▪ Journal of Competitiveness

# THE IMPACT OF GREEN CREDIT POLICIES ON FIRM PRODUCTIVITY

*Song Chen, Mingxiao Dai*, Kuangnan Fang, Xiangcheng Huang, Jing Zhang**

**Abstract:**

Green credit policies prompt enterprises to consider their environmental footprint when making financial decisions, thereby encouraging industries to transform and upgrade, and prompting structural adjustments. Using data from China's A-share listed companies from 2007 to 2019, this study examines the impact of the 2012 Green Credit Guidelines on firms' total factor productivity (TFP). By employing the DID strategy, we find that green credit policies do not significantly affect the TFP of heavily polluting enterprises; notably, this result holds true after a series of robustness tests. Furthermore, we demonstrate that, subject to stricter financing constraints resulting from the policy shock, heavily polluting enterprises adapt their product structures to mitigate the policy's adverse effects. Finally, the study underscores the role of enterprise ownership in moderating the efficiency of green credit policies on productivity.

***Keywords:*** *green credit, productivity, total factor productivity, heavily polluting enterprises, product mix*

**JEL Classification**: G28, Q56, D24, L25

## 1. INTRODUCTION

Ever since the Equator Principles were introduced in 2003, green credit has gained global recognition as an effective means of steering the economy toward a greener trajectory. In early 2012, China's banking regulator introduced the Green Credit Guidelines (Guidelines) ([2012]) to set clear standards for green lending practices. This policy was intended to shift lending away from high-pollution, high-energy industries and toward enterprises committed to reducing emissions and conserving energy. This marked a major step forward in China's journey toward a greener economy.

Green credit policies (GCP) serve as a key tool of environmental governance: they impose environmental criteria on corporate behavior and redirect financial resources through specialized instruments. These policies also require banks to apply environmental vetting in

https://doi.org/10.7441/joc.2025.04.09

lending decisions and even adopt strict measures like a 'one-vote veto' to control environmental risks. Through such measures, green credit seeks to restrain the unchecked expansion of energy-intensive, HPEs. Green credit also employs various financial instruments – for example, dedicated carbon-reduction lending facilities and green bonds – to finance clean energy, energy efficiency, and environmental protection projects. Priority is given to high-quality initiatives in these areas, ensuring that funding is directed toward critical low-carbon and conservation efforts.

The guidelines offer detailed instructions to financial institutions on implementing green credit practices—helping traditional industries to go green and encouraging low-carbon, circular economic development. The issuance of these guidelines was a landmark for green finance in the banking sector, steering banks to embed environmental sustainability into their performance metrics and strengthening their sense of environmental and social responsibility.

Many studies have investigated how various environmental regulations affect firm productivity, but less research directly addressed the GCP's impact on productivity. Most prior work has explored the mechanisms of environmental regulation impacts on firms, without isolating the role of green credit. To address this gap, our study specifically evaluates how the 2012 GCP affected the productivity of HPEs, including its influence on firm behavior and product-mix adjustments. For instance, if banks restrict lending to high-pollution companies under Guidelines, those firms may cut back on investment, which could reduce their operational efficiency. Furthermore, earlier research on green credit has tended to emphasize outcomes like innovation and investment, paying little attention to how such policies internally change firm behavior or product portfolios. In contrast, our analysis takes a holistic view of the GCP's implementation, examining its overall effect on enterprise productivity. Through this approach, we aim to offer a more comprehensive understanding of how effective green credit policies are and what they imply for sustainable development.

Specifically, we employ data from China's listed companies from 2007 to 2019. Using the Guidelines enacted in 2012 as a policy backdrop, we construct a quasi-natural experiment and utilize the difference-in-difference strategy (DiD) to assess the policy's impact on heavily polluting enterprises (HPEs) compared to non-HPEs. Our findings suggest that the GCP does not significantly influence the total factor productivity (TFP) of heavily polluting enterprises, and our results hold after various robustness tests. Further, our analysis shows that while the policy heightens financing constraints for HPEs, these enterprises respond by adjusting their

https://doi.org/10.7441/joc.2025.04.09

product mix, thereby mitigating the policy's negative impact on TFP. Additionally, our heterogeneity analysis highlights differentiated effects based on firm ownership and characteristics.

## 2. THEORETICAL BACKGROUND

Our study draws on literature examining determinants of enterprise TFP. It encompasses internal firm characteristics that boost TFP, such as debt leverage, which optimizes capital structure and efficiency (M. R. King & Santor, 2008), and research and development (R&D) investment, especially for exporters (Lileeva, 2010). Management practices, R&D commitment, product innovation, workforce education, and the educational background of decision-makers also significantly influence TFP (Syverson, 2011). Internationally trading firms show higher TFP (Love & Ganotakis, 2013), and climate impacts on TFP are more pronounced in poorer nations (Letta & Tol, 2019). Additionally, economic geography and regional development history affect TFP (Beugelsdijk et al., 2018).

Prior studies on corporate green bonds have largely examined their impact on stock performance. Many rely on event-study methods. For example, Flammer (2021) reports that stock markets respond favorably to green bond issuance events – an effect that is especially strong for initial issuances or those with third-party certification. Similarly, Tang and Zhang (2020) combined an event study with a DiD approach and found that issuing green bonds draws increased media attention and leads to short-lived upticks in stock price. That said, some research suggests these positive effects are not long-lasting, particularly in markets where investors are short-term oriented and green finance regulations remain nascent (Wang et al., 2020).

Regarding firm value, Mathews and Kidney (2012) argue that green bond issuance helps channel funds into sustainable projects while burnishing a company's green reputation. Using a PSM-DiD approach on Chinese listed companies, Zhou and Cui (2019) further show that green bond issuance can boost a firm's profitability and overall financial performance.

Another strand of literature we contribute to is the study of green credit policy. First, sound environmental regulations can align economic growth with environmental protection. Studies have shown that if regulations are well-designed, they motivate firms to implement internal energy-saving and emission-reducing measures, leading to environmental improvements

https://doi.org/10.7441/joc.2025.04.09

without hindering long-term economic growth (Liu et al., 2022; Petitjean, 2019; Porter & van der Linde, 1995).

Secondly, financial innovations and instruments can substantially shape how businesses operate(Guo et al., 2024; Rajan & Zingales, 1996). Building on this idea, GCP has become a key policy tool for regulating environment, allowing banks to influence firm behavior through lending terms and compliance requirements. Studies on green credit cover its effects on firms, banks, and the broader environment. For example, R. G. King and Levine (1993) and Cui et al. (2018) observe that green credit policies prompt banks to adjust their loan portfolios, thereby reducing credit risk and environmental harm. By offering specialized green loans and services, banks help finance companies' sustainability efforts, which directs capital toward eco-friendly projects and away from highly polluting ones(He et al., 2019; Nandy & Lodh, 2012). "Furthermore, green credit policies push banks to cut off lending to highly polluting projects, which sends a strong signal of environmental responsibility to the market and encourages firms to improve their environmental practices (B. Zhang et al. , 2011)). Firms that obtain green credit financing, in turn, demonstrate their environmental commitment to investors and may earn tax benefits, thereby promoting environmental protection, industrial upgrading, and sustainable growth (Bajo et al., 2016; Gao & Mei, 2013). Green credit can also serve as a catalyst for corporate green innovation. Hu et al. (2021) note that such policies encourage firms — particularly those with strong competitive positions or facing steep penalties for non-compliance — to invest more in green innovation. Similarly, Chen et al. (2022) argue that green credit initiatives spur companies to increase R&D spending, improve managerial efficiency, and develop low-carbon technologies, thereby boosting their capacity for green innovation(Kong et al., 2022; S. Zhang et al., 2024). That said, (S. Zhang et al., 2024) caution that factors like agency costs, profit margins, and ownership concentration can temper the innovation benefits of green credit. In sum, fully understanding how green credit policies drive firms' green transformation is crucial for advancing a greener economy.

Our results align with one stream of literature suggesting that strict environmental regulations can hurt firm productivity (Barbera & McConnell, 1990; Gray & Shadbegian, 2003). In theory, tougher environmental rules impose extra compliance costs and constraints on firms, which can erode profits and curtail investment. Such regulations may also hinder technological innovation and reduce competitiveness by forcing firms to scale back production or product variety. Empirical evidence supports this view: Lanoie et al. (2008), for instance, documented

https://doi.org/10.7441/joc.2025.04.09

a short-term drop in TFP following tighter environmental regulation in Quebec. Similarly, Wang et al. (2018) found that stricter water quality standards depressed firm productivity in some regions of China.

Another school of thought, epitomized by the Porter Hypothesis (Porter & van der Linde's, 1995), holds that environmental regulations can actually improve productivity. The idea is that stricter rules push firms to innovate: they develop cleaner technologies and cut waste, which in turn lowers costs and boosts efficiency and competitiveness. In practice, regulations often force technological upgrades, leading to more resource-efficient processes and higher-quality products. A number of studies back this optimistic view. For instance, Hamamoto (2006) found that tighter environmental policies coincided with productivity gains in Japan's manufacturing sector, and Testa et al. (2011) reported significant productivity improvements in the EU construction industry under more flexible green regulations.

The third perspective suggests that the effect of environmental regulation on productivity is context-dependent and potentially non-linear. (Walley & Whitehead, 1994). In other words, the effects can vary by context and may not follow a simple positive/negative pattern. Jaffe et al. (1995), for example, questioned the assumption that environmental rules inherently drag down productivity. In their analysis of how regulations affect net exports, trade flows, and factory location decisions, they found only minimal and statistically insignificant effects. This evidence challenges the conventional belief that stricter environmental regulation always harms TFP.

## 3. RESARCH OBJECTIVE, METHODOLOGY, AND DATA

### 3.1 Research hypotheses

Green credit policies exert a dual effect on TFP (total factor productivity). By restricting bank credit to HPEs, they raise financing constraints, potentially lowering TFP. Yet, these policies can also boost TFP by promoting resource optimization and phasing out inefficient production. Compliance costs and policy thresholds post-implementation may deter production investment, negatively impacting TFP. However, compliant firms can enhance environmental performance and competitiveness through innovation, facilitating easier access to external financing. Conversely, HPEs might face financial constraints that impede environmental investments and pollution control (Becker, 2011; Hering & Poncet, 2014), reducing productivity (Banerjee et

https://doi.org/10.7441/joc.2025.04.09

al., 2020; Eichholtz et al., 2019). GCP can also spur technological innovation to offset environmental regulation costs (Greenstone et al., 2012), aligning with Porter's hypothesis that moderate regulations stimulate innovation and improve TFP (Ciabuschi et al., 2012). Stringent environmental policies drive environmental innovations and productivity, encouraging firms to adopt eco-friendly technologies for technological progress and profit maximization. Compliance with environmental standards can increase social capital and investment opportunities, supporting sustainable development.

Therefore, we hypothesize the following:

**H1a:** GCP drives down the TFP of HPEs.

**H1b:** GCP contributes to the increase of TFP in HPEs.

**H1c:** The effect of GCP on the TFP of HPEs is not significant.

Financing constraints significantly impede enterprise productivity and growth by limiting innovation capacity and scale expansion. Studies, such as those by Haider et al. (2018), Badia and Slootmaekers (2009), and Gatti and Love (2008), consistently show that firms with fewer financing constraints grow faster and have higher productivity. Conversely, those with higher constraints face reduced investment capabilities and productivity. Green credit policies may intensify these effects for HPEs, leading to increased financing constraints (H2a) and decreased bank borrowing (H2b).

Therefore, we hypothesize the following:

**H2a:** GCP contributes to the increase of financing constraints of HPEs.

**H2b:** GCP prompts HPEs to borrow less from banks.

Strict environmental regulations can initially reduce firms' TFP, but profit-maximizing firms often counteract this by adjusting their product mix to minimize environmental costs. This involves shifting production from high-environmental-cost products to those with lower impact, which can mitigate the cost pressures of regulations. Studies, including those by Bernard et al. (2010) and Braguinsky et al., (2021), indicate that product switching and variety increase TFP. Firms facing environmental regulations often adopt strategies to adjust their product mix, either by increasing production of unregulated products or restructuring their product lines, which can improve productivity and profitability despite market demand uncertainties and investment risks. Research by Lipscomb et al. (2008) and Levinson (2009) emphasized the role of product

https://doi.org/10.7441/joc.2025.04.09

mix adjustments in emission reduction and regulatory compliance, especially for firms subject to multiple environmental regulations, as shown by Elrod and Malik (2017). Drawing parallels between GCP and environmental regulations, we hypothesize regarding the impact of GCP on firms' product mix and environmental compliance:

**H3:** HPEs mitigate the negative impact of GCP on TFP by adjusting their product mix.

### 3.2 Data

In this study, we investigate the effects of GCP on TFP (Del Gatto et al., 2011), a key measure of production efficiency that includes all inputs in the production process (Levinsohn & Petrin, 2003; Olley & Pakes, 1992). Important factors (management and technology) and other factors (the market competition and business environment) influence TFP, which indicates technological progress. Our analysis uses data from Chinese A-share listed firms between 2007 and 2019, excluding those with abnormal trading or significant data gaps. Data sources include the Cathay Pacific and Wind databases. Pollution-related indicators are compiled based on information reported in the China Statistical Yearbook.

After matching, our sample comprised 2066 companies, 623 are assigned to the treatment group, while the remaining 1,443 serve as controls. We addressed outliers by winsorizing key variables at the 1% level and mitigated endogeneity by lagging control variables by one period, where standard errors are clustered by industry.

### 3.3 Methodology

The DiD approach in our study estimates the policy's average treatment effect by comparing HPEs (the treatment group) with non-HPEs (the control group) (Mani & Wheeler, 1998). We employed two methods to define these groups: one based on industry emissions and the other on industries affected by GCP restrictions. Our benchmark regression employed the latter method, integrating industry emission standards with policy restrictions to accurately assess policy effects. To analyze green credit's impact on productivity, and following guidelines from the former Chinese Ministry of Environmental Protection, we classified enterprises in industries like mining, textiles, paper, petroleum, chemicals, metal smelting, rubber, plastics, pharmaceuticals, and fur as heavy polluters for the treated subsample, with the remainder forming the control subsample.

https://doi.org/10.7441/joc.2025.04.09

### 3.4 Variables

#### 3.4.1 TFP (total factor productivity)

Ordinary least squares (OLS), together with the Olley–Pakes (OP) and Levinsohn–Petrin (LP) approaches, are commonly applied to estimate total factor productivity (TFP). By applying a logarithmic transformation, the production function can be linearized, with the residual term capturing firm-level productivity. Unlike much of the existing literature that relies on the China Industrial Enterprises Database, this study constructs firm-level TFP measures for listed companies. Specifically, operating revenue is used to proxy total output (Y), employment is adopted as the labor input (L), net fixed assets represent capital input (K), and cash expenditures on current investment serve as investment input (I). Intermediate inputs (M) are obtained by subtracting various operating costs from operating income (Curtis, 2016; Van Biesebroeck, 2007). In addition, the OP method incorporates a firm entry–exit indicator (EXIT) to control for market exit behavior, thereby improving the precision of TFP estimation. In the baseline analysis, both OP- and LP-based TFP measures are employed and compared. To further verify robustness, alternative estimation strategies are implemented.

#### 3.4.2 Other variables

Consistent with the standard difference-in-differences (DiD) framework, three key variables are specified: the policy indicator (Time), the treatment indicator (Treat), and their interaction term. The definition of these variables follows the timing of the Guidelines and the classification of groups described above.

Specifically, the policy indicator Time equals zero in the pre-policy period and takes the value of one after Guidelines' implementation. HPEs are assigned Treat = 1, while firms in non-HPEs are assigned Treat = 0. The DiD term is constructed as the interaction between Treat and Time.

We set some control variables to account for other firm-level factors that may affect productivity. These controls capture firm size and age, leverage, tangible asset intensity, employment scale, operating leverage, earnings volatility, return on investment, and board characteristics. Incorporating these variables helps alleviate potential confounding influences when estimating the effect of the GCP on enterprise productivity (Li et al., 2022; Lu et al., 2022).

https://doi.org/10.7441/joc.2025.04.09

# 4. RESULTS AND DISCUSSION

## 4.1 Baseline result

We define a green credit policy as any policy of a financial institution that limits loans to heavily polluting, high-energy-consumption enterprises and imposes higher interest rates on those loans. Simultaneously, HPEs failing to meet environmental assessment standards may face suspension or cessation of credit services, aimed at incentivizing compliance with environmental protection regulations. This policy aims to redirect funds from HPEs to non-HPEs, fostering the rational allocation of resources.

This study utilizes the Guidelines issued in 2012 as a quasi-natural experiment and employs the DiD method to investigate the impact of GCP on enterprise productivity. The econometric model is as follows:

$$TFP_{it} = \alpha_0 + \theta_1 DID_{it} + \beta X_{it-1} + \gamma_t + \mu_i + \sigma_j + \epsilon_{it} \quad (1)$$

where *i* denotes firm and *t* denotes year. $DID_{it} = Time_t \times Treat_i$. $X_{it-1}$ represents the control variable. *Time* serves as a policy indicator, with a value of 1 from 2012 onwards and 0 for each year before 2012. We assign listed firms in HPEs with *Treat*=1, while listed companies in non-HPEs are *Treat*=0. To account for other economic characteristics that may influence the dependent variable, we include control variables denoted as $X_{it-1}$. These are firm size and age, gearing ratio, tangible assets ratio, number of employees, operating leverage, earnings volatility, return on investment, and two additional variables.

**Tab.1-** The effect of green credit on TFP of heavily polluting enterprises

| Variables | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | TFP_OP | TFP_LP | TFP_OP | TFP_LP |
| DID | -0.019 | -0.053 | -0.008 | -0.039 |
| Size | | | 0.284*** | 0.296*** |
| Age | | | -0.047 | -0.009 |
| Leverage | | | 0.354*** | 0.312*** |
| Tar | | | -0.107 | -0.267** |
| Employee | | | -0.010*** | -0.002 |
| Operating_lever | | | -0.049*** | -0.051*** |
| Std | | | -0.106 | -0.398** |
| Invest_rate | | | 0.001 | -0.246 |
| Dual | | | -0.031 | -0.028 |

https://doi.org/10.7441/joc.2025.04.09

| | | | | |
|---|---|---|---|---|
| FE | Y | Y | Y | Y |
| Observations | 18402 | 18402 | 18402 | 18402 |
| $R^2$ | 0.189 | 0.233 | 0.353 | 0.364 |

Notes: *** denotes significance at 1%, ** at 5%, and * at 10%. Due to space constraints, standard errors for clustering at the industry level are not presented.

Table 1 reports the estimation results for Model 1. TFP_OP and TFP_LP, measure TFP constructed using the Olley–Pakes and Levinsohn–Petrin approaches, respectively. All specifications include firm, regional, and year fixed effects, where inference relies on industry-level clustering of standard errors. Columns (1) and (2) present baseline regressions that control for firm, region, and year fixed effects only. The estimated DiD coefficient in these specifications is negative with statistically insignificant. Columns (3) and Columns (4) incorporate additional control variables, with the DiD coefficient remaining insignificantly negative, suggesting that GCP implementation does not significantly affect enterprise TFP, thus supporting Hypothesis 1c. The control variable coefficients of firm size (Castany et al., 2005) and gearing ratio (Yu et al., 2023) are generally consistent with the prior literature.

### 4.2 Parallel-trend test, robustness checks, and heterogeneity analysis

The detailed processes of our robustness checks are not elaborated here but are available upon request. The checks included parallel-trend tests to ensure the DiD method's assumptions were met, with annual dynamic effects and anticipated effects being non-significant before and after implementing the GCP, respectively. Additional robustness was established through alternative TFP measurements, exclusion of other policy influences, control for industry trends and macro factors, and the application of PSM-double difference modeling (PSM-DiD) to address potential selection biases. Redefinitions of HPEs and placebo tests further substantiated the findings, as did the synthetic difference-in-differences (SDiD) method. Heterogeneity analysis revealed that state-owned enterprises and those with higher fixed asset ratios experienced a more pronounced impact on TFP under green credit policies. Collectively, these tests reinforce the robustness of our findings that GCP do not significantly affect enterprise TFP, with variations observed based on enterprise characteristics.

### 4.3 Mechanisms

#### 4.3.1 Financial constraints

To investigate Hypotheses 2a and 2b, accounting for the implementation of GCP, this study posits that such policies may heighten firms' financing constraints, subsequently impacting their TFP negatively. Thus, the next section aims to ascertain the presence of this mechanism.

Initially, we employed the Whited-Wu index to assess the financing constraints (Whited & Wu, 2006). Higher $WW$ index indicates more corporate financing constraints.

To examine Hypothesis 2a, we established a model to assess the influence of green credit policies on enterprise financing constraints:

$$WW_{it} = \alpha_0 + \theta_1 DID_{it} + \beta X_{it} + \gamma_t + \mu_i + \sigma_j + \epsilon_{it} \quad (2)$$

In model (2), the explanatory variable $WW$ represents corporate financing constraints (WW index). Enterprise, regional and time fixed effects are controlled. The regression result in Table 2 suggests that the Guidelines increase the financing constraints of HPEs. Therefore, these results provide support for Hypothesis 2a.

**Tab.2-** Mechanisms： Enterprise financing constraints

| Variables | (1) |
|---|---|
| | WW index |
| DID | 0.009** |
| Controls | Y |
| FE | Y |
| Observations | 17421 |
| **$R^2$** | 0.369 |

To test hypothesis H2b, we construct a model to analyze the impact of GCP on frim bank borrowing:

$$Ratio_{it} = \alpha_0 + \theta_1 DID_{it} + \beta X_{it} + \gamma_t + \mu_i + \sigma_j + \epsilon_{it} \quad (3)$$

In Model (3), the explanatory variable Ratio follows Zhu et al. (2015) and captures firms' borrowing intensity and structure. It is constructed using multiple indicators reflecting long-term borrowing, short-term borrowing, and bank-related liabilities, scaled by either total assets or total liabilities. Detailed variable definitions are provided in Table 3, which reports the corresponding regression results.

**Tab.3-** Mechanism: Borrowing from banks

| Variables | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | longstr | longrto | shortsrt | shortrto | bankrto |
| DID | -0.027** | -0.014** | 0.003 | -0.012** | -0.012** |
| Controls | Y | Y | Y | Y | Y |
| FE | Y | Y | Y | Y | Y |
| $\mathbf{R^2}$ | 0.046 | 0.014 | 0.046 | 0.011 | 0.013 |

The coefficients of DiD in Table 3 are significantly negative in all regressions except for regression (3). These findings reveal that, following the implementation of the Guidelines, HPEs experience a notable reduction in bank borrowing compared to non-HPEs. This supports the validity of Hypothesis 2b.

### 4.3.2 Changes in enterprise product composition

The preceding estimation results and robustness checks from the DiD model indicate that the GCP does not have a significant negative effect on the TFP of HPEs. However, it is observed that the policy notably heightens the financing constraints faced by these enterprises. This prompts an exploration into how HPEs manage to mitigate the adverse effects on TFP and the mechanisms underlying this outcome.

To delve deeper into this inquiry, the paper further investigates why the TFP of HPEs does not experience a significant decline after policy implementation. It posits that these enterprises, by adjusting their product mix, have been able to alleviate the Guidelines' impact on TFP. To validate this hypothesis, and drawing on the methodology of Bernard et al. (2010), the paper formulates the following model:

$$PS_{it} = \alpha_0 + \theta_1 DID_{it} + \beta X_{it} + \gamma_t + \mu_i + \sigma_j + \epsilon_{it} \quad (4)$$

In model (4), the explanatory variable $PS_{it}$ represents the firm's product mix, which is gauged through three metrics: product change (*PNC*), product conversion rate (*PCR*), and product creation rate (*PAR*). *PNC* is computed as the product of *product_change* and *product_number*. *Product_change* is defined as follows: if the number of products of firm *i* in a given year *t* in 2012 or later differs from the number of products in 2011 (i.e., the year preceding the implementation of the Guidelines), then *product_change* equals 1; otherwise, it equals 0. The number of products is obtained by counting the "main products" listed in the enterprise's annual report. *PCR* measures the year-on-year change in the number of products offered by a firm, while *PAR* captures the rate at which new products are introduced. Both variables are constructed by scaling changes in product counts by their lagged values.

**Tab.4-** Mechanism: Changes in Enterprise Product Composition and product level

| Variables | (1) PNC | (2) PCR | (3) PAR | (4) Add | (5) Drop | (6) Growth |
|---|---|---|---|---|---|---|
| DID | 0.127** | 0.012* | 0.018* | 0.016** | -0.001 | -4.842*** |
| Controls | Y | Y | Y | Y | Y | Y |
| FE | Y | Y | Y | Y | Y | Y |
| $\mathbf{R^2}$ | 0.055 | 0.047 | 0.059 | 0.296 | 0.287 | 0.357 |

The product-switching rate represents the combined impact of changes in product creation and product exit, while *PAR* reflects the firm's process for introducing new products. Table 4 reports the estimation results corresponding to Equation (4). The coefficient of *DiD* is significantly positive in regression (1); in regressions (2) and (3), the coefficients of *DiD* are significantly positive. Thus, the regression outcomes in Table 1 indicate that, following the enactment of the Guidelines, HPEs altered their main product mixes compared to non-HPEs. Supported by the benchmark regression results, Hypothesis 3 is confirmed. This suggests that firms can adapt to environmental regulations by adjusting their product mix (Y. Zhou et al., 2022).

Moreover, to scrutinize changes at the product level, we constructed a model, drawing on Y. Zhou et al. (2022):

$$Y_{i,p,t} = \alpha_0 + \beta_1 DID_{it} + \gamma_t + \mu_i + \rho_p + \epsilon_{i,p,t} \tag{5}$$

*Y* represents three dependent variables: expansion of new products ($Add_{i,p,t}$), exit of incumbent products ($Drop_{i,p,t}$), and change in the size of the incumbent products ($Growth_{i,p,t}$). Where *Add* is 1 if enterprise *i*'s main product *p*'s revenue in year t $value_{i,p,t} > 0$, $value_{i,p,t-1} = 0$, and 0 otherwise. if $value_{i,p,t} = 0$, $value_{i,p,t-1} > 0$, then *Drop* is 1, and 0 otherwise. *Growth* is $value_{i,p,t} - value_{i,p,t-1}$. $\gamma_t$, $\mu_i$ and $\rho_p$ represents time, firm and product fixed effect, which controls for the effect of product characteristics; $\epsilon_{i,p,t}$ represents the random perturbation term.

The estimation of *DiD* is 0.012 in Table 4's column (4), which provides evidence that the GCP implementation substantially raises the likelihood that firms expand their product portfolios. Column (5) examines the impact of GCP on firms' elimination of existing products, with the coefficient of *DiD* being negative but statistically insignificant, suggesting that the

https://doi.org/10.7441/joc.2025.04.09

implementation of a GCP does not significantly affect the probability of firms' elimination of products. In column (6), the focus is on the effect of implementing the GCP on the change in the size of the product within the firm, with the coefficient of *DiD* being -4.9592. Overall, the GCP influences firms' product mix, leading to the expansion of new products and downsizing of existing products in response to regulatory requirements. This adjustment facilitates resource reallocation and efficiency improvement, thereby mitigating the negative impact of the Guidelines on firms' TFP, thus confirming Hypothesis 3.

In addition, we conducted two robustness checks to further validate our findings. The first ruled out potential interference from firms' technological innovation pathways, while the second addressed the possible confounding effects of policies introduced after 2013.

## 5. Conclusions

Green credit policies have gained global attention as financial instruments for reconciling economic development with environmental protection. From the Equator Principles to emerging national-level regulations, a growing number of countries are introducing green financing frameworks to promote low-carbon development. In this context, China's Guidelines represent a significant institutional experiment that offers valuable insights for other economies considering similar reforms.

This study examines how the GCP affects the production efficiency of heavily polluting enterprises. Employing a panel data fixed-effects model with A-share listed companies from 2007 to 2016. The benchmark regression results indicate that GCP does not significantly influence the TFP of HPEs. Various robustness checks, including parallel trend checks, alternative productivity measures, and propensity score matching with PSM-DiD, affirm these conclusions.

A compliance-cost perspective would predict that green credit policies restrain high-polluting firms and hurt their productivity. Our results indeed show that the policy tightened financing for HPEs — they received fewer bank loans and initially saw declines in productivity. However, we also find that those firms responded by altering their product mix to meet market and environmental requirements, which helped offset the policy's negative effects on productivity. Furthermore, the impact of the GCP was not uniform across all firms: with stronger effects observed for state-owned enterprises as well as firms with asset-intensive structures.

https://doi.org/10.7441/joc.2025.04.09

The result of this study, based on Chinese data, have broader implications. Due to differences in regulatory systems, banking structures, and industrial compositions, however, the effectiveness of GCP may vary across countries. Hence, future international comparative studies will need to assess the generalizability of these results and to identify the conditions under which green credit can enhance both productivity and environmental outcomes.

Two key policy directions have emerged: improving policy operability and strengthening corporate environmental responsibility. To improve policy operability, regulators could introduce performance-based incentives for banks, mandate third-party audits of green portfolios, and adopt digital tracking systems to monitor environmental outcomes. These measures would improve transparency and accountability. To strengthen corporate environmental responsibility, governments could implement mandatory ESG (environmental, social, and governance) disclosures, publish "polluter rankings" to apply reputational pressure, and offer tax incentives for verified green investments. Such initiatives would align financial and environmental goals, encouraging firms to adopt environmentally cleaner practices.

These results provide relevant policy implications for policymakers, financial institutions, and enterprises in China and internationally aiming to optimize the use of green credit for sustainable development.

**Acknowledgements**

This work was supported by the Research Project on Humanities and Social Sciences of MOE, (Grant No.23YJA790006, No.24YJA790086), Fujian Provincial Federation of Social Sciences, China (Grant FJ2024B021, FJ2022B086), and the Major Project of the National Social Science Fund of China (Grant No.21&ZD146).

**References**

1. Badia, M. M., & Slootmaekers, V. (2009). The missing link between financial constraints and productivity. (IMF Working Paper No. 09/48). *International Monetary Fund*.
2. Bajo, E., Chemmanur, T. J., Simonyan, K., & Tehranian, H. (2016). Underwriter networks, investor attention, and initial public offerings. *Journal of Financial Economics*, 122(2), 376–408. https://doi.org/10.1016/j.jfineco.2015.12.001

3. Banerjee, R., Gupta, K., & Mudalige, P. (2020). Do environmentally sustainable practices lead to financially less constrained firms? *International evidence. International Review of Financial Analysis*, 68, 101337. https://doi.org/10.1016/j.irfa.2019.03.009
4. Barbera, A. J., & McConnell, V. D. (1990). The impact of environmental regulations on industry productivity: Direct and indirect effects. *Journal of Environmental Economics and Management*, 18(1), 50–65. https://doi.org/10.1016/0095-0696(90)90051-Y
5. Becker, R. A. (2011). Local environmental regulation and plant-level productivity. *Ecological Economics*, 70(12), 2516–2522. https://doi.org/10.1016/j.ecolecon.2011.08.019
6. Bernard, A. B., Redding, S. J., & Schott, P. K. (2010). Multiple-product firms and product switching. *American Economic Review*, 100(1), 70–97. https://doi.org/10.1257/aer.100.1.70
7. Beugelsdijk, S., Klasing, M. J., & Milionis, P. (2018). Regional economic development in Europe: The role of total factor productivity. *Regional Studies*, 52(4), 461–476. https://doi.org/10.1080/00343404.2017.1334118
8. Braguinsky, S., Ohyama, A., Okazaki, T., & Syverson, C. (2021). Product innovation, product diversification, and firm growth: Evidence from Japan’s early industrialization. *American Economic Review*, 111(12), 3795–3826. https://doi.org/10.1257/aer.20201656
9. Castany, L., López-Bazo, E., & Moreno, R. (2005). Differences in total factor productivity across firm size: A distributional analysis (Working Paper No. 2005/1). *Research Institute of Applied Economics*, University of Barcelona. https://www.econstor.eu/handle/10419/117450
10. Chen, S., Wang, K., & Liu, H. (2022). The impact of the Equator Principles on carbon financial markets: A case study based on China’s green credit data. *Energy Strategy Reviews*, 44, 100999. https://doi.org/10.1016/j.esr.2022.100999
11. Ciabuschi, F., Perna, A., & Snehota, I. (2012). Assembling resources when forming a new business. *Journal of Business Research*, 65(2), 220–229. https://doi.org/10.1016/j.jbusres.2010.11.029
12. Cui, Y., Geobey, S., Weber, O., & Lin, H. (2018). The impact of green lending on credit risk in China. *Sustainability*, 10(6). https://doi.org/10.3390/su10062008

13. Curtis, C. C. (2016). Economic reforms and the evolution of China's total factor productivity. *Review of Economic Dynamics*, 21, 225–245. https://doi.org/10.1016/j.red.2015.02.005
14. Del Gatto, M., Di Liberto, A., & Petraglia, C. (2011). Measuring productivity. *Journal of Economic Surveys*, 25(5), 952–1008. https://doi.org/10.1111/j.1467-6419.2009.00620.x
15. Eichholtz, P., Holtermans, R., Kok, N., & Yönder, E. (2019). Environmental performance and the cost of debt: Evidence from commercial mortgages and REIT bonds. *Journal of Banking & Finance*, 102, 19–32. https://doi.org/10.1016/j.jbankfin.2019.02.015
16. Elrod, A. A., & Malik, A. S. (2017). The effect of environmental regulation on plant-level product mix: A study of EPA's Cluster Rule. *Journal of Environmental Economics and Management*, 83, 164–184. https://doi.org/10.1016/j.jeem.2017.03.002
17. Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, 142(2), 499–516. https://doi.org/10.1016/j.jfineco.2021.01.010
18. Gao, L., & Mei, B. (2013). Investor attention and abnormal performance of timberland investments in the United States. *Forest Policy and Economics*, 28, 60–65. https://doi.org/10.1016/j.forpol.2013.01.003
19. Gatti, R., & Love, I. (2008). Does access to credit improve productivity? Evidence from Bulgarian firms. *Economics of Transition*, 16(3), 445–465. https://doi.org/10.1111/j.1468-0351.2008.00328.x
20. Gray, W. B., & Shadbegian, R. J. (2003). Plant vintage, technology, and environmental regulation. *Journal of Environmental Economics and Management*, 46(3), 384–402. https://doi.org/10.1016/S0095-0696(03)00031-7
21. Greenstone, M., List, J. A., & Syverson, C. (2012). The effects of environmental regulation on the competitiveness of U.S. manufacturing (Working Paper No. 18392). *National Bureau of Economic Research*. https://doi.org/10.3386/w18392
22. Guo, Y., Ge, H., Liao, Z., Hu, Y., & Huang, B. (2024). The influence of financial innovation on enterprise risk management. *Finance Research Letters*, 62, 105098. https://doi.org/10.1016/j.frl.2024.105098
23. Haider, Z. A., Liu, M., Wang, Y., & Zhang, Y. (2018). Government ownership, financial constraint, corruption, and corporate performance: International evidence. Journal

of International Financial Markets, *Institutions and Money*, 53, 76–93. https://doi.org/10.1016/j.intfin.2017.09.012

24. Hamamoto, M. (2006). Environmental regulation and the productivity of Japanese manufacturing industries. *Resource and Energy Economics*, 28(4), 299–312. https://doi.org/10.1016/j.reseneeco.2005.11.001
25. He, L., Zhang, L., Zhong, Z., Wang, D., & Wang, F. (2019). Green credit, renewable energy investment and green economy development: Empirical analysis based on 150 listed companies of China. *Journal of Cleaner Production*, 208, 363–372. https://doi.org/10.1016/j.jclepro.2018.10.119
26. Hering, L., & Poncet, S. (2014). Environmental policy and exports: Evidence from Chinese cities. *Journal of Environmental Economics and Management*, 68(2), 296–318. https://doi.org/10.1016/j.jeem.2014.06.005
27. Hu, G., Wang, X., & Wang, Y. (2021). Can the green credit policy stimulate green innovation in heavily polluting enterprises? Evidence from a quasi-natural experiment in China. *Energy Economics*, 98, 105134. https://doi.org/10.1016/j.eneco.2021.105134
28. Jaffe, A. B., Peterson, S. R., Portney, P. R., & Stavins, R. N. (1995). Environmental regulation and the competitiveness of U.S. manufacturing: What does the evidence tell us? *Journal of Economic Literature*, 33(1), 132–163.
29. King, M. R., & Santor, E. (2008). Family values: Ownership structure, performance and capital structure of Canadian firms. *Journal of Banking & Finance*, 32(11), 2423–2432. https://doi.org/10.1016/j.jbankfin.2008.02.002
30. King, R. G., & Levine, R. (1993). Finance and growth: Schumpeter might be right. *The Quarterly Journal of Economics*, 108(3), 717–737. https://doi.org/10.2307/2118406
31. Kong, G., Wang, S., & Wang, Y. (2022). Fostering firm productivity through green finance: Evidence from a quasi-natural experiment in China. *Economic Modelling*, 115, 105979. https://doi.org/10.1016/j.econmod.2022.105979
32. Lanoie, P., Patry, M., & Lajeunesse, R. (2008). Environmental regulation and productivity: Testing the porter hypothesis. *Journal of Productivity Analysis*, 30(2), 121–128. https://doi.org/10.1007/s11123-008-0108-4
33. Letta, M., & Tol, R. S. J. (2019). Weather, climate and total factor productivity. *Environmental and Resource Economics*, 73(1), 283–305. https://doi.org/10.1007/s10640-018-0262-8

34. Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservables. *The Review of Economic Studies*, 70(2), 317–341. https://doi.org/10.1111/1467-937X.00246
35. Levinson, A. (2009). Technology, International Trade, and Pollution from US Manufacturing. *American Economic Review*, 99(5), 2177–2192. https://doi.org/10.1257/aer.99.5.2177
36. Li, S., Liu, Q., Lu, L., & Zheng, K. (2022). Green policy and corporate social responsibility: Empirical analysis of the Green Credit Guidelines in China. *Journal of Asian Economics*, 82, 101531. https://doi.org/10.1016/j.asieco.2022.101531
37. Lileeva, A. (2010). The benefits to domestically owned plants from inward direct investment: The role of vertical linkages. *Canadian Journal of Economics/Revue Canadienne d'économique*, 43(2), 574–603. https://doi.org/10.1111/j.1540-5982.2010.01584.x
38. Lipscomb, M., Mobarak, M., Keller, W., Javorcik, B., Mattoo, A., Maskus, K., Redding, S., Mansur, E., Olmstead, S., Yeaple, S., Utar, H., Chen, M., Walsh, R., Chari, A., Iacovone, L., Raisanen, S., Nicar, S., & Holladay, S. (2008). The effect of environmental enforcement on product choice and competition: Theory and evidence from India.
39. Liu, B., Wang, J., Li, R. Y. M., Peng, L., & Mi, L. (2022). Achieving carbon neutrality—The role of heterogeneous environmental regulations on urban green innovation. *Frontiers in Ecology and Evolution*, 10. https://doi.org/10.3389/fevo.2022.923354
40. Love, J. H., & Ganotakis, P. (2013). Learning by exporting: Lessons from high-technology SMEs. *International Business Review*, 22(1), 1–17. https://doi.org/10.1016/j.ibusrev.2012.01.006
41. Lu, Y., Gao, Y., Zhang, Y., & Wang, J. (2022). Can the green finance policy force the green transformation of high-polluting enterprises? A quasi-natural experiment based on "Green Credit Guidelines." *Energy Economics*, 114, 106265. https://doi.org/10.1016/j.eneco.2022.106265
42. Mani, M., & Wheeler, D. (1998). In Search of pollution havens? Dirty industry in the world economy, 1960 to 1995. *The Journal of Environment & Development*, 7(3), 215–247. https://doi.org/10.1177/107049659800700302
43. Mathews, J. A., & Kidney, S. (2012). Financing climate-friendly energy development through bonds. *Development Southern Africa*, 29(2), 337–349. https://doi.org/10.1080/0376835X.2012.675702

44. Nandy, M., & Lodh, S. (2012). Do banks value the eco-friendliness of firms in their corporate lending decision? Some empirical evidence. *International Review of Financial Analysis*, 25, 83–93. https://doi.org/10.1016/j.irfa.2012.06.008
45. Olley, G. S., & Pakes, A. (1992). The dynamics of productivity in the telecommunications equipment industry (Working Paper No. 3977). *National Bureau of Economic Research*. https://doi.org/10.3386/w3977
46. Petitjean, M. (2019). Eco-friendly policies and financial performance: Was the financial crisis a game changer for large US companies? *Energy Economics*, 80, 502–511. https://doi.org/10.1016/j.eneco.2019.01.028
47. Porter, M. E., & van der Linde, C. (1995). Toward a new conception of the environment-competitiveness relationship. *Journal of Economic Perspectives*, 9(4), 97–118. https://doi.org/10.1257/jep.9.4.97
48. Rajan, R. G., & Zingales, L. (1996). Financial Dependence and Growth (Working Paper No. 5758). *National Bureau of Economic Research*. https://doi.org/10.3386/w5758
49. Syverson, C. (2011). What Determines Productivity? *Journal of Economic Literature*, 49(2), 326–365. https://doi.org/10.1257/jel.49.2.326
50. Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, 61, 101427. https://doi.org/10.1016/j.jcorpfin.2018.12.001
51. Testa, F., Iraldo, F., & Frey, M. (2011). The effect of environmental regulation on firms' competitive performance: The case of the building & construction sector in some EU regions. *Journal of Environmental Management*, 92(9), 2136–2144. https://doi.org/10.1016/j.jenvman.2011.03.039
52. Van Biesebroeck, J. (2007). Robustness of productivity estimates. *The Journal of Industrial Economics*, 55(3), 529–569. https://doi.org/10.1111/j.1467-6451.2007.00322.x
53. Walley, N., & Whitehead, B. (1994). It's not easy being green. *Harvard Business Review*. https://hbr.org/1994/05/its-not-easy-being-green
54. Wang, C., Wu, J., & Zhang, B. (2018). Environmental regulation, emissions and productivity: Evidence from Chinese COD-emitting manufacturers. *Journal of Environmental Economics and Management*, 92, 54–73. https://doi.org/10.1016/j.jeem.2018.08.004

55. Wang, J., Chen, X., Li, X., Yu, J., & Zhong, R. (2020). The market reaction to green bond issuance: Evidence from China. *Pacific-Basin Finance Journal*, 60, 101294. https://doi.org/10.1016/j.pacfin.2020.101294
56. Whited, T. M., & Wu, G. (2006). Financial constraints risk. *The Review of Financial Studies*, 19(2), 531–559. https://doi.org/10.1093/rfs/hhj012
57. Yu, W., Du, B., Guo, X., & Marinova, D. (2023). Total factor productivity in Chinese manufacturing firms: The role of E-commerce adoption. *Electronic Commerce Research*. https://doi.org/10.1007/s10660-023-09711-7
58. Zhang, B., Yang, Y., & Bi, J. (2011). Tracking the implementation of green credit policy in China: Top-down perspective and bottom-up reform. J*ournal of Environmental Management*, 92(4), 1321–1327. https://doi.org/10.1016/j.jenvman.2010.12.019
59. Zhang, S., Zhang, M., & Meng, S. (2024). Corporate transaction costs and corporate green total factor productivity. *Finance Research Letters*, 61, 105041. https://doi.org/10.1016/j.frl.2024.105041
60. Zhou, X., & Cui, Y. (2019). Green bonds, corporate performance, and corporate social responsibility. *Sustainability*, 11(23), 6881. https://doi.org/10.3390/su11236881
61. Zhou, Y., Guo, Q., & Zhou, D. (2022). Environmental regulation and firms' product mix optimisation strategies—Empirical evidence from multi-product exporting firms. *Chinese Industrial Economy*, 6, 117–135.

**Contact information**

**Associate prof. Song Chen**
Taizhou University
College of Micro-Finance
China
E-mail: 77810388@qq.com

**Dr. Mingxiao Dai (Co-Corresponding Author)**
Jinan University
School of Economics
Postdoctoral Research Station

https://doi.org/10.7441/joc.2025.04.09

Dongguan Rural Commercial Bank
China
E-mail: daimingxiao@aliyunc.com
ORCID: 0009-0004-1120-2625

**Prof. Kuangnan Fang**
Xiamen University.
Center for New Quality Productive Forces Resarch
School of Economics
China
E-mail: xmufkn@xmu.edu.cn
ORCID: 0000-0003-0934-7281

**Xiangcheng Huang**
Guangxi Rural Commercial Bank
China
E-mail: hxcxmu@163.com

**Prof. Jing Zhang (Corresponding Author)**
Xiamen University.
School of Economics
China
E-mail: jzhang1@xmu.edu.cn
ORCID: 0000-0002-4608-6853

https://doi.org/10.7441/joc.2025.04.09