

Bank-Firm Relationship and Corporate Green Innovation: Evidence from China

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Abstract: This paper analyzes the correlation between bank-firm relationship and corporate green innovation in heavy pollution industries in China. It is found that bank-firm relationship has positively effect on corporate green innovation. The result is robust to Heckman two-stage analysis and Placebo test. Mechanism analysis shows that bank-firm relationship can reduce information asymmetry between borrower and lender, and foster corporate to obtain more debt financing and advance environmental governance. Moreover, the effect of bank-firm relationship on green innovation is more pronounced for corporate located in the area with poor green finance and low environmental regulatory information. Our findings suggest that bank-firm relationship can promote corporate green innovation and contribute to the development of green finance.

Keywords: Bank-firm relationship, Corporate, Green innovation, Information asymmetry, China.

1. Introduction

Green innovation, as a key factor in maintaining environmental management, is an important method to reduce environmental pollution and has been recognized as a main corporate response to environmental regulations (Lee and Kim 2011). The factors driving firms to engage in green innovation include environmental regulations, technological capabilities, managerial environmental concern, competitive pressures, customer green demand and so on (Taklo and Tooranloo 2021). However, green innovation also implies costly investments and risky returns. Firm's green innovation is also restrained by financial resources, especially when firms face higher financing constraints (Yu et al. 2021).

It is argued that bank-firm relationship can reduce information asymmetry between bank and firm (Boot and Thakor 2000), which will induce better monitoring, improve the borrower's corporate governance (Dass and Massa 2011) and increase access to finance (Agarwal and Elston 2001). Therefore, it can be inferred that bank-firm relationship can facilitate corporate green innovation. Unfortunately, there is no prior literature studying the impact of bank-firm relationship on corporate green innovation.

Using firm-level data on Chinese listed companies in high-polluting industries during 2008–2020, this study examines whether bank-firm relationship promotes corporate green innovation. The results show that firms with bank-firm relationship apply more green invention patent and utility model patents than ones with non-bank-firm relationship. We also find that the impact of bank-firm relationship on green innovation is more important in firms operating in the areas with poor development of green finance and low transparency of environmental regulatory information. Additionally, two plausible channels through which bank-firm relationship helps firms to invest green innovation are explored. First, bank-firm relationship is associated with more bond finance. Second, bank-firm relationship induces firm to establish the strategy of green development. The results are robust to instrumental variable test and Placebo test.

Our study contributes to the existing literature in two respects. First, it complements the previous literature on the

interplay between bank-firm relationship and innovation. Cosci et al. (2016) find that relationship lending may be an effective way to overcome the disadvantage of bank loans in the financing of innovation, but do not distinguish the difference between traditional innovation and green innovation. We provide complementary evidence on the effect of bank-firm relationship on green innovation.

Second, this study enriches the existing literatures on green finance, which focuses on the products and determinants of green finance, including green securities, green investments, climate finance, carbon finance, green insurance and green credit (Akomea-Frimpong et al. 2022). However, fewer studies investigate the green finance from the perspective of social capital. Our results first suggest that the effect of bank-firm relationship on corporate green innovation may be relevant.

The remainder of this paper is organized as follows. Section 2 provides a theoretical framework and hypotheses development. Section 3 describes sample and measurement choices. Section 4 presents our results, and Section 5 provides concluding remarks.

2. Theory Analysis and Hypothesis Development

Environmental issues have received a great deal of attention over the last few decades. Therefore, corporates especial in high-polluting industries face more stringent environmental regulations. Failure to compliance with environmental regulation will put firms in operational risk even in danger of business termination (Pellegrino and Lodhia 2012). Green innovation has become an important response for corporate to cope with the pressure of environmental regulation (Lee and Kim 2011).

Financial resources are highly associated with the companies' innovation (Hall 2010). However, corporate's innovations create wide information gaps between insiders and capital markets because the idiosyncratic and intangible (Eberhart et al. 2008), which will triggers adverse selection for capital providers and moral hazard for capital users. Encaoua et al. (2013) also found that banking system is generally unsuitable to support innovation activity because of

shortage of adequate instruments to evaluate innovation projects. Nevertheless, bank-firm relationship will help reduce asymmetric information between bank and corporate. With the close bank-firm relationship, bank can access to corporate private information, including environmental performance and R&D information and assess their risks conveniently. Consequently, bank-firm relationship will provide opportunity for bank to support corporate green innovation.

The Chinese government launched its groundbreaking Green Credit Policy in 2007 and issued Green Credit Guidelines in 2012 that aim to encourage banking institutions to develop green credit and adopt stronger environmental and social risk management. The Green Credit Guidelines set out how banks should address sustainability issues at the board and top management level and how to integrate environmental and social considerations into the entire lending circle with a robust evaluation mechanism. Any banks who violate Green Credit Policy will be punished by the central government or banking supervision departments. Additionally, bank-firm relationship can induces better monitor and improves borrower's corporate governance (Dass and Massa 2011). Therefore, bank has also an incentive to promote corporate with bank-firm relationship to establish green strategy and reduce credit policy risks.

Additionally, banks also provide a unique informational role in the lending process due to private information collection (James 1987). When negotiating a debt contract, bank-firm relationship can facilitate bank to share industries information with borrower. Consequently, bank-firm relationship will help corporate to lower the decision risk on green innovation. Accordingly, we state hypothesis as follows:

H1: bank-firm relationship is conducive to corporate's green innovation.

Green finance is a new financial pattern to integrate environmental protection with economic profits. Contrary to the traditional finance which focuses on economic performance, green finance pays more attention to environmental performance (Wang and Zhi 2016). Green finance increases financial flows from the public, private and not-for-profit sectors to sustainable development priorities, helping corporate to access external capital for green investment and resolving financing constraints of firms to green innovation (Yu et al. 2021). In the area with poor green finance, traditional finance dominates capital market and the local financial system can hardly supports corporate's green development. Consequently, the role of bank-firm relationship in financial support on corporate's green innovation will be more effective in the area with poor green finance. Therefore, we state hypothesis as follows:

H2: the positive effect of bank-firm relationship on corporate's green innovation is more pronounced for corporate located in the area with poor green finance.

As mentioned above, bank-firm relationship will help reduce asymmetric information between bank and borrower. For high-polluting industries, the environmental information is vital for bank' lending decisions. If corporate is located in the area with high government transparency, bank can get access to corporate's environmental regulatory information conveniently. Accordingly, the effect of bank-firm relationship on corporate green innovation will decreases. On the contrary, bank can obtain more environmental performance information from borrower with bank-firm relationship, which might be specific constraints imposed by

government entities in the area with low government transparency. Therefore, we state hypothesis as follows:

H3: the positive effect of bank-firm relationship on corporate's green innovation is more pronounced for corporate located in the area with low environmental regulatory information.

3. Research Design

3.1. Sample Selection

This study focuses on high-polluting industries in China because these corporates are subject to high environmental regulation to change their environmental practices. Due to available data of green innovation, the initial sample comprises listed companies in high-polluting industries in China from year 2008 to 2020. We also exclude firm-year observations with missing variables and the first year of IPO. After these restrictions, 9,647 firm year observations comprise our final sample.

3.2. Measurements of Main Variables

3.2.1. Measurement of green innovation

According to Ren et al. (2021b), we measure corporate green innovation using number of green invention patent applications and green utility model patent applications. The article uses the patent application information of invention and utility model for listed companies in the China Research Data Service Platform (CNRDS). The green patent is identified according to the green list of international patent classifications launched by the World Intellectual Property Organization (WIPO). The natural logarithm of the number of green invention patents and green utility model patents applied for by each firm each year plus 1 is used as a proxy variable for the firm's green innovation respectively.

3.2.2. Measurement of bank-firm relationship

The notion of "guanxi" has generated a voluminous literature in understanding the Chinese approach to commercial relationships and social networking. In the Chinese banking market, "guanxi" is believed to be a significant variable in banking relationships (Yin and Matthews 2017). Consequently, we measure bank-firm relationship based on the background of a firm's chairman or CEO. A firm is considered bank-firm relation if its chairman or CEO is a current or former officer in the banks or departments of banking supervision.

3.3. Baseline Regression Model

In order to examine the impact of bank-firm relationship on green innovation, we construct the following baseline model (1) with the use of ordinary least squares (OLS):

$$Gp_{i,t} = \alpha_0 + \alpha_1 Br_{i,t} + \alpha_2 X_{i,t} + Year + Industry + \varepsilon_{i,t} \quad (1)$$

$Gp_{i,t}$ is the independent variable which means green innovation of firm i in year t . We use Gip to represent the number of green invention patents and Gup to represent the number of green utility model patents applied respectively.

Br represents bank-firm relationship which equal to one for corporate with bank-firm relationship and zero otherwise; $X_{i,t}$ is a set of corporate-level control variables. To be consistent with the Ren et al. (2021a), this paper also controls the firm size (Size), asset-liability ratio (Lev), and return on total assets (Roa), market value (Tobinq), Capital

expenditure(Capex) , nature of property rights (Soe), listing years (Age) in model(1); Year and Industry represent time and industry fixed effects, respectively; $\varepsilon_{i,t}$ is the model residual term. Model (1) also controls the robust standard error.

3.4. Data Sources

The data sources of this article are as follows: green patent data comes from China Research Data Service Platform (CNRDS); other data comes from the CSMAR database. In order to avoid the influence of outliers, continuous variables

are tailed at the 1% level.

4. Empirical Results and Analysis

4.1. Descriptive Statistics

Table 1 is a descriptive statistic of the main variables. It reveals that mean Gip and Gup are 0.179 and 0.183 respectively, which suggest that few corporates invest green innovation. mean Bs is 0.035, which also reveals the low ratio of bank-firm relationship in our sample.

Table 1. Descriptive statistics

Variables	Mean	Median	SD	Min	Max
Gip	0.179	0.000	0.529	0.000	2.944
Gup	0.183	0.000	0.492	0.000	2.565
Bs	0.035	0.000	0.183	0.000	1.000
Size	22.203	22.014	1.336	19.517	26.179
Lev	0.442	0.438	0.218	0.051	1.018
Roa	0.043	0.038	0.072	-0.239	0.256
Tobin'Q	2.083	1.597	1.462	0.852	9.514
Capex	0.082	0.056	0.085	0.001	0.504
Soe	0.454	0.000	0.498	0.000	1.000
Age	10.863	11.000	6.652	0.000	28.000

4.2. Baseline Regression Analysis

Table 2 shows the results of ordinary least squares (OLS) regression using equation (1). The dependent variables in columns (1) to (2) is Gip and Gup respectively. The Br

coefficient is significantly positive in all regression models. The results show that corporate with bank-firm relationship can indeed foster its green innovation, which verifies hypothesis 1.

Table 2. Regression results of the effect of bank-firm relationship on corporate green innovation

Variables	(1) Gip	(2) Gup
Br	0.053** (2.016)	0.045*** (2.693)
Size	0.157*** (21.084)	0.159*** (23.385)
Lev	-0.117*** (-4.639)	-0.099*** (-4.036)
Roa	-0.104 (-1.449)	-0.325*** (-5.225)
Tobin'Q	0.026*** (7.209)	0.031*** (8.929)
Capex	-0.021 (-0.378)	-0.024 (-0.427)
Soe	0.011 (0.910)	0.030*** (2.955)
Age	-0.002* (-1.918)	-0.005*** (-5.119)
_cons	-3.324*** (-21.084)	-3.197*** (-21.814)
Ind	Yes	Yes
Year	Yes	Yes
N	9647	9647
R ²	0.179	0.238

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

4.3. Cross-Sectional Analyses

We perform further analyses of the cross-sectional variation of the association between bank-firm relationship and corporate green innovation. Firstly, we class sample based on the regional development of green finance according to Wang (2020). The results from re-estimating our baseline regression model based on regional development of green finance are reported in table 3. As shown in columns (1) and

(2) of Table 3 where the dependent variable is Gip, the coefficient of Br is not significant in the provinces with good green finance while significant in the provinces with poor green finance. Meanwhile, the coefficient of Br is not different in columns (3) and (4) where the dependent variable is Gup. Considering the importance of green invention patent exceeds that of green utility model patent, it can be concluded that the positive effect of bank-firm relationship on corporate's green innovation is more pronounced for corporate located in the area with poor green finance. Therefore, hypothesis 2 is confirmed.

Table 3. Regional development of green finance and the effect of bank-firm relationship on green innovation

Variables	(1) Gip	(2) Gip	(3) Gup	(4) Gup
	Provinces with good green finance	Provinces with poor green finance	Provinces with good green finance	Provinces with poor green finance
Br	0.018 (0.395)	0.065** (1.984)	0.031 (0.868)	0.026 (0.862)
Size	0.200*** (16.889)	0.115*** (14.141)	0.200*** (18.447)	0.121*** (15.996)
Lev	-0.148*** (-3.179)	-0.071** (-2.536)	-0.155*** (-3.457)	-0.038 (-1.375)
Roa	-0.116 (-0.853)	-0.072 (-0.945)	-0.558*** (-5.337)	-0.163** (-2.158)
Tobin'Q	0.024*** (3.820)	0.020*** (4.954)	0.031*** (5.406)	0.024*** (5.929)
Capex	-0.044 (-0.462)	0.022 (0.348)	-0.066 (-0.702)	0.028 (0.399)
Soe	0.037 (1.538)	0.010 (0.771)	0.060*** (3.252)	0.012 (0.952)
Age	-0.003 (-1.504)	0.001 (0.498)	-0.008*** (-5.230)	-0.001 (-1.244)
_cons	-3.953*** (-15.105)	-2.529*** (-14.117)	-3.812*** (-15.528)	-2.469*** (-14.899)
Ind	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	4018	5629	4018	5629
R ²	0.231	0.171	0.328	0.200

Secondly, we class sample based on the regional transparency of environmental regulatory information according to (IPE 2020). The results of the comparison between cities with high transparency of environmental regulatory information and ones with low transparency are report in table 4. As show in columns (1) and (2) of table 4, the coefficient of Br is not significant in the cities with high

transparency of environmental regulatory information while significant in the cities with low transparency, consistent with hypothesis 3 that the positive effect of bank-firm relationship on corporate's green innovation is more pronounced for corporate located in the area with low environmental regulatory information.

Table 4. Regional transparency of environmental regulatory information and the effect of bank-firm relationship on green innovation

Variables	(1) Gip	(2) Gip	(3) Gup	(4) Gup
	Cities with high transparency of environmental regulatory information	Cities with low transparency of environmental regulatory information	Cities with high transparency of environmental regulatory information	Cities with low transparency of environmental regulatory information
Br	-0.050 (-0.942)	0.084** (2.151)	0.060 (1.216)	0.024 (0.684)
Size	0.242*** (19.666)	0.087*** (9.270)	0.220*** (20.134)	0.106*** (11.171)
Lev	-0.147*** (-2.750)	-0.112*** (-3.172)	-0.090* (-1.913)	-0.094** (-2.480)
Roa	-0.348** (-2.230)	0.068 (0.731)	-0.471*** (-3.805)	-0.202** (-2.130)
Tobin'Q	0.034*** (4.724)	0.014*** (3.316)	0.037*** (5.827)	0.017*** (3.755)
Capex	0.043 (0.368)	0.022 (0.294)	0.025 (0.212)	-0.007 (-0.099)
Soe	0.041 (1.578)	0.028 (1.515)	0.082*** (3.822)	0.000 (0.006)
Age	-0.005** (-2.299)	-0.002 (-1.368)	-0.011*** (-6.626)	-0.002 (-1.366)
_cons	-5.011*** (-19.057)	-1.823*** (-9.142)	-4.279*** (-17.657)	-2.060*** (-10.189)
Ind	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	3619	3245	3619	3245
R ²	0.301	0.118	0.382	0.170

4.4. Mechanism Analysis

In this section, we examine specific channels through which bank-firm relationship prompt corporate green

innovation. As discussed in section 2, there are two different channels: access to credit resource, and the environmental governance channel. The channel of access to credit resource channel suggests that bank-firm relationship can reduce

information asymmetry between borrower and lender, and foster corporate to obtain more debt financing. Thus, corporate will has the financial resource to support green innovation. The channel of environmental governance proposes that bank-firm relationship will help bank to monitor the corporate environmental performance and advance the environmental governance.

We use bank debt financing and bond financing as dependent variables respectively and bank-firm relationship as independent variable to examine the channel effect of access to credit resource channel. The results are shown in columns (1) and (2) of table 5 respectively. The dependent variable Loan in columns (1) represents bank debt financing which is measured with the amount of cash received from bank loan divided by total assets. The dependent variable Bond in columns (2) means bond financing which is calculated with the amount of cash received from bond

issuance divided by total assets. The coefficient of Br is positive significant in columns (1) and (2), which demonstrates that bank-firm relationship can help corporate obtain debt financing.

Additionally, we use environmental investment and corporate green development strategy as dependent variables respectively and bank-firm relationship as independent variable to test the channel effect of environmental governance. The results are presented in columns (3) and (4) of table 5 respectively. The dependent variable Einvest in columns (3) denote corporate environmental investment scaled by total assets. The dependent variable Greenstrategy is a binary variable that take values of one if a corporate establish the green development strategy, and 0 otherwise. The coefficient of Br is positive significant in columns (3) and (4), which shows that bank-firm relationship can help corporate to strengthen environmental governance.

Table 5. Mechanism analysis

Variables	(1) Loan	(2) Bond	(3) Einvest	(4) Greenstrategy
Br	0.017* (1.791)	0.015** (2.011)	0.007** (1.968)	0.152* (1.740)
Size	0.012*** (7.084)	0.005*** (15.825)	-0.000 (-0.555)	0.159*** (10.998)
Lev	0.459*** (42.952)	0.006*** (5.414)	-0.000 (-0.168)	-0.198** (-2.144)
Ppe	0.034*** (2.873)	-0.005*** (-2.948)		
Roa	-0.025 (-0.685)	0.007** (2.268)	0.001 (0.194)	0.009 (0.035)
Tobin'Q	-0.015*** (-10.054)	0.000 (1.156)		
Cfo	-0.108*** (-4.786)	-0.013*** (-4.018)		
Soe	-0.022*** (-5.950)	-0.002** (-2.557)	0.000 (0.492)	0.025 (0.657)
Age	-0.001*** (-5.883)	-0.000*** (-3.077)	0.000** (2.143)	-0.011*** (-4.085)
Growth			-0.000* (-1.761)	-0.004 (-0.701)
Indep			0.010* (1.755)	-0.041 (-0.141)
_cons	-0.224*** (-6.021)	-0.104*** (-15.305)	0.145*** (21.638)	-4.875*** (-14.403)
Ind	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
N	9647	9647	9647	9647
R ² / Pseudo R ²	0.440	0.076	0.055	0.090

t statistics in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01; The last line for coloum 4 is Pseudo R²

4.5. Robustness Test

4.5.1. The Heckman two-stage analysis

If some unobserved determinants of green innovation also change around bank-firm relationship, the establishment of bank-firm relationship could still be endogenous. according, we apply the Heckman (1979) two-stage approach to alleviate the endogeneity concern. In the first-stage analysis, we estimate probit model to predict the presence of bank-firm relationship with the mean value of bank-firm relationship in

the same year and industry, then calculated the 2SLS estimator for the second stage of the Heckman model.

Table 6 reports the results of Heckman-2SLS approach. Columns (1) presents the results of Heckman's first-stage model. Columns (2) and (3) show the results of Heckman's second-stage model. As shown in columns (2) and (3) in table 6, the coefficients of instrumental variables—namely, Br_iv—are positively significant, suggesting that bank-firm relationship has a positive and significant relationship with corporate green innovation. Hence, we can confirm that the positive relationship between bank-firm relationship and corporate green innovation is valid after appropriately accounting for significant endogenous concerns.

Table 6. Heckman two-stage analysis

Variables	(1)	(2)	(2)
	first Br_iv	second Gip	second Gup
Br	0.006*** (7.54)		
Br_iv		6.893* (1.74)	7.401* (1.86)
Size	0.000 (1.43)	0.150*** (28.63)	0.169*** (35.61)
Lev	-0.008*** (-8.95)	-0.007 (-0.15)	0.011 (0.27)
Roa	0.006** (2.12)	-0.135 (-1.48)	-0.367*** (-4.46)
Tobin'Q	0.001*** (11.26)	0.006 (0.76)	0.014** (2.05)
Capex	-0.000 (-0.19)	0.021 (0.33)	0.004 (0.07)
Soe	-0.002*** (-5.20)	0.042*** (2.68)	0.068*** (4.81)
Age	0.000*** (12.07)	-0.005*** (-3.01)	-0.008*** (-5.11)
Constant	0.031*** (9.32)	-3.397*** (-19.53)	-3.850*** (-24.49)
Year	YES	YES	YES
N	9,647	9,647	9,647
R ²	0.056	0.101	0.151

4.5.2. Placebo Test

In order to test for the robustness of the results presented above, this paper also uses Placebo test to examine whether other unobserved factors affect company green innovation. The Placebo test was conducted as follows: we first randomized the value of Br for every firm-year and repeated this random process for 500 times. We then analyzed the distribution of the estimated coefficients of Br under randomization. If the mean value of the Br estimated coefficient is close to 0, this would mean that the unobserved

random factors do not have significant influence over the benchmark estimation result.

The results of the Placebo test are shown in Figure 1, where Figure 1a shows the kernel density distribution of 500 randomized estimates of the Br coefficient with Gip as the dependent variable, and Figure 1b with Gup as the dependent variable. The mean values of the Br coefficients in Figure 1a and 1b are closer to 0, which means that the unobserved random factors did not have significant impact on the benchmark results and that the Baseline regression model is robust.

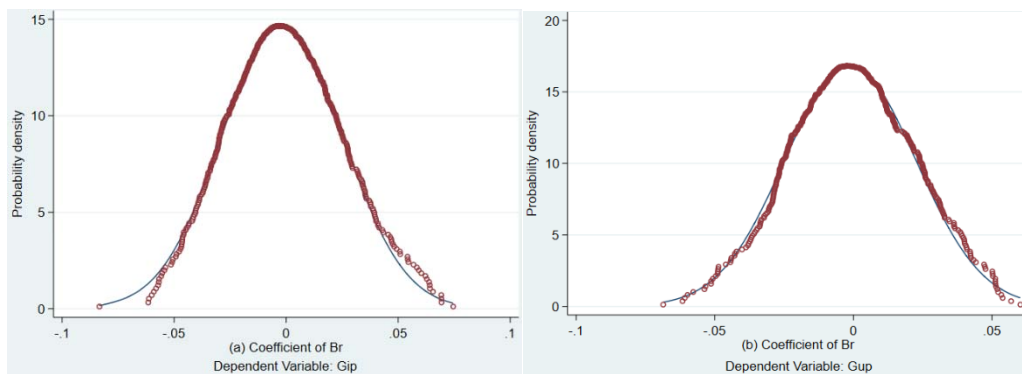


Figure 1. Kernel density distribution with randomized coefficients of Br

Note: This figure describes the result of Placebo test. X-axis represents coefficients of Br; Y-axis represents probability density of coefficient of Br; (a) Randomized coefficient estimate-Gip; (b) Randomized coefficient estimate-Gup.

5. Conclusion

Green innovation is an important method to reduce environmental pollution which attracts great attention and efforts from governments and corporates. We find that bank-firm relationship can significantly promote corporate's engagement in green innovation. Specifically, the positively

effect of bank-firm relationship on green innovation is more pronounced for corporate located in the area with poor green finance and low environmental regulatory information.

Additionally, we examine the channels through which bank-firm relationship influence corporate' green innovation. Our results show that bank-firm relationship can reduce information asymmetry between borrower and lender, and foster corporate to obtain more debt financing. Additionally, bank-firm relationship will help bank to monitor the corporate environmental performance and advance the environmental governance.

Our study complements the previous literature on the interplay between bank-firm relationship and innovation. We

provide new evidence on the effect of bank-firm relationship on green innovation. this study also enriches the existing literatures on green finance. As far as we're concerned, this study first suggests that the effect of bank-firm relationship on corporate green innovation is relevant. These findings will enhance our understanding of the role of bank-firm relationship in green development.

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