Environment, Development and Sustainability
https://doi.org/10.1007/s10668-024-04919-5

Discovering the sustainable development role of fintech credit and the pilot low carbon project on greenwashing in China

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Received: 5 February 2024 / Accepted: 11 April 2024

Abstract
Low-carbon development is important to reduce global warming, allow people to live in normal temperatures and climates, and limit the loss of labor productivity by avoiding air pollution. However, greenwashing prevents low-carbon development by making companies appear more eco-friendly than they are. Therefore, this study examines the influence of financial technology (FinTech) credit and the implementation of the Pilot Low Carbon Project on corporate greenwashing in China from 2015 to 2021. The study uses the method of moment quantile regression (MMQR) to determine that FinTech credit and low-carbon projects prevent greenwashing behavior and promote environmentally sustainable corporate practices in China. Fintech plays a crucial role in monitoring the environmental impact of urban development, especially in the context of the Low Carbon City Initiative. The influence of Fintech Credit on greenwashing experiences a notable reduction in the higher quantiles, especially between the 75th and 95th culminating in a significant decrease to approximately −0.07. Companies outside the low carbon city areas consistently experience a negative impact of Fintech Credit on greenwashing. This investigation contributes significantly to the discourse on the interplay between greenwashing, FinTech and sustainable urban development. It also provides valuable insights for the development of strategies aimed at mitigating misleading environmental claims made by companies.

Keywords Greenwashing · Fintech credit · Pilot low carbon project · Sustainable development · Quantiles moments

1 Introduction

The Sixth Assessment Report of the Intergovernmental Panel on Climate Change documents that the average global surface temperature has risen by 1.09 degrees Celsius from pre-industrial times to recent times. Of the five common socio-economic pathways discussed in the report, only the discussion of the lowest emissions scenario will contribute to

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Published online: 16 May 2024

limiting global climate change to 1.5 degrees. Celsius by the turn of the century, as envisioned by the Paris Agreement. Such considerations suggest that a faster and more conscientious reduction of carbon (CO_2) emissions and other greenhouse gas (GHG) emissions is needed immediately. China is one of the world's largest emitters of carbon dioxide. China has set itself the target of reducing CO_2 emissions to 30.60% by 2030. In addition, the country is trying to achieve carbon neutrality by 2060. China has adopted several climate policies on energy efficiency, the use of renewable energy and changing consumption patterns at provincial and national level. For example, the country has adopted the Strategic Plan for Energy Development 2014 to 2020. Such action plans promote the use of renewable energies. The Green Travel Action Plan, which was adopted from 2019 to 2022, also seeks to promote newer forms of energy in vehicles and low-carbon travel methods. The studies by Qiu et al. (2021) and Hsieh et al. (2020) state that these climate policy measures help to reduce carbon intensity.

Apart from the provincial and national policies mentioned above, China is also busily implementing climate policies at the city level. Notable city-level climate policies include the China Pilot Low Carbon City Program (CPLCCP). It was introduced in 2010. It is important to note that while cities account for only about 2% of the global land area, they consume about 78% of global energy and about 60% of carbon emanations. The National Development Reform Commission was tasked with implementing the CPLCCP. The first batch of the CPLCCP was launched in eight cities on July 19, 2010. In addition, the National Development Reform Commission has also successively implemented the second and third rounds of the CPLCCP in 2012 and 2017. The policy measures include the formulation of sustainable energy and the development of a targeted system to reduce GHG emissions, which should lead to a low-carbon standard of living (Khanna et al., 2014; Cheng et al., 2019; Song et al., 2020).

However, the extent to which the CPLCCP program has helped to combat greenwashing, i.e. the practice of exaggerating sustainability commitments (Zhang, 2023b), remains to be investigated. The term 'greenwash' was first created to document the dishonesty of companies in presenting their environmental protection performance statements (Zhang, 2023a). The term is used in the context when a company spreads false information to project a socially responsible and environmentally friendly image. According to corporate social responsibility theory, dishonest companies use greenwashing as an advertising strategy (Lee et al., 2018). In order to enter the competition and increase market share, companies develop the practice of greenwashing (Smith & Font, 2014). In this context, companies deceive consumers about their environmental practices (Parguel et al., 2015).

A handful of studies have examined the impact of the CPLCCP on emission levels (Huo et al., 2022; Pan et al., 2022). It is an important tool in China to compensate for market failures and promote the path of sustainability. Nevertheless, it is unclear whether the CPLCCP is effective in curbing greenwashing. Previous research has hardly investigated how the implementation of CPLCCP can promote corporate governance sustainability and prevent greenwashing. This study therefore addresses this major lacuna and explores in depth the impact of CPLCCP in preventing greenwashing.

Fintech has transformed business activities, money markets and finance over the last decade. Fintech includes online banking activities, cryptocurrencies, crowdfunding activities and blockchain. Fintech has managed to drive financial inclusion and democratize financial services. Fintech is helping to promote green financing activities. The study by Cen and He (2018) shows that fintech enhances energy efficiency and thus benefits climate change.

In addition, FinTech helps companies to make optimal use of energy and thus reduce pollution (Muganyi et al., 2021). However, FinTech devices lead to the generation of e-waste and cause GHG emissions (Lu et al., 2023). Although FinTech impacts the environment through various channels, it is still unclear how FinTech might impact greenwashing in the context of China. Therefore, newer forms of evidence are needed to investigate the role of fintech in greenwashing and climate change.

Based on the above, this study examines the impact of CPLCCP and fintech on greenwashing in Chinese cities, including those that have introduced low-carbon projects. This research, which draws on the findings of Guo et al. (2023) and Muganyi et al. (2022), is particularly pertinent given China's rapid economic growth and significant progress. In addition, it is important to understand the impact of fintech credit on greenwashing is key to evaluate the effectiveness of China's environmental policies, as suggested by Hu et al. (2023) and Liao et al. (2023). By analyzing the ecological change driven by Chinese citizens, one can determine whether these initiatives actually improve environmental standards or promote more superficial sustainability claims Figure 1.

This research makes several contributions. First, we contribute to the literature by examining the impact of fintech credit on greenwashing. While Xie et al. (2023) investigated the impact of fintech on corporate greenwashing in China, this study extends broadened their framework with quantile analysis to split the difference between investors in the tails of the distribution. Second, this study is the first to examine the impact of China's Pilot Low Carbon City Program (CPLCCP) on greenwashing. Third, the study examines the role of fintech and the CPCCP in greenwashing practices that hinder the PRC's goal of achieving zero emissions. This phenomenon also hinders global sustainability goals such as the UN

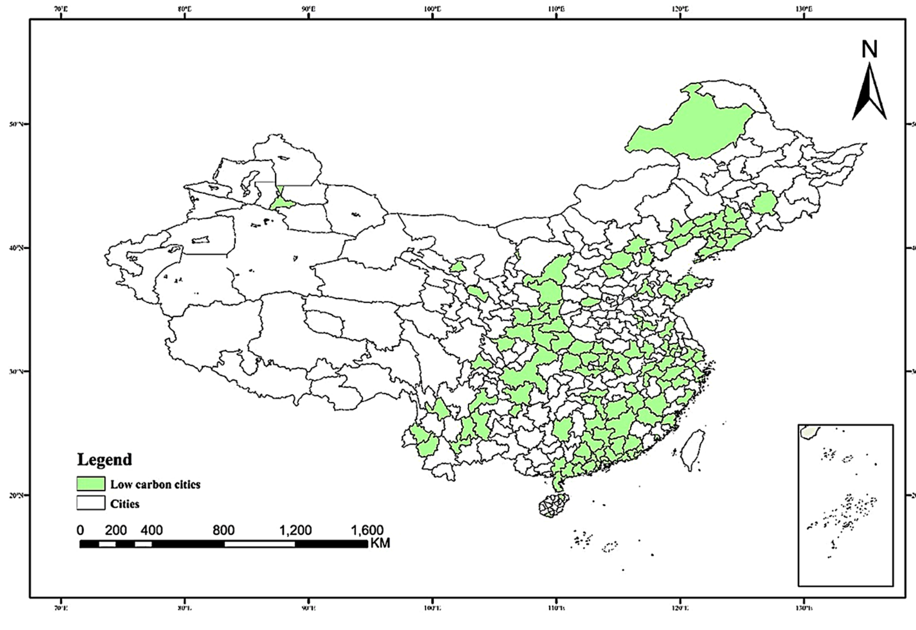

Fig. 1 China pilot low carbon cities distribution

Sustainable Development Goals (SDGs) by obscuring the environmental and social impacts of companies (Nations, 2020). Fourth, this study simultaneously contributes to the policy discussion on achieving the SDGs. Thu study employs the novel econometric estimation technique, namely Method of Moments Quantile Regression (MMQR) developed by Machado and Santos Silva (2019). The MMQR represents a methodological advance as it circumvents the limitations of mean-based research. Given the different effects of Fintech and CPCCP on greenwashing depending on the emission levels, the application of the method of moments quantile regression proves to be suitable to investigate the heterogeneity of the influence of the regressors on the target variables.

China is one of the largest markets for green finance and is responsible for 1/3 of global greenhouse gas emissions, but the low level of transparency in China increases concerns about greenwashing (Kapron, 2023). Taking these concerns into account, the study analyzes for the first time the impact of Fintech on greenwashing with a comprehensive dataset from the Low Carbon City Initiative using the MMQR approach, contributing to existing knowledge.

The empirical results document interesting findings. In cities where the Low Carbon Project has been enforced, companies note a positive effect of fintech on the prevalence of greenwashing. The analysis also shows that the size of a company has a variable influence on greenwashing, depending on the quantile range. There is also a positive correlation between company size and greenwashing, regardless of company size. In contrast, the age of the company shows an increasingly smaller positive influence on greenwashing the further one moves into the quantile range.

The rest of the article is structured as follows. Literature review gives an overview of the related literature. Methodology and Data describes the dataset and methodology. Empirical Results presents and discusses the results. Conclusion and Policy Implications concludes by pointing out the need to develop new policy implications.

2 Literature review

Researchers have analyzed the impact of financial development on carbon emissions in many studies. Some studies state that financialization has a carbon-reducing effect (see e.g., Guang-Wen et al., 2023), while others state that financial progress increases environmental pollution (Raheem et al., 2020; Pata et al., 2023). On the one hand, financialization can increase economic expansion and the consumption of energy from fossil fuels, but on the other hand, it can also support green growth by increasing environmental funds (Tamazian et al., 2009). Fintech is a new indicator of financialization that has recently come to the fore, and its effects on greenwashing are a matter of debate. Free et al. (2024) call for the expansion of research on the nexus of greenwashing and sustainability, and some studies examine greenwashing from the perspective of firm and consumer behavior (Fella & Bausa, 2024; Li et al., 2024; Liu et al., 2024a).

The recent studies in the literature explore the concepts of greenwashing, FinTech, and ESG disclosures, and summarizes several research findings to offer a holistic understanding of the interrelationships and emphasize the significant societal concerns (Zhang & Kong, 2022). Wu and Huang (2022) highlight the importance of combating greenwashing in ESG information in order to implement carbon neutrality strategies and effectively promote green finance. The requirement for publicly traded companies to disclose information on environmental, social and governance (ESG) factors, as explored by Khan (2022), demonstrates the importance of these factors in assessing company performance and guiding investor approaches (Cepni et al., 2023).

A key element of this discussion concerns the widespread phenomenon of greenwashing, where companies often amplify or distort their ESG efforts in order to obtain funding or cultivate a positive public image, as highlighted in research conducted by (Li & Wang, 2022). Empirical evidence has shown that greenwashing practices negatively affect stakeholder trust and necessitate stricter ESG reporting criteria (Glavas et al., 2023).

Liao et al. (2023) investigated the influence of financial report comment letters on the practice of greenwashing in companies listed on the A-share market. They found a clear link between these letters and an increase in greenwashing, which is often characterized by the use of persuasive language and manipulation of tone. (Hu et al., 2023) examined how companies respond to environmental taxes and found that tax reform only minimally encourages environmentally friendly innovation and investments. This means that companies with high pollution levels may develop greenwashing practices to meet regulatory requirements. Zhang et al. (2022) investigated the impact of subsidy shocks on greenwashing among companies listed on the Chinese stock exchange. They point out that after the removal of subsidies, greenwashing practices increased, especially among financially constrained companies and in less competitive markets. In particular, companies reduce their investments in innovation in times of financial difficulties. Xie et al. (2023) investigated the influence of fintech on the practice of corporate greenwashing in China. The findings suggest that fintech has a significant positive effect on curbing such fraudulent behavior and promoting the adoption of green practices by companies. This effect is particularly pronounced when fintech is combined with financial constraints.

Greenwashing is seen in the studies by Siano et al., 2017) and Yang et al. (2020) as a strategy for decoupling against the background of environmental aspects. Companies accept the need to adopt environmental practices, but not at the expense of economic efficiency. As information disclosure contributes to perception (Deegan, 2002), companies engage in greenwashing by disclosing information (Bowen, 2014). On the basis of carbon disclosure projects, companies can disclose their strategies for reducing GHG emissions. However, companies may not be fighting climate change realistically. Their activities are symbolic and not practiced in a real sense (Gonzalez & Ramírez, 2016). MacKay and Munro (2012) argued that companies use information about climate change to influence public perceptions rather than as a tool to bring about real change in business practices.

When companies are confronted with new institutional requirements, they often respond only superficially and may not carry them out (Zhang et al., 2022). Companies often declare planned capital expenditures to protect the environment, but the actual amount spent is often less than the stated amount (Patten, 2005). Companies have internal management organizations for environmental issues, but they do not function properly. The organizations actively participate in environmental protection projects and make the relevant information public. However, the work of the companies has not improved significantly (Iatridis & Kesidou, 2018). The study by Marquis and Tofel (2016) argues that even during environmental crises, companies partially disclose their environmental behavior.

There is an extensive literature examining the nexus between fintech and the development of the economy (Allen & Gale, 1994; Bollaert et al., 2021; Beck et al., 2016; Houston et al., 2010). Similarly, there is a growing literature examining issues related to fintech and climate change (Ullah et al., 2023; Jahanger et al., 2023; Su et al., 2020; Zeraibi et al., 2021). However, discussions in the literature on the nexus between fintech, greenwashing, and climate change issues are still sparse. There is a policy discussion on how fintech could play an important role in the context of climate change. The empirical literature on the relationship between greenwashing by Fintech and climate change is still unexplored.

Fintech credit promotes entrepreneurship and job creation under SDG 8 (decent work and economic growth) by providing small and medium-sized enterprises (SMEs) with critical financing that is often overlooked by traditional banks (Danladi et al., 2023). It promotes innovation under SDG 9 (Industry, Innovation, and Infrastructure) by funding start-ups and innovative projects that drive technological progress. Sustainable cities and communities (SDG 11) can finance sustainable urban projects that create environmentally friendly and sustainable urban environments (Liu et al., 2024b). In addition, fintech platforms that focus on sustainable investments channel funds into sustainable businesses as part of SDG 12 (Responsible Consumption and Production) (Mirza et al., 2023).

Many researchers have focused primarily on evaluating cities that favor low-carbon practices. These studies have examined the intricate relationship between the creation of environmentally conscious urban centers and the presence of businesses that conduct activities with sustainable tools (Chen et al., 2022; Muganyi et al., 2022; Zeng et al., 2023). A study by You et al. (2022) examined the impact of urbanization on CO_2 emissions in 352 Chinese cities from 2000 to 2015. Using spatial Durbin and threshold regression models, they investigated the relationship between CO_2 emissions and various dimensions of urbanization. Their findings indicate a non-linear relationship between these two factors. In particular, urbanization brings economic benefits to small, medium and large cities, while megacities show an opposite trend. The detrimental impact of urbanization on land are more pronounced in smaller and larger cities than in their larger counterparts. The study finds that a tipping point in urbanization can be observed, due to multiple environmental, financial, and technological advancements.

China's government has developed a low-carbon city program to reduce energy consumption and carbon (CO_2) emissions from major cities. However, the impact of this program on improving environmental quality and promoting sustainable development is mixed. For example, the study by Feng et al. (2021) documents that the introduction of the CPLCCP has increased carbon intensity, contrary to the objective of the CPLCCP. The study argues that these unexpected results could be due to the development of infrastructure, which consumes more energy. In contrast to the study by Zeng et al. (2023), the CPLCCP has significantly reduced carbon intensity. The study argues that these empirical results are due to improved urban governance, urban innovation, and the optimization of industrial structure. The study by Huo et al. (2022) uses a cost-benefit analysis to argue that the pilot cities in China were able to reduce CO_2 emissions. These cities reduced emissions by adapting the industrial structure and promoting technological innovations that led to research and development of low-carbon technologies.

The study by Zhang (2023a) examined the impact of the centralization of national environmental quality on the greenwashing behavior of companies. The study shows that the centralization of national environmental quality significantly reduces the greenwashing behavior of enterprises. The study further demonstrates that firms associated with cleaner production and firms with a larger dose of green financing are less likely to engage in greenwashing. The study highlights the role of government regulation in curbing greenwashing behavior. The work of Zhang (2023b) is perhaps the only study that documents how CPLCCP affects greenwashing. The study shows that companies affected by the pilot programs tend to engage in more greenwashing. In particular, these companies are selective in publishing positive information and suppress negative news. Such behavior is prevalent for state-owned firms, companies in areas with heavy government intervention, and companies in high-growth areas. The findings thus highlight how pilot projects mislead investors and regulators.

3 Methodology and data

3.1 Methodology

The standard ordinary least squares (OLS) method can be used to quantify the correlation between fintech and other factors related to greenwashing practices (Liao et al., 2023). However, the OLS method minimizes the sum of squared residuals without understanding the relationship between the variables at the different tails of the joint distribution (Muganyi et al., 2022). For panel data, fixed-effects procedures are used to perform analyzes. The study utilizes the procedure of Machado & Silva (2019) to understand the dynamics within the distribution tails in a panel data framework. A well-known approach for quantile panel data regressions integrates additive fixed effects into the joint distribution. Compared to existing quantile approaches, the main advantage of Machado and Silva's (2019) regression is the use of additive fixed effects to provide distributional estimates of the dependent variable.

The MMQR is particularly suitable when the explanatory variables of the model are endogenous. In particular, MMQR provides estimates of regression quantiles that do not overlap, a crucial condition that is often overlooked in empirical applications (Machado & Silva 2019). The conditional quantiles estimate Qy(τ|X) of the location-scale variant model can be shown as in Eq. (1):

$$y_{it} = a_i + X_{it}'b + (\vartheta_i + Z_{it}'d)U_{it} \tag{1}$$

where $P(ci+Zit'\gamma>0)=1$ determines the probability. (a, b′, c, d′) are the coefficients to be estimated. (a*i*, c*i*), *i* = 1, 2, 3,…, n,corresponds to the fixed effect "*i*" for each individual in the panel. *Z* defines a *k*-vector of operators in *X* as in Eq. (2):

$$Z_i = Z_i\left(X\right), i = 1, \ldots, k \tag{2}$$

Xit and *Uit* are i.i.d and do not vary over time (*t*). Uit is orthogonal to Xit to guarantee a consistent estimation, as introduced by Machado & Silva (2019). After including quantiles in Eq. 1 and with some adjustments, Eq. (3) can be constructed:

$$Q_y\left(\tau|X_{it}\right) = \left(a_i + c_i q\left(\tau\right)\right) + X_{it}'b + Z_{it}'dq\left(\tau\right) \tag{3}$$

In Eq. (3), *Qy*(τ|*Xit*) refers to the quantile distribution *Yit* depending on the position of the independent factors observed in *Xit*. *Xit′* corresponds to the vector of regressors. The expression $Xit'-ai(\tau)\equiv ai+ciq(\tau)$ refers to the scalar estimate for individual effects (i) at quantile (τ).

$$min\sum i\sum t\rho_{it}(R_{it}-(\delta_i+Z'_{it}+\gamma) \tag{4}$$

The parameter $q(\tau)$ is the ($\tau-$th) quantile snippet, which reflects the solution of the subsequent optimization problem. In Eq. (4), the term $\rho\tau(Rit-(\delta i+Zit'\gamma)q)$ represents the verification function.

3.2 Data

This study aims to evaluate the prevalence of greenwashing practices among companies listed on the A-share market of Shanghai and Shenzhen stock exchanges for the period from 2015 to 2021 with 7364 observations (nearly 1052 firms). The dataset is limited to the year 2015 due to the limited accessibility of financial report comment letters prior to this period. The data on environmental, social, and governance (ESG) disclosure are obtained from the Refinitiv Eikon database. The dependent variable is the estimated greenwashing of companies. Following Liao et al. (2023), and Zhang (2023a), greenwashing can be measured as in Eq. (5):

$$\mathrm{GW}_{i,t}=\frac{\frac{\left[ESG\ Disclosure_{i,t}-\overline{ESG\ Disclosure_{i,t}}\right]}{\sigma\ ESG\ Disclosure}}{\frac{\left[ESG\ action\ _{i,t}-\overline{ESG\ action\ _{i,t}}\right]}{\sigma\ ESG\ action}} \tag{5}$$

where GW is greenwashing, ESG disclosure provides transparent and comprehensive information about a company's ESG performance. $\overline{\mathrm{ESG\ Disclosure}}$ stands for the mean ESG disclosure score for all companies included in the study; σ ESG Disclosure refers to the measurement of the standard deviation of ESG disclosure scores across all companies; ESG Action: This stands for the current ESG performance of the company as assessed by the CSI ESG Rating; $\overline{\mathrm{ESG\ Disclosure}}$is the mean value of the actual ESG Action across all companies included in the study; σ ESG Action refers to the standard deviation of the ESG Action; i and t stand for the company and the year, respectively.

The study includes Fintech credit (FINT), which encompass the various credit options and innovative intermediaries that have emerged in the wake of the digital revolution. This variable is quantified in logarithmic millions of USD and indicates the evolution of Fintech credit in China. To assess the impact of the CPLCC program, a dummy variable is employed as LCC. Companies in cities participating in the CPLCCP are assigned a value of one, indicating that they are actively participating in the program. Of the total number of observations, 4,850 companies are assigned a value of 1, while 2,525 companies are assigned a value of 0, indicating their activity in cities not covered by the CPLCCP.

In addition, the study selects a number of variables to include relevant factors that influence greenwashing, thus reducing the risk of a problem with omitted variables. Return on assets (ROA) is derived by dividing year-end net income by average net assets. The leverage ratio (LEV) is calculated by dividing net profit after tax by total assets. The company size (SIZE) is quantified by the natural logarithm of a company. The company age (AGE) is calculated by subtracting the year of listing from the current year, which reflects the company's market experience and maturity. The liquidity ratio (LIQUIDITY) assesses a company's short-term liquidity and its ability to meet immediate financial obligations by dividing current assets by current liabilities. It is worth noting that several studies in the existing literature have confirmed the suitability of this variable. Figure 2 shows the data for the companies in the sample.

Table 1 contains the descriptive statistics of the sample for 7375 observations. The average value for GW is slightly below zero at -0.019, indicating a low level of GW. However, the wide range of scores from −2.390 to 3.413 indicates significant variability between companies and Chinese cities influenced by the CPCCP. FINT has an average score of 12.223 with a low standard deviation, indicating consistency between companies. However, there is a slight tendency towards lower values. ROA has a wide range, from −0.417 to 0.215. There are several outliers, as shown in Fig. 2.

The SIZE is 23,235, with a moderate range and a slight tendency towards larger companies. The AGE shows a considerable variation, ranging from less than one year to more than 26 years. This wide range reflects a combination of newly founded and established companies. The LEV is at a moderate average of 0.469, indicating a good balance between debt and assets for the companies. Liquidity, as measured by the average value of 1.918, shows considerable variation between companies, as evidenced by a high maximum value and extreme skewness and kurtosis. The kurtosis coefficients of the series exhibit excessive kurtosis as the number is above or close to three, which signifies the deviation of these series from the normal distribution. All data fields pass the Jarque-Bera test and fail the normality test. This is evidenced by the probability values, which are significant at a 99% confidence interval, indicating that the time periods of the series do not follow a normal distribution. The elevated Jarque-Bera values for most variables indicate that the data do not follow a normal distribution, which confirms the MMQR framework. Quantile approaches capture the relationships between non-normally distributed series more strongly (Pata et al., 2022; Kartal et al., 2023), and therefore the study prefers to use the MMQR approach.

4 Empirical results

Figures 3,4, and 5 illustrate the outcomes of a panel analysis utilizing the MMQR. These figures delineate the findings for all cities (Model-1), cities with implemented low-carbon pilot projects (Model-2), and cities without participation in low-carbon city initiatives (Model-3).

The effect of FINT on greenwashing practices is shown to be minimal in the lower quantiles, i.e., a marginal positive effect on the frequency of greenwashing incidents. This effect decreases when the middle quantiles are considered (35th to 65th percentile). It is noteworthy that the influence of Fintech Credit on greenwashing decreases significantly in the higher quantiles, especially between the 75th and 95th percentiles, and is around −0.07 in the 90th percentile. The Low Carbon City project shows analogous trends and exhibits parallel patterns and impact levels in the lower, middle and upper quantiles.

The analysis unveils that the size of a company has a variable influence on greenwashing, depending on the quantile range. A 1% augmentation in company size correlates with a 1% escalation in greenwashing in the lower quantiles, a 1.5% increase in the middle quantiles, and a 2% increase in the 90th percentile. The impact of leverage on greenwashing also

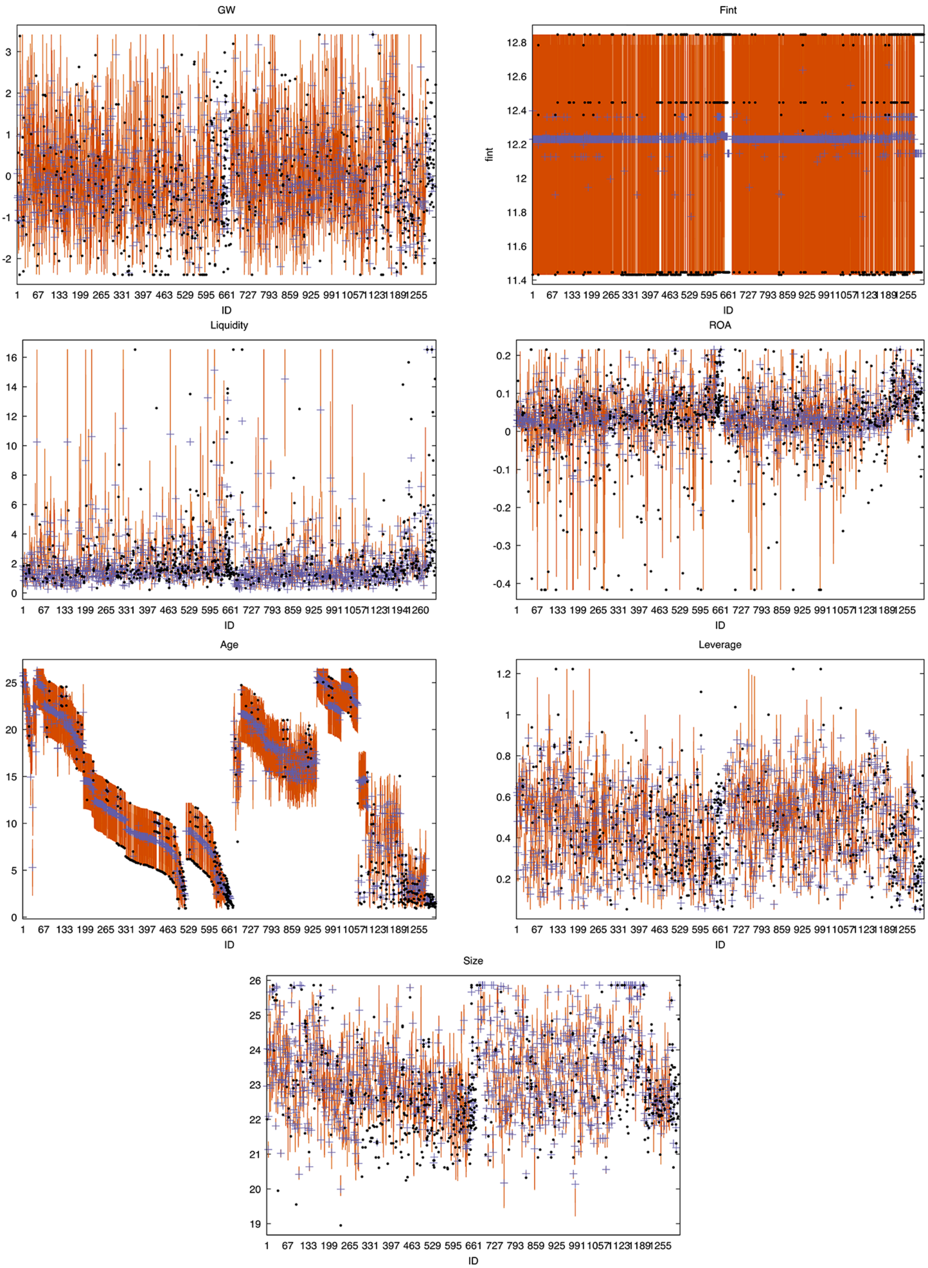

Fig. 2 Boxplot for the independent variables. Note The orange part is the boxplot, the black dots are the outliers

Table 1 Descriptive statistics

	GW	FINT	LCC	ROA	SIZE	AGE	LEV	LIQUIDITY
Mean	-0.019	12.223	0.656	0.042	23.235	14.776	0.469	1.918
Median	-0.141	12.372	1.000	0.038	23.121	15.367	0.479	1.403
Maximum	3.413	12.845	1.000	0.215	25.859	26.444	1.222	16.523
Minimum	-2.390	11.431	0.000	-0.417	18.951	0.838	0.052	0.212
Std. Dev.	1.153	0.543	0.475	0.073	1.181	7.101	0.197	1.888
Skewness	0.502	-0.499	-0.658	-1.883	0.219	-0.149	0.078	4.226
Kurtosis	3.186	1.715	1.433	13.642	2.845	1.891	2.612	27.349
Jarque-Bera	318.400	809.325	1280.926	38977.950	66.133	403.515	53.649	203196.500
JB p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

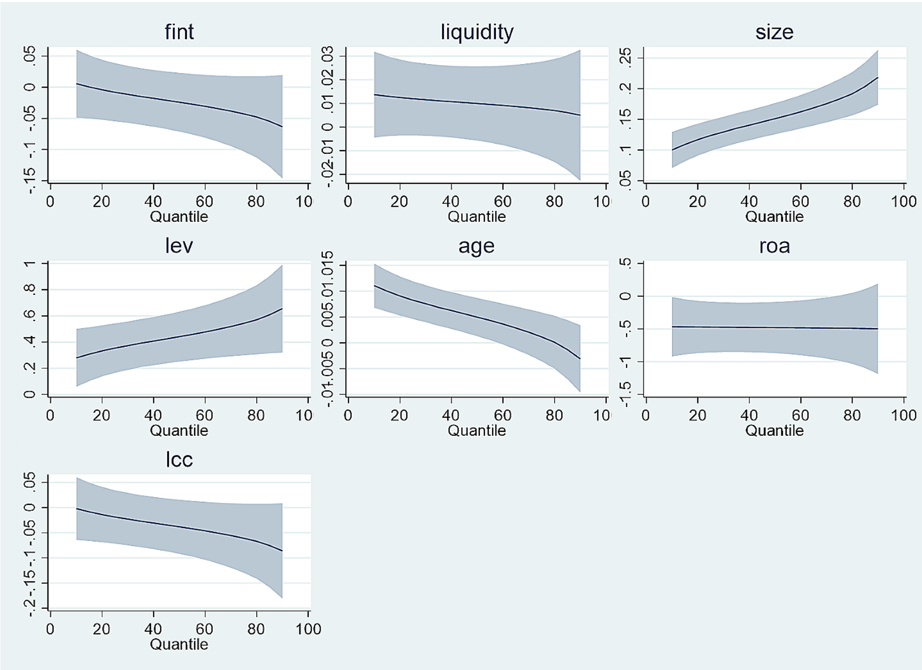

Fig. 3 MMQR results for Model-1

shows a gradual increase across the quantiles, rising from 2% in the lower to 6% in the upper ranges.

Figure 3 illustrates the diverse effects of a company's age on greenwashing activities and shows a reasonable and limited increase in influence across quantile levels. Furthermore, the impact of ROA and liquidity on greenwashing remains stable across the quantiles, with values of around −0.5 and 0.1 respectively.

Figure 4 focuses on the companies participating in the CPCCP. With the exception of the highest quantile (90th percentile), this illustration shows that Fintech Credit has a positive influence on greenwashing across all quantiles. Specifically, a 1% increase in Fintech Credit

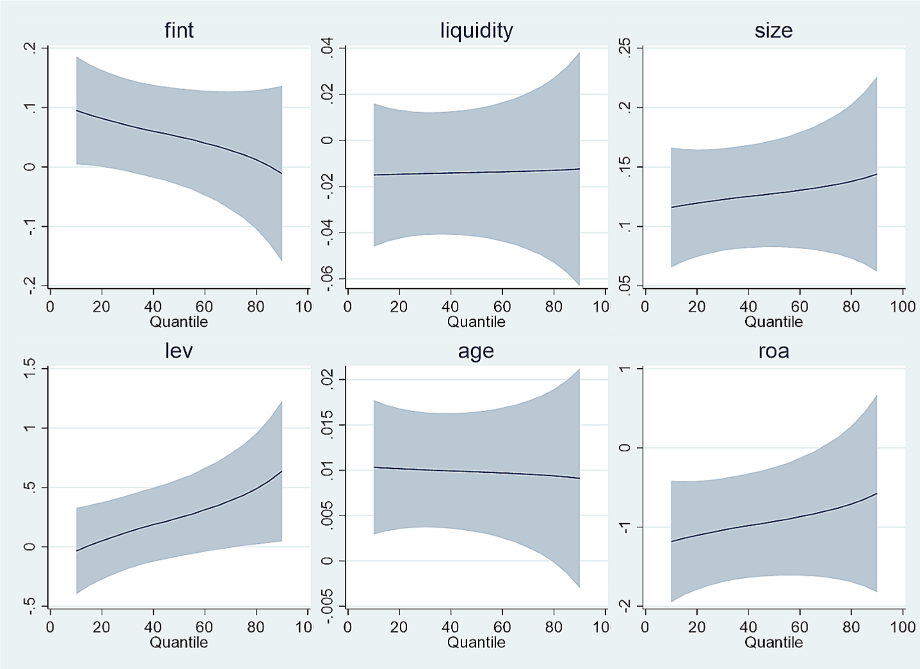

Fig. 4 MMQR results based for Model-2

leads to a 0.9% increase in greenwashing in the 10th percentile, which falls to 0.5% in the 50th percentile and approaching negligible levels at the 90th percentile.

There is also a clear positive correlation between company size and greenwashing. This correlation intensifies from the smallest to the largest quantile and ranges from 0.9 to 1.7%. The LEV has an increasingly positive effect on greenwashing, rising from 0.05% at the lowest quantile to 0.6% at the highest quantile. The age of the company has only a small but consistently positive effect on greenwashing, amounting to 0.01% across all quantiles. The results also show a consistent inverse relationship between ROA and greenwashing at all levels, with the negative effects being more pronounced at higher quantiles.

Figure 5 illustrates the outcomes of a panel MMQR at various quantiles, relating to a company that has not implemented the CPCCP. Based on the visual trends in the charts, it can be inferred that Fintech Credit has a detrimental effect on greenwashing across a wide range of quantiles, ranging from −0.2% to -0.5%. The influence of liquidity on greenwashing appears to be stable and slightly positive across all measured values. It varies from around 0.04 to 0.02 from lower to higher quantiles.

The findings underline a remarkable and positive correlation between the size of a company and the occurrence of greenwashing. This correlation strengthens with increasing company size and lies between 0.9% and 2.5% between the 10th and 90th percentile. This impact amplifies from the lowest to the highest quantile, with the effect ranging from 0.9 to 1.7% of the overall influence on global warming.

Conversely, the age of the company shows a progressively diminishing positive influence on greenwashing as it descends through the quantiles, ranging from 0.05 to 0.01%.

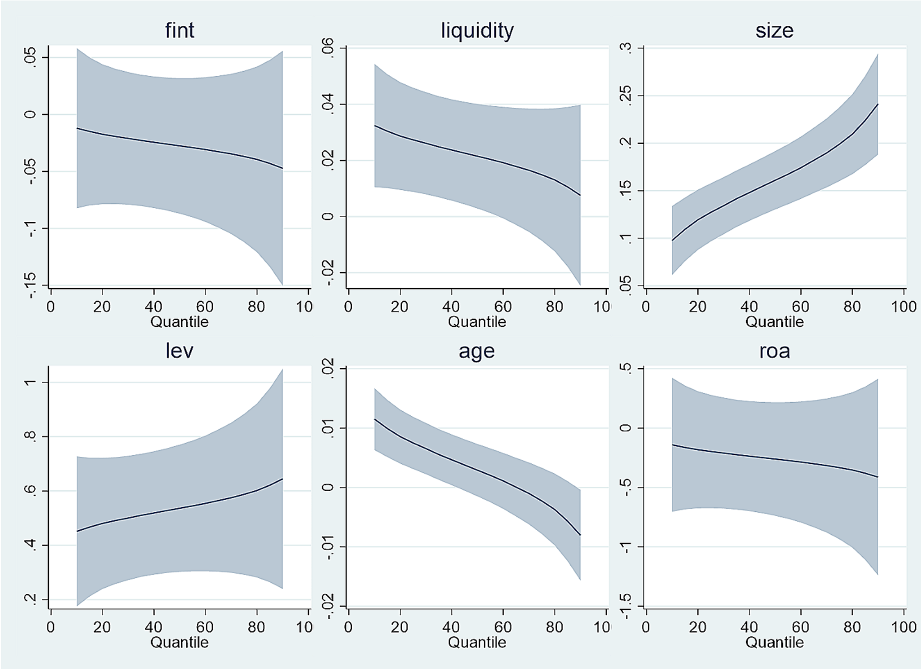

Fig. 5 MMQR results based for Model-3

The analysis reveals a persistent inverse relationship between ROA and greenwashing at all levels. Furthermore, the adverse effect of this phenomenon becomes increasingly clear towards higher values, ranging from −0.2% to -0.5%.

4.1 Discussion findings

The effects of FINT vary in different contexts. The impact of FINT is initially minimal in the broad spectrum of companies (Model 1) and diminishes further in the higher quantiles. Conversely, companies participating in the Low Carbon City Project (Model 2) experience a predominantly positive influence of FINT on greenwashing, except at the highest quantiles. Conversely, FINT consistently harms greenwashing in companies that do not participate in the Low Carbon City initiative (Model 3).

In cities where the Low Carbon City Project has been implemented, companies tend to experience a positive influence of Fintech Credit on the occurrence of greenwashing. This observation is consistent with the findings of Xie et al. (2023), who conclude that fintech significantly mitigates such fraudulent practices and promotes the adoption of environmentally friendly corporate behavior. In these environmentally-oriented regions, there is a possibility that Fintech Credit is associated with an uptick in greenwashing. This phenomenon could be due to corporate efforts to portray themselves as more environmentally friendly or to align themselves with the green initiatives of the Low Carbon City Project.

However, this positive effect decreases or even becomes negative at the higher percentiles. This suggests that Fintech Credit may not promote or even reduce the greenwashing practices of the largest or most influential companies as determined by the quantile metric. This finding contradicts Zhang (2023b), who finds that the low-carbon project does not prevent corporate greenwashing behavior. Companies outside the low carbon city areas consistently experience a negative influence of Fintech Credit on greenwashing. This means that the introduction of Fintech Credit is associated with a decrease in greenwashing in regions not covered by the Low Carbon City project.

Without the imposition of environmental standards, as seen in low-carbon cities, Fintech Credit may be more inclined to adhere to authentic environmental improvement practices and place less emphasis on greenwashing. The relationship between company size and greenwashing is consistently positive in all scenarios, but it is more pronounced for firms that are not part of the low carbon city framework. This indicates a strong correlation between larger company size and increased greenwashing activities in such environments. Different patterns can also be observed in the impact of the debt ratio on greenwashing. While the influence of the debt ratio gradually increases across the quantiles for the general companies, it is relatively weak for the companies in the Low Carbon City project.

The effect of company size on greenwashing follows a consistent pattern across different scenarios, with a positive effect. The analysis indicates a positive correlation between the size of a company and its involvement in greenwashing practices. The likelihood of a company being involved in greenwashing activities increases as the size of the company increases. This stronger correlation between larger company size and the tendency to exaggerate or misrepresent environmental efforts is particularly notable in the Carbon City environment.

The analysis reveals different patterns in relation to the influence of leverage on greenwashing. The influence of leverage on greenwashing generally increases gradually across quantiles for companies, indicating that companies with higher leverage are more prone to greenwashing as their size or financial complexity increases. This trend is less pronounced for companies participating in the Low Carbon City Project. The fact that leverage had less of an impact for these companies suggests that the environmental focus and policies associated with the Low Carbon City initiative may have mitigated the extent to which financial leverage influences greenwashing behavior.

Data on company age, where available, shows a consistent but slightly positive impact on greenwashing for both general and low carbon city-affiliated companies. An examination of the influence of age on greenwashing practices shows a nuanced but consistent pattern between various categories of companies. The Low Carbon City project, which aims to promote sustainability and reduce carbon emissions, does not appear to significantly alter the propensity for greenwashing associated with age.

ROA and greenwashing have a consistent inverse relationship. This means that the frequency or intensity of greenwashing decreases when ROA increases, indicating improved financial performance. Surprisingly, this negative correlation strengthens in higher quantiles, which represent larger or more financially stable companies. This trend is especially evident for companies not involved in the Low Carbon City project. As financial performance improves in these companies, there is a more significant decrease in greenwashing practices than in companies in the lower quantiles or those participating in the Low Carbon City initiative. This finding suggests that a better financial situation enables or encourages companies, especially larger companies that are not affected by the environmental focus of the Low Carbon City project, to engage in less greenwashing, possibly because they have more resources to invest in genuine sustainability practices. These findings are consistent with previous studies (Hu et al., 2023; Liao et al., 2023) and show that ROA, company size, leverage ratio, and liquidity are the most important factors for greenwashing.

5 Conclusion and policy implications

5.1 Conclusion

This study examined the influence of financial technology (FinTech) credit and the implementation of the Pilot Low Carbon Project on corporate greenwashing in China from 2015 to 2021. The research demonstrates the effectiveness of the MMQR approach in finding that Fintech credit and low-carbon projects discourage greenwashing behavior and promote environmentally sustainable corporate practices in China.

5.2 Policy implications

Policy recommendations should aim to harmonize technological progress with environmental regulation to effectively tackle the problem of greenwashing in China, especially with regard to the combination of fintech and the Low Carbon City Initiative. Fintech has green characteristics and advantages due to technology. They can be utilized scientifically and technically to promote green development by reducing greenwashing. This will be helpful in shifting the economy to green development and a low carbon economy.

It is important to use the opportunities offered by FinTech's to improve transparency in environmental reporting. This includes formulating policies that promote the use of blockchain and related technologies to ensure accurate monitoring and documentation of ecological data. This in turn enhances the credibility of environmental claims and reduces the potential for fraudulent marketing practices. Fintech has a critical role to play in monitoring the environmental effects of urban development, particularly in the context of the Low Carbon City Initiative. Financial regulators need to encourage the development of fintech products. There is an urgent need for higher levels of investment in the research and development of fintech products and how they can be used to mitigate greenwashing. Financial regulators in China should enforce strict standards to enforce regulatory practices related to the use of fintech that promote environmental well-being.

Consumers also need to be educated about greenwashing practices. Such steps will enable consumers to make well-informed choices when selecting corporate products. Raising consumer awareness will encourage companies to adhere to environmental guidelines when advertising their products. Fintech companies can enable consumers to invest in green technologies and educate them on the ecological impact of choosing products and services.

5.3 Future research

Bringing ESG criteria into the financial sector via fintech solutions is crucial. Encouraging the adoption of fintech tools to integrate ESG factors by financial institutions can significantly improve the accuracy of environmental impact assessments and disclosures. This, in turn, can play a crucial role in effectively addressing the problem of greenwashing. This holistic approach, encompassing technological, regulatory and consumer-oriented strategies, provides a comprehensive framework to improve environmental sustainability and accountability in China. Future empirical research is needed to identify similar contexts in the context of other major economies. Future research should focus more on how policy makers promote green pilot projects in urban areas. Furthermore, in the future, researchers could analyze the impact of Fintech in minimizing greenwashing for other high carbon emitting countries, such as the United States and India. Methodologically, the relationship between greenwashing and financial development can be investigated using Fourier-based approaches and taking structural breaks into account. In this way, the existing knowledge on greenwashing can be expanded and a contribution to the roadmap for low-carbon development can be made.

Author contributions UKP: Conceptualization, Writing Original Draft, Writing - Review & Editing, Investigation. KSM: Data Curation, Software, Investigation. Formal analysis, Writing Original Draft. AAN: Investigation, Writing - Review &Editing, Writing Original Draft. SG: Methodology. Writing - Review &Editing,

Funding Research Supporting Project number (RSP2024R87), King Saud University, Riyadh, Saudi Arabia. Open access funding provided by the Scientific and Technological Research Council of Türkiye (TÜBİTAK).

Data availability The datasets analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical approval Not applicable.

Consent to participate Not applicable.

Consent to Publish All authors consent to publish.

Competing interests The authors have no relevant financial or non-financial interests to disclose.

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