecture that the effect of Fintech on green bonds issuance is highly pronounced in bonds without high ratings. Table 7 Column (1) shows the test results. We define high-rating bonds as those with AA ratings or above. The interaction term is negative and statistically significant, supporting our conjecture.

Next, from the Fintech perspective, we argue that collaborations and communications between the IT sector, financial sector, and other organizations are very important for Fintech development given its introduction of new technologies into the financial sector. At the city level, travel cost constitutes an important friction to collaborations and communications (Catalini et al., 2020). Following Yao and Li (2022), we use the Chinese High-Speed Railways (HSR) construction as a quasi-natural experiment to see whether the enhancement effect of Fintech on green bonds issuance is more pronounced in cities connected to the HSR network than in other areas. In China, HSR is a cost-effective transport mode with high travel speed and relatively lower costs. We argue that in cities connected to the HSR network, Fintech developers can gain more opportunities to collaborate and communicate with other organizations because the high travel speed across cities brought by the HSR network creates a larger market for developers to match partners for Fintech projects. In addition, HSR network allows team members in inter-organizational collaborative Fintech projects to easily interact face-to-face, which can facilitate more efficient contact and interaction to build rapport, share tacit knowledge, and resolve differences. Thus, HSR connection is helpful for Fintech development and functions. Based on the above arguments, we conjecture that the effect of Fintech on green bonds issuance is more

pronounced in cities connected to the HSR network than in other areas. We define a city with at least one HSR station as connected to the HSR network. The opening dates of the HSR station are collected from the official website 12306.cn, which is maintained by the National Railway Administration of China. Table 7 Column (2) shows the results that the interaction term is positive and statistically significant, supporting our conjecture.

To delve deeper into the underlying motives behind bond issuance, we create a new dummy variable, *Refinance*, based on the use of proceeds from the green bond. This variable differentiates between funds earmarked for funding new projects and those intended for the refinancing of existing projects. A value of one is assigned to *Refinance* if the primary purpose of the issuance is to refinance an ongoing green project and zero otherwise. We argue that the impact of Fintech on green bond issuance is less prominent for refinancing projects. This conjecture arises from the notion that new projects inherently are less transparent compared to existing projects. Besides, refinancing bonds can be seen as renewals, conveying positive signals regarding a borrower's outlook (Karavitis et al., 2021). In the green bond market, green bond renewals indicate the borrower's ability to meet obligations and succeed in their green endeavors. This positive outlook may contribute to improved credibility and trustworthiness, fostering a more favorable environment for future bond issuance opportunities. In this scenario, the impact of Fintech may be minimal due to the already enhanced creditworthiness of refinancing projects. On the other hand, new projects are inherently characterized by uncertainty (Loch et al., 2008). Investors often harbor reservations regarding the newly issued green bonds, uncertain whether the invested funds will genuinely contribute to a green project. In this context, Fintech is anticipated to exhibit a more pronounced and effective role in providing transparency and mitigating information asymmetry, particularly in the financing of new projects. In line with our conjecture, as shown in Table 7 Column (3), the interaction term between refinance

and Fintech is negative and statistically significant, indicating that Fintech development has a more pronounced impact on new green bond issuance.

Given the unique institutional background in China where the state plays an important role in the economy, we create a dummy variable, *NonSOI*, to differentiate state-owned issuers (SOIs) and non-state-owned issuers (NonSOIs). *NonSOI* is assigned a value of one if the issuer is not state owned and zero otherwise. We argue that the effect of Fintech on green bond issuance is more pronounced for NonSOIs because in Chinese financial markets, NonSOIs encounter severer information asymmetry than SOIs (Tang and Fang, 2022) and Fintech can be effective in mitigating information asymmetry. In China, SOIs often have implicit government guarantees. SOIs are entities owned and operated by the government and since SOIs are owned by the government, there is a widespread perception that the government will step in to support them in times of financial distress. This ownership structure creates an implicit understanding that the government will not allow SOIs to fail. With the help of Fintech development, information asymmetry can be reduced to the minimum. While SOIs are inherently less susceptible to information asymmetry concerns, the advantage in these circumstances leans towards NonSOIs. Therefore, we should observe that NonSOIs tend to issue more green bonds with the Fintech development. In line with our prediction, as presented in Table 7 Column (4), the interaction between Fintech and NonSOIs is positive and significant, suggesting that Fintech development has a more pronounced impact on green bond issuance for NonSOIs[9].

[9] To answer the question whether the results on the Chinese market are generalizable to other regions, we also conduct subsample test by retaining only those bonds issued by NonSOIs, as they operate independently of government control. The result reveals that the coefficient of Fintech remains positive and statistically significant. Our additional analysis reinforces the notion that Fintech can drive green bond issuance even in the absence of strong state influence. This supports the argument that such activities are reflective of free-market dynamics rather than being driven solely by government initiatives, enhancing the generalizability of our findings.

To explore regional heterogeneity, we introduce a dummy variable, *Eastern*. Following Huang et al (2023), we assign *Eastern* the value of one if the green bond issuer is located in Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Guangdong, or Shandong, and zero otherwise. Fintech has achieved greater advancement in the eastern region of China, notably in major Fintech hubs such as Hangzhou and Shenzhen, home to industry giants Alibaba and Tencent. We hypothesize that, owing to the well-established Fintech culture in the eastern area, issuers located in this region will experience more positive effects with the continued development of Fintech innovation. The innovation diffusion is influenced not only by the features of the technology itself but also by user characteristics (Ryu, 2018). Given that users embrace and engage with new services or technologies at various time periods and to varying extents, Fintech users can be categorized into early adopters and late adopters, determined by the time they are exposed to the new technology (Kim et al., 2010). Early adopters play a crucial role as opinion leaders who inspire others to embrace and utilize new technologies by providing evaluative information (Rogers, 1995). On the other hand, late adopters exhibit resistance to change and harbor skepticism toward changes (Escobar-Rodríguez and Romero-Alonso, 2014). Early adopters anticipate that the benefits of Fintech usage outweigh the risks, while late adopters perceive the risks associated with Fintech usage as greater than the benefits. In green bond market, we posit that users in the eastern region of China are early adopters of Fintech, given the longstanding Fintech environment in the east. Consequently, we anticipate that, as Fintech develops, early adopters, represented by users in the eastern region, are inclined to issue more green bonds. Consistent with our prediction, as shown in Table 7 Column (5), the interaction between Fintech and Eastern is positive and significant, suggesting that Fintech development has a more pronounced impact on green bond issuance in the eastern region of China.

[Insert Table 7 Here]

5.5 Additional Tests

One may be concerned about the possible multicollinearity in our dataset since some of the city-level control variables are highly intercorrelated as presented in the correlation table. To mitigate the multicollinearity issue, following Tibshirani (1996) and Shi et al (2020), we apply the LASSO regression model in our baseline analysis. LASSO, or Least Absolute Shrinkage and Selection Operator, addresses multicollinearity and overfitting issues by adding a regularization term, which is a penalty based on the absolute values of the coefficients, to the ordinary least squares (OLS) objective function. The regularization term imposes constraints on the sum of the absolute values of the coefficients, leading many of them to be exactly zero, thus offering models with higher prediction accuracy. We present the LASSO regression result in Table 8 Column (1). There remains a significantly positive impact of Fintech on green bond issuance, indicating the robustness of our results despite the high correlations between some of our city-level control variables.

Another concern is there may exist underlying market factors related to the green bond issuance, such as the macro-economic development, the secondary market's volatility, and the capital and monetary market's liquidity. Following Agca et al (2023), we take these factors into account by employing an alternative regression model:

$$Log(Issue\_scale)_{i,c,t} = a_0 + \alpha_1 Inf_t + a_2 SSE_t + a_3 Bondrate_t + a_4 Dep_t + a_5 Loan_t + \varepsilon_{i,c,t} \quad (3)$$

where Inf_t stands for the monthly inflation rate; SSE_t represents the yearly return of CSI300 Index;

$Bondrate_t$ is the monthly rate of China 10-year Treasury bond yield; Dep_t is the one-year deposit rate; $Loan_t$ represents the one-year loan rate. All variables are between 2016 and 2020. Residuals from Equation (3) are used as the adjusted green bond issuance $Adj\_Log(Issue\_scale)_{i,c,t}$. The results are in Table 8 Column (2) and (3). The outcomes are consistent with the baseline regression results. Hence, our results remain robust after considering other possible market-driven factors.

[Insert Table 8 Here]

6. Discussion and Conclusions

Based on bond-city-year data from China, this study empirically documents a significant positive relationship between Fintech development and the promotion of green bond issuance. Using a two-stage least square estimation with the distance to Hangzhou city as an instrumental variable, the Heckman two-stage regression to address the self-selection bias, and a staggered DiD model that identifies a series of Fintech-facilitating initiatives in Chinese cities as an exogenous shock, we validate the robustness of our findings.

Delving deeper into the underlying mechanisms driving this association, the investigation reveals two plausible channels through which Fintech accelerates the development of green bonds. First, the increased supply of green bonds can be attributed to an enhanced intermediary market facilitated by Fintech advancements. Second, the growing demand for green bonds is stimulated by an improved environmental awareness catalyzed by Fintech innovations.

Furthermore, our analysis uncovers several heterogeneity patterns. First, we find that the abovementioned positive effect is particularly intensive for bonds without high ratings and whose proceeds are not used for refinancing. Additionally, we also find that the positive effect of Fintech

development on green bond issuance is notably more pronounced for non-stated-owned issuers, cities with better travel connectivity, as proxied by the development of the Chinese HSR network, and those located in the eastern region of China.

Our empirical findings necessitate increased focus from policymakers, investors, and financial intermediaries on the potential of regional Fintech development in green finance products. The implications are particularly relevant to policymakers and regulators. It is essential for regulators to understand the unique role of Fintech infrastructures and the environment in promoting green bond issuance, especially in relation to intermediary development. They should actively refine legislation and supervisory frameworks to adapt to the developing intermediaries embracing Fintech, while protecting investors. Moreover, regulators should guide innovative entities to enhance environmental awareness. For investors, it is vital to utilize the transparency and accessibility provided by Fintech in assessing and investing in green bonds. Financial intermediaries are also encouraged to acknowledge the usefulness of Fintech as a valuable tool for investment matchmaking, bridging the gap between bond financing and investors.

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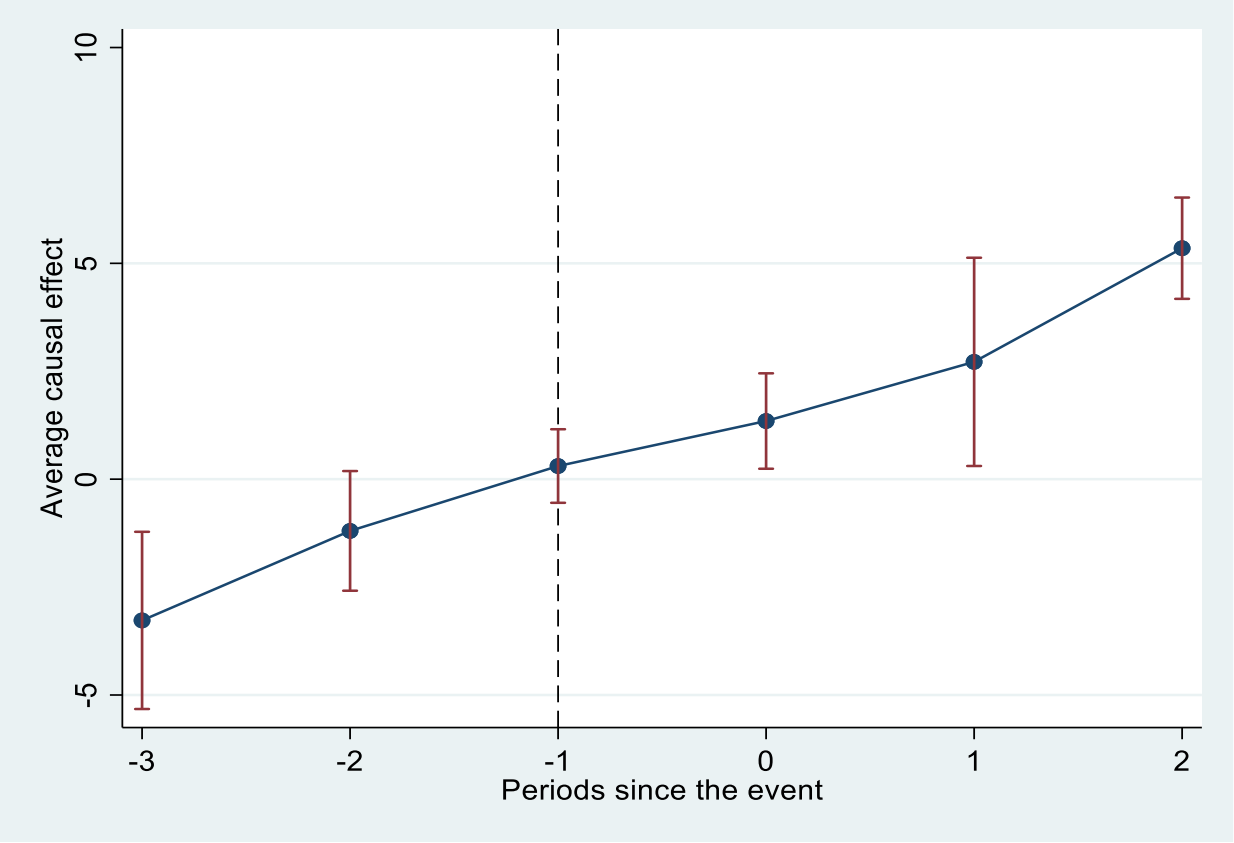


Notes: The figure shows the impact of Fintech-facilitating policies in a number of Chinese cities on the green bond issuance between 2016 and 2020. -3, -2, and -1 refer to the time three years, two years, and one year before the real timer of policy implementation, respectively. 0, 1, and 2 refer to the time in, one year, and two years after the real timer of policy implementation, respectively. The red lines represent 95% confidence intervals. Year and city fixed effects are included.

Figure 1. Event Plot of the Effect of Fintech-Facilitating Policy on Green Bond Issuance

Table 1. Summary Statistics

VARIABLES	Obs.	Mean	Median	Std. Dev.	Min	Max	p25	p75
Log(Issue_scale)	2,153	5.97	0.00	9.21	0.00	24.12	0.00	18.42
Fintech_index	2,153	236.60	233.59	34.08	125.50	334.50	213.40	260.70
Bond_term	2,153	1.43	0.00	2.87	0.00	20.00	0.00	2.68
High_rating	2,153	0.24	0.00	0.43	0.00	1.00	0.00	0.00
Log(Approval_scale)	2,153	6.46	0.00	6.54	0.00	24.64	0.00	0.00
Log(GDP_percapita)	2,153	8.28	10.62	4.92	0.00	13.19	0.00	11.53
Log(Population)	2,153	11.73	15.06	6.52	0.00	17.35	13.35	15.75
Log(Total_loan_percapita)	2,153	8.64	10.57	4.91	0.00	13.87	9.59	12.08
Log(City _area)	2,153	7.15	9.06	4.03	0.00	12.92	7.56	9.71
Log(Green_words)	2,153	7.18	8.65	3.29	0.00	9.44	8.46	8.79
Log(Distance)	2,153	6.77	6.98	0.91	0.00	8.31	6.42	7.28
Refinance	2153	0.04	0.00	0.20	0.00	1.00	0.00	0.00
NonSOI	2153	0.76	1.00	0.43	0.00	1.00	1.00	1.00
Eastern	2153	0.19	0.00	0.39	0.00	1.00	0.00	0.00
IntEnv	2,153	9.10	9.03	3.03	1.76	15.19	7.21	11.35
EnvAwa	2,153	8.69	8.70	0.19	7.02	9.43	8.60	8.79
HSR_connection	2,153	0.75	1.00	0.43	0.00	1.00	1.00	1.00

Notes: This table presents the summary statistics of all the variables in this study. The sample period is from 2016 to 2020. Variable definitions are shown in the Appendix, Table A1.

Table 2. Variable Correlations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) *Log(Issue_scale)*	1																
(2) *Fintech_index*	0.55***	1															
(3) *Bond_term*	0.78***	0.43***	1														
(4) *High_rating*	0.54***	0.13***	0.41***	1													
(5) *Log(Approval_scale)*	0.86***	0.46***	0.66***	0.50***	1												
(6) *Log(GDP_percapita)*	0.42***	0.13***	0.33***	0.22***	0.37***	1											
(7) *Log(Population)*	0.37***	0.03	0.29***	0.21***	0.32***	0.94***	1										
(8) *Log(Total_loan_percapita)*	0.45***	0.15***	0.35***	0.24***	0.39***	0.95***	0.97***	1									
(9) *Log(City_area)*	0.30***	-0.04*	0.24***	0.18***	0.27***	0.91***	0.98***	0.95***	1								
(10) *Log(Green_words)*	0.25***	0.29***	0.20***	0.15***	0.21***	0.49***	0.49***	0.50***	0.46***	1							
(11) *Log(Distance)*	-0.27***	-0.42***	-0.21***	-0.09***	-0.25***	-0.28***	-0.27***	-0.28***	-0.19***	-0.36***	1						
(12) *IntEnv*	0.30***	0.65***	0.21***	0.03	0.23***	0.07***	0.00	0.05**	-0.06***	0.35***	-0.47***	1					
(13) *EnvAwa*	0.25***	0.16***	0.16***	0.11***	0.20***	0.10***	0.07***	0.09***	0.04*	0.00	0.01	0.06***	1				
(14) *HSR_connection*	0.30***	0.38***	0.23***	0.15***	0.26***	0.08***	0.04**	0.08***	-0.02	0.11***	-0.24***	0.27***	0.09***	1			
(15) Refinance	0.34***	0.14***	0.36***	0.37***	0.51***	0.15***	0.14***	0.16***	0.12***	0.10***	-0.05**	-0.17***	0.07***	0.11***	1		
(16) NonSOI	-0.87***	-0.49***	-0.69***	-0.74***	-0.43***	-0.36***	-0.32***	-0.39***	-0.26***	-0.23***	0.20***	0.07*	-0.22***	-0.25***	-0.29***	1	
(17) Eastern	0.74***	0.50***	0.52***	0.61***	0.37***	0.35***	0.29***	0.36***	0.21***	0.23***	-0.29***	0.65***	0.23***	0.23***	0.24***	-0.58***	1

Notes: This table presents the Pearson correlation coefficients of all the variables in this study. The sample period is from 2016 to 2020. Variable definitions are shown in the Appendix, Table A1. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Fintech Index and Green Bonds Issuance

	Log(Issue_scale)			
	(1)	(2)	(3)	(4)
Fintech_index	**0.040*** **	**0.048*** **	**0.033*** **	**0.030** **
	(0.004)	**(0.005)**	**(0.004)**	**(0.015)**
High_rating	10.451***	10.211***	8.826***	8.687***
	(0.447)	(0.451)	(0.509)	(0.507)
Bond_term	0.914***	0.890***	0.732***	0.713***
	(0.065)	(0.064)	(0.063)	(0.062)
Log(Approval_scale)	0.177***	0.203***	0.138***	0.158***
	(0.021)	(0.022)	(0.022)	(0.022)
Log(GDP_percapita)	-0.021	-0.053	0.020	0.014
	(0.036)	(0.037)	(0.049)	(0.051)
Log(Population)	0.057	0.015	0.100**	0.035
	(0.053)	(0.051)	(0.047)	(0.045)
Log(Total_loan_percapita)	0.605***	0.495***	0.564***	0.532***
	(0.103)	(0.107)	(0.163)	(0.162)
Log(City_area)	-0.521***	-0.398***	-0.609***	-0.563***
	(0.092)	(0.099)	(0.145)	(0.143)
Log(Green_words)	-0.105***	-0.068***	-0.004	0.001
	(0.021)	(0.022)	(0.099)	(0.098)
Constant	-8.956***	-10.342***	-7.083***	-5.610
	(0.784)	(1.069)	(1.267)	(3.705)
Year Fixed Effect	No	Yes	No	Yes
City Fixed Effect	No	No	Yes	Yes
Observations	2,153	2,153	2,153	2,153
Adj. R-squared	0.862	0.865	0.908	0.910

Notes: This table presents the OLS estimation results based on the baseline model, in which the dependent variable is *Log*(*Issue_scale*), the natural logarithm of the scale of issued green bonds, and the independent variable is *Fintech_index*, which is the Peking University Digital Financial Inclusion Index of China (PKU-DFIIC). Several bond- and city-level control variables are included. Variable definitions are shown in the Appendix, Table A1. Robust standard errors are reported in parentheses under estimated coefficients. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Instrument Variable Approach and Heckman Test

	IV(2SLS)		Heckman	
	(1)	(2)	(3)	(4)
	1st Stage	2nd Stage	1st Stage	2nd Stage
	Fintech_index	*Log(Issue_scale)*	*Green_bond*	*Log(Issue_scale)*
Log(Distance)	-76.510***			
	(-30.79)			
Fintech_index			**0.019*** **	**0.011*** **
			(0.007)	**(0.003)**
$\widehat{Fintech\_index}$		**0.040*** **		
		(12.43)		
Inverse_Mills				-0.081
				-0.368
Controls	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	No	No
City Fixed Effect	Yes	Yes	No	No
Observations	2,153	2,153	2,153	2,153
Adj. R-squared		0.864		

Notes: This table presents the estimation results of two-stage least square model and Heckman two stage model. *Log(Distance)* is the instrument variable, measured as the natural logarithm of the spherical distance between specific city and Hangzhou. *Green_bond* is a dummy variable being 1 if the city has issued green bond in a year, and otherwise 0. Other variables are the same as those used in Table 2. Variable definitions are shown in the Appendix, Table A1. Robust standard errors are reported in parentheses under estimated coefficients. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

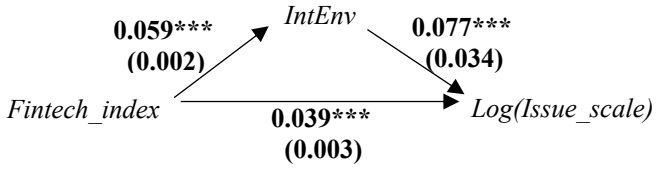
Table 5. Staggered Difference-in-Difference (DiD) and DiD Two Stage Test

	Staggered DiD	DiD Two Stage	
	Log(Issue_scale)	*Log(Issue_scale)*	
	(1)	(2)	(3)
Treat_Post	**2.093****	**3.423*****	
	(0.883)	**(-4.91)**	
Event_-3			-3.272***
			(-3.12)
Event_-2			-1.198*
			(-1.69)
Event_-1			0.305
			(-0.70)
Event_0			1.347**
			(-2.39)
Event_1			2.717**
			(-2.21)
Event_2			5.350***
			(-8.94)
Controls	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
City Fixed Effect	Yes	Yes	Yes
Observations	2,153	2,153	2,153
R-squared	0.911		

Notes: This table presents the results of the staggered Difference-in-Difference (DiD) regression and DiD two stage regression. Our identification strategy employs a series of regional policies that aims to facilitate financial technology development as an exogenous shock. *Treat_Post* is the variable of interest, which equals one if a city *i* implements the policy in and after year *t*, otherwise 0. In the DiD two stage model, *Event_-3*, *Event_-2*, and *Event_-1* refer to the time three years, two years and one year before the real timer of policy implementation, respectively. *Event_0*, *Event_1*, and *Event_2* refer to the time in, one year, and two years after the real timer of policy implementation, respectively. Controls, city and year fixed effects are included. Variable definitions are shown in the Appendix, Table A1. Robust standard errors are reported in parentheses under estimated coefficients. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

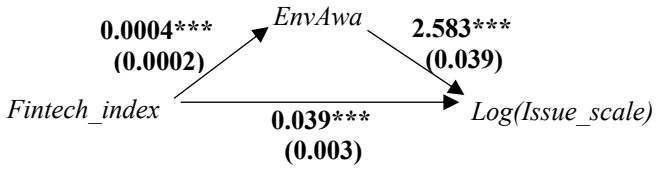
Table 6. Effects of Mediating Tests

Panel A: Mediating Effect of Intermediary Environment



	Coef(β_1*γ_2)	Z
Sobel	0.005	2.255**
Goodman-1 (Aroian)	0.005	2.253**
Goodman-2	0.005	2.256**

Panel B: Mediating Effect of Environmental Awareness



	Coef(β_1*γ_2)	Z
Sobel	0.001	2.323**
Goodman-1 (Aroian)	0.001	2.323**
Goodman-2	0.001	2.348**

Notes: This table presents the estimation results of mediation tests. In Panel A, *IntEnv* is the Development of Intermediary Environment, a sub-index of the Marketization Index for China's Provinces. In Panel B, *EnvAwa* is the Environmental protection focus, measured by the natural logarithm of the total number of environmental-related words appearing in city government work reports. Variable definitions are shown in the Appendix, Table A1. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Heterogeneity Test: Credit Ratings, High Speed Railway, Refinance, NonSOI, and Region

	Log(Issue_scale)				
	(1)	(2)	(3)	(4)	(5)
Fintech_index	0.064***	0.006	0.030**	-0.001	0.006
	(0.018)	(0.014)	(0.015)	(0.014)	(0.012)
Fintech_index*High_rating	**-0.066*** **				
	(0.011)				
High_rating	26.041***				
	(2.966)				
Fintech_index*HSR_connection		**0.022*** **			
		(0.006)			
HSR_connection		-5.189***			
		(1.213)			
Fintech_index*Refinance			**-0.058*** **		
			(0.018)		
Refinance			13.070***		
			(4.756)		
Fintech_index*NonSOI				**0.044*** **	
				(0.010)	
NonSOI				-18.253***	
				(2.739)	
Fintech_index*Eastern					**0.030*** **
					(0.010)
Eastern					1.628
					(2.701)
Controls	Yes	Yes	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes	Yes	Yes
City Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	2,153	2,153	2,153	2,153	2,153
Adj. R-squared	0.913	0.912	0.913	0.936	0.930

Notes: This table presents the estimation results of heterogeneity tests. *High_rating* is a dummy variable that equals 1 if a bond is rated AA or above, and otherwise 0. *HSR_connection* is a dummy variable that equals 1 if a city has a HSR station, otherwise 0. *Refinance* is a dummy variable that equals 1 if the proceeds of green bonds are partly used for refinancing, otherwise 0. *NonSOI* is a dummy variable that equals 1 if the issuer is not state-owned, otherwise 0. *Eastern* is a dummy variable that equals 1 if the green bond is issued in a city located in the eastern region of China otherwise 0. Variable definitions are shown in the Appendix, Table A1. Robust standard errors are reported in parentheses under estimated coefficients. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Table 8. Additional Tests

	Lasso Regression	Residual Test	
	Log(Issue_scale)	*Adj_Log(Issue_scale)*	
	(1)	(2)	(3)
Fintech_index	**0.039*** **	**0.047*** **	**0.030** **
	(0.003)	**(0.005)**	**(0.015)**
Controls	Yes	Yes	Yes
Year Fixed Effect	Yes	No	Yes
City Fixed Effect	Yes	Yes	Yes
Observations	2,153	2,153	2,153
R-squared		0.860	0.906

Notes: This table presents the LASSO regression and residual regression results. *Adj_Log(Issue_scale)* in the residual test is the adjusted green bond issuance proxied by the residuals from Equation (3). Year and city fixed effects are included. Variable definitions are shown in the Appendix, Table A1. Robust standard errors are reported in parentheses under estimated coefficients. ***, **, and * represent significance at the 1%, 5%, and 10% levels, respectively.

Supplementary Appendix

A1. Variable Definitions

Table A1. Variable Definitions

Variables	Definitions
Log(Issue_scale)	Natural logarithm of the scale of issued green bonds (in RMB Yuan).
Fintech_index	Peking University Digital Financial Inclusion Index of China (PKU-DFIIC).
Bond_term	Terms of the loan of bonds in years.
High_rating	Dummy of whether bonds are at credit levels of AA, AA+, or AAA (Yes=1, No=0).
Log(Approval_scale)	Natural logarithm of the approved scale of issued green bonds (in RMB Yuan) by financial authorities.
Log(GDP_percapita)	Natural logarithm of the Gross Domestic Product per capita (in RMB Yuan) of cities.
Log(Population)	Natural logarithm of the population of cities.
Log(Total_loan_percapita)	Natural logarithm of the total loan balance of financial institutions (in RMB Yuan) of cities.
Log(City_area)	Natural logarithm of the administrative area (in square kilometers) of cities.
Log(Green_words)	Natural logarithm of the number of words related to "Green Development" in the annual reports of the government of cities.
Log(Distance)	Natural logarithm of the spherical distance (in kilometers) between county where the household is located and Hangzhou.
Green_bond	Dummy of whether a city has issued green bonds in a year (Yes=1, No=0).
IntEnv	Development of Intermediary environment, a sub-index of China Market Index.
EnvAwa	Environment protection focus, natural logarithm of the number of words related to environment protection in the announcements of city governments.
HSR_connection	Dummy of whether cities have a HSR station in a year (Yes=1, No=0).
Refinance	Dummy of whether the proceeds of green bonds are used for refinancing (Yes=1, No=0).
NonSOI	Dummy of whether the issuer is not state-owned (Yes=1, No=0).
Eastern	Dummy of whether the green bond is issued in a city located in the eastern region of China (Yes=1, No=0).

A2. Fintech Index

The Fintech index used in this study is The Peking University Digital Financial Inclusion Index of China (PKU-DFIIC). This index was produced by a research team from the Institute of Digital Finance at Peking University and Ant Group. The index covers 31 provinces (and municipalities directly under the Central Government and autonomous regions, referred to as "provinces"), 337 cities above the prefecture level (and regions, autonomous prefectures, alliances, referred to as "cities"), and nearly 2,800 counties (and county-level cities, banners, municipal districts, referred to as "counties"). The data do not include Hong Kong SAR, Macao SAR, and Taiwan province. Spanning from 2011 to 2020 (data at the county level spans from 2014 to 2020), PKU-DFIIC involves coverage breadth, usage depth, and digitization level; usage depth involves sub-indexes such as payment, insurance, credit, investment, and money funds.

The following Table A2 shows the details of the primary, secondary, and specific indicators of the index. The primary indicators include coverage, usage depth, and digital support services. Coverage measures the proportion of users receiving corresponding internet finance services. Usage depth measures the depth of Internet financial services used within the population, including the depth of payment, credit, insurance, investment, and credit reporting services. For digital service support, convenience, including the cost of capital, is the main factor included in assessing the service quality.

Table A2. Fintech Index

Primary indicator	Secondary indicator		Specific indicator
Coverage	Account coverage rate		Number of Alipay accounts per 10,000 people
			Proportion of Alipay users with linked bank cards
			Average number of bank cards linked to each Alipay account
Usage depth	Payment business		Average number of payments per person
			Average payment amount per person
			Percentage of high-frequency (active 50 times or more annually) users among users active 1 time or more annually
	Credit business	For individuals	Number of Internet consumer loan users per 10,000 Alipay adult users
			Average number of loans per person
			Average loan amount per person
		For small and micro business owners	Number of Internet small and micro business loan users per 10,000 Alipay adult users
			Average number of loans per small and micro business owner
			Average loan amount per small and micro business owner
	Insurance business		Number of insured users per 10,000 Alipay users
			Average number of insurance policies per person
			Average insurance amount per person
	Investment business		Number of Internet investment and financial management participants per 10,000 Alipay users
			Average number of investments per person
			Average investment amount per person
	Credit reporting business		Number of Alipay users per 10,000 using credit-based life services (including finance, accommodation, travel, socializing, etc.)
			Average number of calls per person to personal credit reporting
Digital support services	Convenience		Percentage of mobile payments
			Percentage of mobile payment amount
			Financial service costs
			Average loan interest rate for small and micro business owners
			Average loan interest rate for individuals