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Environmental Regulation and the Cost of Bank Loans: International Evidence

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Abstract

Using a sample of 27 countries between 1990 and 2014, we find that banks charge a higher interest rate on their loans when lending to firms that face more stringent environmental regulations. Further, we show that firms facing such regulations maintain lower financial leverage, incur more operating expenses, and have fewer banks participating in their loan syndicate. The results of the subsample analysis suggest that the increase in the cost of bank loans is more pronounced for financially constrained firms, firms in industries with high environmental litigation risk, and those located in bank-based economies. Overall, our results provide evidence that the observed higher loan spread is the result of environmentally sensitive lending practices by banks.

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Many companies no longer see corporate responsibility as a moral issue, but as core business risks and opportunities. More and more investors accept that environmental and social factors put company value at stake. This leads to the question of what the potential financial impacts of those risks and opportunities could be…

- The KPMG Survey of Corporate Responsibility Reporting (2013)

1. Introduction

In recent years, we have witnessed governments around the world ramping up their environmental regulations to curb carbon emissions in order to combat climate change.[1] Moreover, anecdotal evidence (recent reports by KPMG, for example) reveals that companies themselves increasingly view such issues as financial rather than nonfinancial and therefore treat them as meaningful risk factors and internally develop policies to address them. These new developments have revived researchers' interest in an old question: how do environmental policies affect firms? The impact of these policies, whether they are voluntarily adopted by firms as part of their corporate social and environmental responsibility or imposed on them by governments, have been the subject of intense debate for decades. Literature has studied this issue predominantly from two related perspectives: corporate environmental responsibility (CER hereafter), and firms' competitiveness and innovation. The first angle that is the focus of our study looks at the environmental regulation-firm relation from the perspective of CER. The objective of these regulations is to enhance corporate environmental responsibility by making it mandatory for firms to become more environmentally sensitive and responsible. These studies mainly conduct a cost-

[1] For example, the 2015 Paris Climate Accord, a multilateral agreement that involves 175 parties (174 states and the European Union), requires a long-term commitment by the signatory parties to reduce their CO_2 emission and their carbon footprints to assure that the increase in global average temperature is kept bellow 2°C.

benefit analysis to determine the pros and cons of these regulations and, more generally, those of CER.[2]

Ever since the passage of the first major environmental regulations in the 1970s, businesses, policymakers, and academics have debated the impact on firms of such regulations and more generally the relevance of CER. Two main opposing views dominate this debate. On the one hand, advocates of CER argue that the cost associated with these environmental policies should be viewed as a tool to manage risk or as an investment in intangible assets such as human capital, reputation, and innovation. Studies in this camp generally focus on firms' social and environmental profiles and document a significant positive (negative) effect on firms with a good (concerning) profile (Sharfman and Fernando, 2008; Oates et al., 1993; El Ghoul et al., 2011; El Ghoul et al., 2018; Chava, 2014; Goss and Roberts, 2011; Guenster et al., 2011; Jiao, 2010; Flammer, 2013; Clarkson et al., 2011). On the other hand, the critics view these costs as a drain on firms' resources. They view these costs as a manifestation of the agency conflict similar to the self-dealing problem as in Yermack (2006). They argue that the cost associated with these policies is a diversion of firm resources, does not benefit investors or lenders, is not rewarded by the market, and could have been invested more profitably. Studies that support this view also focus on firms' social and environmental profiles, and predominantly find little or no evidence of a positive impact of these policies on firms (Mahapatra, 1984; Jaffe and Palmer, 1997; Nelling and Webb, 2009; Hamilton et al., 1993; Brammer et al., 2006). These mixed results in the literature leave the issue of environmental regulation-firm relation (and more generally the issue of CER-firm relation) an open question. In fact, Renneboog et al. (2008), Kempf and Osthoff (2007), and Sharfman and

[2] The other strand of the literature focuses on firm's competitiveness and innovation. One group of these studies argue that firms would be more innovative and competitive with more stringent environmental regulations (e.g., Porter Hypothesis), while the other group argues that stronger regulations stifle innovation. While not the focus of our paper, we briefly discuss this issue in Section 4.6.

Fernando (2008) call for more research that investigates the impact of these regulations on cost of capital. In particular, Sharfman and Fernando (2008, p. 589) call for a study to examine cost of debt in an international setting *"*where the pressure for firms to improve their environmental risk management is potentially stronger (e.g., Europe and Australia), both from regulation and from societal pressure*."* In this paper, we respond to this call by focusing on environmental regulation rather than firms' social and environmental profiles and study its impact on loan contracting and cost of debt in an international setting. Specifically, we examine whether and to what extent lenders view environmental regulation as a relevant risk factor and incorporate it into different dimensions of their loan contracts.

Parallel to the rise of socially responsible investing, there has been substantial growth in environmentally sensitive lending as well (Chava, 2014; Cogan, 2008).[3] Evidence suggests banks are more sensitive to environmental issues than other lenders (Chang et al., 2018). Moreover, bank loans have historically been arguably one of the most important sources of external finance (Houston and James, 1996). During 1970 to 1985, bank loans accounted for 79% of external financing for firms in the United Kingdom, 49% in Germany, 78% in France, 41% in Canada, and 66% in Japan (Tirole, 2006). Overall, these patterns have continued over time. As a percentage of GDP, bank loans remain an important source of external finance, with lower and upper middle-income economies having a ratio of less than 50% by the end of the 2000s, whereas for high income economies (Organization for Economic Cooperation and Development, (OECD)) this ratio is slightly below 125% (Allen et al., 2013, Figure 1, p. 764). In addition, it is a well-established

[3] Chava (2014, p. 2223) reports that *"*a large number of banks, representing approximately 80% of the global lending volume, have adopted the Equator Principles (http://www.equator-principles.com), are signatories to the United Nations Environment Programme's Statement by Banks, and have agreed to consider social and environmental issues in project finance*."* The report by Cogan (2008) also reveals that the global banking sector has a clear agenda to include climate change concerns in their lending decisions and that 72.5% of the banks in the survey are involved in clean and renewable energy lending.

notion in the banking literature that banks as delegated monitors have access to information that may be unavailable to outsiders, and thus they are in a unique position to assess their borrowers' risk and their ability to repay loans. Therefore, if environmental regulation is a relevant (risk) factor that affects firms' future cash flows, banks are among the best stakeholders, if not the best, to show sensitivity to this risk factor and reflect it in their loan contracts.

Our empirical findings support the view that environmental regulation is relevant to lenders and that they charge higher interest rates on loans issued to firms that face stronger environmental regulations. Using the within-country variation of a measure of environmental policy stringency (EPS hereafter) developed by Botta and Koźluk (2014), for a sample of 27 countries (except the U.S.) between 1990 and 2014, we find strong evidence that a stiffer environmental regulation is associated with higher bank loan spreads. Specifically, we find that a one standard deviation increase in EPS leads to about a 15.8% increase in the cost of bank loans, which is both statistically and economically significant. For an average firm in our sample that has a loan spread of 170.45 basis points, this translates into an increase of about 27 basis points. This result survives after addressing endogeneity through a difference-in-difference approach, and is robust to different model specifications, inclusion of year, country, industry, firm, loan type, and purpose fixed effects. While this result strongly suggests that environmental regulation is a meaningful risk factor to lenders, the impact may not be limited to loan spreads. Lenders have other options beyond loan spread to mitigate the risk (Goss and Roberts, 2011). For example, they can issue secured loans, shorten maturity, and increase up-front fees. We explore these options, and we find empirical evidence consistent with these predictions. A one standard deviation increase in EPS leads to about a 7.6% increase in the likelihood of issuance of a secured loan, increases loan up-front fees by about 25%, and shortens loan maturity by about 4% (though statistically insignificant).

What is the mechanism through which environmental regulation affects firms? We argue that stronger environmental regulation increases firms' environmental liabilities. Therefore, to the extent that environmental liabilities represent a meaningful risk factor to lenders, we expect them to charge higher interest rates on loans issued to firms that face strong environmental regulations. Environmental liabilities are legally binding, can potentially lead to a substantial and continuous outflow of funds, and failure to comply may lead to downgrades in bond rating (Graham et al., 2001), ultimately resulting in lawsuits or bankruptcy (Schneider, 2011; Chang et al., 2018). In particular, Chang et al. (2018) find a negative relationship between environmental liabilities and financial leverage and conclude that environmental liability is a (an imperfect) substitute for financial liability and that firms with better environmental profiles have enhanced debt capacity and better access to bank loans. Anecdotal evidence also supports the idea that environmental liability risk is relevant and has increased substantially around the world. Due to the oil spill in the Gulf of Mexico in 2010, British Petroleum (BP) was charged $42 billion.[4] To clean up its environmental damage in Amazon region, Chevron was ordered to pay $9.5 billion in 2011.[5] More recently, in June 2016, the partial settlement of Volkswagen's emission scandal was valued at $14.7 billion.[6] These growing examples reveal the significance of environmental liability risk.

By raising the regulatory threshold and thereby increasing firms' environmental liabilities, more stringent environmental regulations systematically undermine existing environmental profiles of all firms in a country. Firms that are marginally in compliance with existing regulations may be in violation of the new and stronger regulations once those regulations go into effect. This

[4] *Economist*, 8 February 2014.
[5] *Economist*, 5 March 2014.
[6] In her press conference on June 28, 2016, Sally Yates, U.S. Deputy Attorney General, stated that "while this announcement [of the partial settlement] is an important step forward in achieving justice for the American people, let me be clear, it is by no means the last … Our criminal investigation is active and ongoing." https://www.justice.gov/opa/speech/deputy-attorney-general-sally-q-yates-delivers-remarks-press-conference-announcing-147.

in turn increases their environmental liabilities, reduces their debt capacity, and subjects them to increased risk stemming from future compliance and litigation and to increased costs associated with compliance (e.g., the cost of environmental waste management). Our evidence is consistent with these predictions. First, similar to the main result in Chang et al. (2018), we find a negative relationship between EPS and firms' debt ratio, indicating that firms maintain lower leverage when facing stronger environmental regulations. This result is consistent with the idea that environmental liability can substitute for financial leverage. Also, given that leverage is one of the main inputs to Merton's (1974) distance-to-default model, this result also alleviates the concern that reported higher loan spread is proxying for firms' default risk. Second, we find a strong positive link between EPS and operating expenses, perhaps reflecting the increased compliance costs associated with a costlier waste management system that is typically required by the stiffer regulations. Third, consistent with Merton (1987), Heinkel et al. (2001), Chava (2014), and El Ghoul et al. (2018), we provide evidence that loans issued to firms that face stronger environmental regulations have a narrower lenders base as reflected by fewer participants in their loan syndicates. This result implies that as stronger regulations increase firms' environmental liabilities, banks tend to avoid lending to these firms; consequently, these firms have to pay higher interest rates on their loans.

We provide more corroborating evidence by conducting a series of subsample analyses. We split our sample into firms with high and low financial constraints. Stronger environmental regulations undercut firms' debt capacity. By undermining firms' environmental profile, these regulations increase environmental liabilities that are known to have several features in common with leverage. Thus, the impact of such regulations should be larger for financially constrained firms that already have small or limited debt capacity. Using a measure of financial constraint developed by Kaplan and Zingales (1997), we show that financially constrained firms are the main drivers of our results. One standard deviation increase in EPS is associated with a 23% increase in loan spread for financially constrained firms, whereas the impact is statistically insignificant for firms with low financial constraints.

Next, we split our sample into firms with high and low environmental litigation risk based on their industries and hypothesize that our results should be stronger for firms in high litigation-risk industries.[7] In addition to increasing firms' business risks, increased environmental liabilities resulting from more stringent regulation can also affect lenders through litigation risk for the borrower (which increases borrower's credit risk), by lender litigation risk (due to lender liability laws), and through lender reputation risk for being associated with a borrower with environmental concerns (Chava, 2014). This implies that firms in industries with high environmental litigation risk should be affected more by a stronger regulation. Consistent with this argument, we find that the effect predominantly exists in firms operating in such industries. While one a standard deviation increase in EPS has no statistically significant impact on firms in industries with low environmental litigation risk, it increases loan spreads by 19% for firms in industries with high environmental litigation risk (more potential polluting industries).

Lastly, we explore the implication of bank-based *vis-à-vis* market-based economies for our analysis. We hypothesize that the impact of environmental regulation should be stronger for firms in bank-based economies. Our earlier evidence suggests that loans issued to firms that face stronger environmental regulations have a smaller syndicate size. Firms have fewer participants in their loan syndicates and end up paying higher interest rates on their loans if they cannot easily switch to an alternative source of external finance. Given the evidence for environmentally sensitive

[7] Some of the leading industries in environmental litigation cases are communication, electric, oil and gas extraction, and chemical products industries. See Appendix D.

lending practices by banks (Cogan, 2008; Chava, 2014; Chang et al., 2018), firms in bank-based economies that rely heavily on bank loans have a hard time switching to another source of financing in the market relative to firms in market-based economies. Our results are consistent with these predictions. Using Demirguc-Kunt and Levine (2001) and Levine (2002) classifications, we split our sample into market- and bank-based economies. We show that a one standard deviation increase in EPS leads to an increase of about 49% in loan spread for firms in bank-based economies, while for firms in market-based economies that can relatively easily switch to another source of financing, this effect is 10%.

Our study makes several contributions to different strands of the literature. We contribute to the law and finance literature that investigates the effects of country-level legal changes on firms' cost of capital (e.g., Qian and Strahan, 2007; Bae and Goyal, 2009). We also add to the voluminous literature on CER-firm relations. Due to lack of a reliable measure of environmental regulation stringency that is comparable across different countries, most of the prior studies focus mainly on U.S. firms and their environmental profiles (Sharfman and Fernando, 2008; El Ghoul et al., 2011; Goss and Roberts, 2011; Chava, 2014, just to name a few). Our paper improves upon these studies in multiple dimensions. First, we employ a recently developed measure of stringency of environmental regulation that is comparable across different countries. Due to the difference in the regulatory environment in each country, generalizing the findings in the U.S. to other countries requires more research (Sharfman and Fernando, 2008) that needs such a reliable measure. Using EPS, the newly developed measure, we examine the impact of environmental regulations on loan contracts internationally. To the best of our knowledge, this is the first cross-country study that examines the impact of environmental regulation on the cost of bank loans and provides international evidence on the mechanisms through which these regulations affect lenders and borrowers. Second, using EPS allows us to depart from common practices in the literature (El Ghoul et al., 2011; Goss and Roberts, 2011; Chava, 2014; El Ghoul et al., 2018) by focusing on governments' environmental regulations rather than firms' environmental profiles. This has two advantages. First, it is easy to argue that a firm's environmental profile is endogenous, as it is an internal choice and can be changed.[8] However, environmental regulations are set by governments and thus it is easier to argue that they are exogeneous to firms. Therefore, focusing on environmental regulation alleviates concerns about endogeneity issues such as the omitted variable bias. Second, by exploiting the time series and cross-sectional variation in the stringency of environmental regulation — a property unavailable prior to EPS; we only observed time series variation of regulations in one country — we employ an empirical design that can be effectively interpreted as the difference-in-difference estimator (Imbens and Woolridge, 2009), which further reduces endogeneity concerns. Moreover, our paper also contributes to the banking literature. Our results reflect banks sensitivity to environmental concerns and adds to the evidence on environmentally sensitive lending provided by Chang et al. (2018), Chava (2014), and Cogan (2008). We show that in addition to the usual default risk proxies that affect different aspects of loan contracts (see Dennis et al., 2000), the risk associated with environmental regulation also affects the cost and other features of loans.

The remainder of this paper is organized as follows. Section 2 provides some background, reviews the related literature, and develops our hypotheses. Section 3 describes the data, their sources, our measure of environmental regulation stringency, and our empirical design. In Section 4, we present and discuss our empirical results. Section 5 concludes.

[8] While most companies can change their environmental profiles, some companies due to their line of business are, by definition, unable to do so and would be an exception to our argument. Sin stocks are examples of such companies.

2. Background and hypothesis development

2.1. Background and literature review

In the last two decades, there has been a growing trend of governments and firms all around the world actively implementing more stringent environmental regulations and policies. This policy shift on environmental issues by governments and firms is evident in the UN Global Compact-Accenture CEO study conducted in 2010.[9] In a survey of more than 750 CEOs from all over the world, 93% state that sustainability and environmental protection activities are crucial factors in their companies' future success. More recently, the 2015 Paris Climate Accord, a multilateral agreement that involves 175 governments around the world, is committed to curbing firms' CO_2 emission and their carbon footprints through a combination of environmental regulations and market incentives.

The impact of such regulations on firms has been under scrutiny for a couple of decades. Two opposing views have emerged over these years. The advocates of these policies generally find a positive impact on firms of such policies, whereas the critics document no link, weak links, or at times a negative relation. For example, on the one hand, Sharfman and Fernando (2008) show that firms with improved environmental risk management have lower cost of capital. Oates et al. (1993) show that firms' motivation to adopt more efficient abatement technologies increase as the level of the pollution tax rate increases. El Ghoul et al. (2011) and El Ghoul et al. (2018) show that firms that are more socially and environmentally responsible have lower cost of equity, while Chava (2014) finds that firms with environmental concerns have higher cost of equity. Similarly, firms with social and environmental concerns have significantly higher cost of bank loans (Goss and Roberts, 2011; Chava, 2014). The evidence in Guenster et al. (2011), Jiao (2010), Flammer (2013),

[9]The full reports can be accessed at:https://www.unglobalcompact.org/docs/news_events/8.1/UNGC_Accenture_CEO_Study_2010.pdf

and Clarkson et al. (2011) suggests that firm value and corporate environmental performance are positively associated. On the other hand, Mahapatra (1984) concludes that pollution control expenditures are suboptimal allocations of firms' resources and are not rewarded by investors. Jaffe and Palmer (1997) find a weak link between compliance costs and innovation, as measured by successful patent applications. Similarly, Nelling and Webb (2009) also find no link between corporate social responsibility and firm financial performance. While Hamilton et al. (1993) find no statistical difference between socially responsible funds and conventional funds, Brammer et al. (2006) show that firms that score higher on social performance realize lower returns. Due to these mixed findings, the issue of CER-firm relation remains an open and pressing question, especially against the backdrop of recent ramped-up regulations to combat climate change. In fact, Renneboog et al. (2008), Kempf and Osthoff (2007), and Sharfman and Fernando (2008) call for more research to study the impact of corporate responsibility on cost of capital. Specifically, Sharfman and Fernando (2008) call for more research to study cost of debt in an international setting.

2.2. Hypothesis development

Conducting cross-country studies requires reliable and comparable measures of environmental policy stringency across different countries. Up until recently, the lack of such measures made cross-country studies of the economic impact of environmental regulations limited and narrow in scope. However, a recently developed environmental policy stringency index (Botta and Koźluk, 2014) fills this void and provides us an opportunity to conduct an international analysis of the economic effect on firms of environmental regulations. Using this index, we specifically analyze the relation between the stringency of environmental regulations and the cost of bank loans.

We focus on bank loans as a proxy for cost of debt for several reasons. First, as reported by Chava (2014), similar to socially responsible investing, there has been a dramatic shift towards environmentally sensitive lending practices by a considerable number of lenders. For instance, in his comprehensive assessment of 40 of the world's largest banks, Cogan (2008) finds that banks have conducted more than 100 studies analyzing firms' regulatory strategies regarding climate change. He finds that 23 of those banks include discussions of climate change on their latest annual shareholders reports. Nine of those banks have assigned a board member to observe the company's climate-related policies. Thirty four of those banks replied to the latest annual survey operated by carbon disclosure project (CDP). He also reports that 29 of the banks in his survey are involved in clean and renewable energy lending. More recently, consistent with the Cogan (2008) survey, the results in Chang et al. (2018) indicate that banks are more sensitive to environmental issues than other lenders. Second, bank loans remain one of the most important sources of external finance (Houston and James, 1996; Tirole, 2006). For example, Allen et al. (2013) show that lower and upper middle-income economies have a ratio of bank loan to GDP that is less than 50% by the end of the 2000s, whereas for high income economies (OECD) this ratio is slightly below 125% (see Figure 1, p.764). Third, given the fact that banks have access to firms' private information, the banking literature views them as delegated monitors. These monitors, therefore, have the unique ability to have a more accurate assessment of the risks and exposures of their borrowers. Thus, given that banks are more sensitive to environmental issues relative to other lenders (Chang et al., 2018), it follows that if the stringency of governments' environmental regulations is believed to have a significant impact on borrowers' ability to repay loans, banks would then design their loan contracts to reflect this risk factor.

Nevertheless, why would lenders be concerned about environmental regulations? How could these regulations constitute a risk factor and affect lenders? There are several reasons why stringency of environmental regulations could be a risk factor to lenders. More stringent environmental regulations can increase firms' environmental liabilities. These liabilities have been mainly categorized as a "nonfinancial issue." Most firms keep most of their environmental liabilities off their balance sheets. However, over the last two decades, with the ever-growing awareness of the public about the environmental impact of corporations, the conventional lines between "financial" and "nonfinancial" issues are increasingly distorted. In its 2017 survey, KPMG concludes, "environmental and social issues such as climate change, water scarcity, and human rights will increasingly be seen as financial rather than nonfinancial issues."[10] In the same survey, KPMG reveals that "for the first time in the history of its survey, more than 60% of companies across all industry sectors" release a corporate responsibility (CR) report. In 2017, 78% of Fortune Global 250 companies included CR information in their annual financial reports. The continuous and substantial growth of this practice since 2011 (44% in 2011, 55% in 2013, and 65% in 2015) reflects the fact that investors and lenders find environmental liabilities to be increasingly relevant. Empirical evidence in academic studies are also consistent with the idea that environmental liability is a meaningful risk factor. Environmental liabilities are legally binding, can potentially lead to substantial and continuous outflow of funds, and failure to comply may lead to bankruptcy (Chang et al., 2018). Environmental liabilities can increase bankruptcy risk (Schneider, 2011) and adversely affect bond ratings (Graham et al., 2001). Results in Bauer and Hann (2010) suggest that adverse environmental events represent a risk factor to nonsecured bondholders. Studies by Barth and McNichols (1994), Clarkson et al. (2011), and Li, Simunic, and

[10] https://assets.kpmg.com/content/dam/kpmg/xx/pdf/2017/10/kpmg-survey-of-corporate-responsibility-reporting-2017.pdf

Ye (2014) show how substantial and consequential these liabilities can be. Chang et al. (2018) show that environmental and financial liabilities have several important features in common and that environmental liabilities increase firms' business risk. This leads to our first and main hypothesis.

H_1: Firms that face more stringent environmental regulations pay larger spreads on their banks loans.

As pointed out by Dennis et al. (2000) and Goss and Roberts (2011), in addition to charging higher spreads, banks have multiple options to mitigate the risk they face from their borrowers. Those options include issuing secured loans, shortening maturity, increasing upfront fees, and adding covenants. This motivates our next hypothesis.

H_{2a}: Loans issued to firms that face more stringent environmental regulations are more likely to be secured.

H_{2b}: Loans issued to firms that face more stringent environmental regulations have shorter maturity.

H_{2c}: Loans issued to firms that face more stringent environmental regulations have larger up-front fees.

H_{2d}: Loans issued to firms that face more stringent environmental regulations have more covenants written on them.

Moreover, increased environmental liabilities stemming from more stringent regulations can affect the risk exposure of the lenders through other channels as well. For example, these regulations can expose the borrowers to litigation risk, which increases their credit risk (Chava, 2014). Due to lender liability laws, lenders themselves are also exposed to lender litigation risk. According to the Comprehensive Environmental Response, Compensation, and Liability Act in the United States (CERCLA, commonly referred to as Superfund) and Environmental Liability Directive in Europe, lenders can be directly responsible for polluting activities of their borrowers. Stricter environmental regulation makes lenders more concerned about firms' flexibility in dealing with new rules and potential risk of litigation. According to chapter 25 of the Guide to Commercial Banking Law (Gotcher, 2011, p. 25-1) "… Although most bankers initially think they have no stake in environmental issues, these issues can expose lenders to liability… Because banks do not discharge toxic wastes and are not directly involved in business that harms the environment, bankers often assume that environmental laws do not apply to them. They are absolutely wrong." In addition, banks have reputation capital at risk for association with an environmentally insensitive borrower (Chava, 2014). Thus, if a sufficiently large number of lenders avoid a firm due to its environmental liabilities, this firm would have fewer participants in its loan syndicate than a firm without such concerns. This firm would then have to pay a higher interest rate on its loans if it cannot easily find another source of financing (Merton, 1987; Heinkel et al., 2001; Chava, 2014). Hence, the above discussion not only reinforces our first two hypotheses, but also motivates our next two.

H_3: Firms that face more stringent environmental regulations have fewer participants in their loan syndicates.

H_4: The adverse effect of more stringent environmental regulations on cost of bank loans is more pronounced for a subsample of firms that belong to industries that are more susceptible to environmental litigation risk.

In addition to showing the common features between financial leverage and environmental liabilities, Chang et al. (2018) also find a negative relation between them, suggesting that environmental liability is a (an imperfect) substitute for financial leverage and that firms with better environmental profiles have enhanced debt capacity and better access to bank loans. A more stringent environmental regulation undermines firms' existing environmental profiles and thereby reduces their debt capacity. Therefore, given the existing leverage of a firm, a reduced debt capacity resulting from stronger environmental regulation makes the firm's distance to default smaller and their default probability larger (Merton, 1974). Thus, we expect the following.

H_5: Firms that face more stringent environmental regulations maintain lower leverage ratio.

H_6: The adverse effect of more stringent environmental regulations on cost of bank loans is more pronounced for a subsample of firms that are financially constrained.

Firms that have fewer participants in their loan syndicates pay higher spreads on their loans if they cannot easily access alternative sources of financing. Firms located in countries with bank-based economies rely mainly on bank loans as the source of external finance. Therefore, given the increasing trend in environmentally sensitive lending practices by banks and their sensitivity to environmental issues (Cogan, 2008; Chava, 2014; Chang et al. 2018), if banks avoid a borrowing firm in a bank-based economy, it would be difficult for the firm to switch to an alternative source of financing.

H_7: The adverse effect of more stringent environmental regulations on cost of bank loans is more pronounced for a subsample of firms located in bank-based economies.

In the next step, we turn to data and our empirical methodology that we use to confront the foregoing hypotheses with the data.

3. Data and empirical design

3.1. Data

In this study, we focus on the cost of bank loans for firms in 27 countries[11] over a 25-year period. We obtain syndicated loan data from Thomson Reuters Loan Pricing Corporation, DealScan. Specifically, we study loans that originated between January 1990 and December 2014. Following the literature (Flannery, 1994; Diamond and Rajan, 2000), we exclude financial and quasi-public firms (SIC code, 6000-6999, 9000-9999). DealScan includes data on loan prices, terms, and detailed information related to the lenders and borrowers. Each loan is identified as a distinct observation, and the price and nonprice terms are fixed at the facility level. For each facility, we collect the costs of loans by using the all-in-spread-drawn variable (the total annual spread, paid over London Interbank Offered Rate (LIBOR)) as a proxy. Firms' accounting information is from Global COMPUSTAT. It is merged with the DealScan data using the information available at the end of the most recent year prior to the time of loan origination. Companies are assigned to a country using the firms' headquarters as reported in Global COMPUSTAT. Country-level variables are collected from the World Bank website. After matching the DealScan loan data with the firm-level accounting information and country-level variables, our final sample includes 6,347 firm-year observations from 1990 to 2014.

Our main variable of interest is EPS, environmental policy stringency index. Created by Botta and Koźluk (2014), this index is constructed by scoring and aggregating a combination of individual country's selected environmental policy instruments that are largely related to climate and air pollution. EPS is the first quantitative indicator to measure the level of stringency of

[11] U.S. is excluded from our sample because DealScan is heavily skewed towards U.S. firms, and therefore if included, our results would then be predominantly driven by these firms, biasing our findings towards the U.S. firms and making any inference about the impact of these regulation on firms in an international setting much less reliable.

countries' environmental regulations at the international level. The index is scored on a zero to six scale, where six is the most stringent regulation. The EPS is highly and significantly correlated with other alternative proxies for environmental policy stringency that have been used in the literature. Those measures are based on surveys, environmental outcomes, and other policy-based measures. (See Botta and Koźluk, 2014, for more detail.) However, while other measures mainly focus on the U.S, the EPS index covers a wide range of countries and does so over a relatively long period of time (between 1990-2012 with some exceptions for countries that have data up to 2015). This dataset is publicly available on the OECD website.[12]

[Table 1 here]

Table 1 reports the average EPS and loan spread (in basis points) by country. In our sample, South Korea has the most stringent environmental regulations with an average EPS score of 2.78. It is followed by Denmark and Australia with average EPS scores of 2.64 and 2.57, respectively. Brazil, with an average EPS of 0.45, has the least stringent environmental regulations. Russia and South Africa, with average EPS scores of 0.62 and 0.65, respectively, rank second and third among countries with the least stringent environmental regulations. The last column indicates that Indonesia, with 329 bps, has the highest cost of bank loans while Finland, with a loan spread of approximately 40 bps, has the lowest average cost of bank loans for the sample period. Table 2 provides the summary statistics of all the variables that we use in our analysis. The mean EPS score for our sample is 1.77. The average firm in our sample has financed 32% of its assets with debt and pays a spread of 170.45 bps on its loan. Forty three percent of the loans in our sample are term loans, and the average size of a loan facility is about $2,330 million and matures in 53 months.

[Table 2 here]

[12] https://stats.oecd.org/Index.aspx?DataSetCode=EPS

3.2. Empirical design

To investigate the effect of environmental policy stringency on the cost of bank loans, our first and main hypothesis, we employ the following regression model.

$$\begin{aligned} \text{Ln(Spread)} = f\,(&\text{EPS Index; Borrower Characteristics;} \\ &\text{Loan Characteristics; Country Characteristics;} \\ &\text{Country, Industry, and Year Fixed Effects)} \end{aligned} \qquad (1)$$

Ln(Spread) is our proxy for cost of bank loan. It is the natural log of all-in-spread-drawn variable in DealScan, which is the spread that a borrower pays annually over the LIBOR in basis points. The main independent variable is EPS index. It is the measure of environmental policy stringency of a borrower's country in the year that a loan is issued to that borrower. Following the literature (e.g., Qian and Strahan, 2007; Graham et al., 2008), we also include a wide range of control variables that could potentially affect the cost of bank loans. These control variables include borrower, loan, and country characteristics.

The first set of these variables controls for borrower characteristics and includes asset size, profitability, and leverage. It is important to control for size because on the one hand, larger firms have less trouble accessing external financing and have fewer information asymmetry problems. Therefore, they are likely to have a lower cost of bank loans. On the other hand, due to their sheer size, larger firms can borrow more and as a result may have higher borrowing costs. We also control for firms' profitability because profitable firms have a lower chance of default and are expected to pay a lower spread on their loans. Leverage is another firm-level control variable. It is one of the main inputs in Merton's (1974) distance to default formula; thus, firms with a higher leverage ratio have a higher default risk. All else equal, these firms are expected to have a higher cost of bank loans, making it imperative to control for leverage.

A second set of control variables is related to loan characteristics. The first variable is the size of the loan. The riskiness of a borrower and the size of a loan issued to such a borrower are connected. All else equal, riskier borrowers receive relatively smaller loans. We also control for the loan maturity and term loan. The former is the number of months between the loan issuance date and loan end date, and latter is a dummy variable that equals 1 if the loan is a term loan and 0 otherwise. Finally, we control for all loan types and purposes in our analysis. Loan purposes are generally categorized into capital expenditures, backup line, general purposes, recapitalization, refinancing, acquisitions, and other purposes. The final sets of controls are related to country characteristics. These controls include country's GDP (to control for countries' economic growth) and indexes related to countries' political stability and anticorruption. Detailed information about all variables, their sources, and measurements are provided in Appendix A.

All regressions also include country, industry, and year fixed effects. The country fixed effects take into account any unobserved time-invariant country-specific features that could affect the cost of bank loans. The simultaneous inclusion of industry, year, and country fixed effects guarantees that the coefficient on EPS captures the actual effect of within-country changes in environmental regulations over time and not just cross-sectional correlations. With this empirical design, in each year a given country could be classified either as treatment or control, allowing us (as shown by Imbens and Woolridge, 2009) to interpret the coefficient on EPS as the difference-in-difference estimator.[13] Essentially, this empirical design allows us to measure the average within-country changes in the cost of bank loans for firms in countries that revise their environmental regulations relative to concurrent changes in the cost of bank loans to firms in countries that do not revise their environmental regulations. Moreover, using the EPS index allows us to move our focus away from

[13] This empirical design is also used by other researchers. (See Alimov, 2015.)

firms' environmental profiles, the common practice in the literature, and focus on environmental regulations. Unlike a firm's environmental profile that is the firm's choice and an endogenous decision that can be changed, environmental regulations are set by governments and are arguably exogeneous to firms. Thus, in addition to the advantages of our empirical design that is discussed above, using the EPS index rather than firms' environmental profiles has the benefit of making our analysis less susceptible to endogeneity issues such reverse causality.

4. Empirical results

4.1. Baseline results: EPS and loan spread

Table 3 reports our baseline results where we analyze the economic impact of environmental policy stringency on the cost of bank loans. In this table, we use six specifications to test our first and main hypothesis. In the first column, we regress loan spread on EPS without including the control variables. In Specifications (2) to (4) we sequentially add firm-level, loan-level, and country-level control variables. Column 5 includes all the control variables in our regression model. All specifications include year, industry, and country fixed effects as well as dummies controlling for loan type and purpose. Khan et al. (2016) argue that inclusion of both firm and time fixed effects resembles a generalized difference-in-differences approach, which improves the causal interpretation. Therefore, in Model 6 we include firm fixed effect and remove industry fixed effect from specification.

[Table 3 here]

We observe that the coefficients on EPS are statistically and economically significant in all models. Focusing on Columns 5 and 6, which have the largest set of control variables and fixed effects, we see that EPS coefficients in the two models are close to each other. The EPS coefficients in Models 5 and 6 are 0.147 (*t*-stat of 3.74) and 0.127 (*t*-stat of 2.70), respectively. This implies that for a one standard deviation increase in EPS (it is approximately 1 – see Table 2), cost of bank loan increases by about 13.5% to 15.8%. This is an economically significant change. For an average firm in our sample that pays a loan spread of 170.45 bps, this is tantamount to an increase of about 23 bps to 27 bps in the interest it pays on its loan.

Most control variables have the expected signs. More profitable firms pay lower interest on their loans. This is reflected by the negative and statistically significant coefficient on this variable. The coefficient on firm size is positive and statistically significant. Due to their sheer size, larger firms can borrow more and as a result may be associated with higher borrowing cost. The positive and statistically significant coefficient on leverage shows that cost of bank loan rises as the amount of debt in a firm's capital structure increases. Except for Model (6), loan amount is insignificant. The effect of loan amount is muted because of including firm size in our models. As pointed out by Chava (2014), loan size and firm size are correlated. In fact, Chava (2014) only controls for firm size and not loan amount. Controlling for firm size and credit risk, banks charge higher spreads on longer-term debt to compensate for higher liquidity risk. Consistent with this notion, the coefficient on loan maturity is positive and statistically significant. The signs of country-level variables are also predominantly consistent with our expectation. While GDP surprisingly does not have an impact on the loan spread (perhaps its effect is muted due to the inclusion of year and country fixed effects), an increase in political stability and anticorruption indices is associated with lower cost of bank loans.

4.2. Endogeneity: Difference-in-difference approach

Endogeneity, particularly in the form of the omitted variable problem, is a valid concern with our findings. Imbens and Woolridge (2009) argue that inclusion of country, year, and industry fixed effects assures that our EPS estimate is reflecting within-country changes in EPS and not just cross-sectional correlation and can be interpreted as the difference-in-difference estimator. Similarly, Khan et al. (2016) argue that inclusion of both firm and time fixed effects resembles a generalized difference-in-differences approach and improves the causal interpretation. Our specifications control for these fixed effects. Therefore, we believe it is unlikely that our results suffer from endogeneity. However, to alleviate these concerns more convincingly, we also employ difference-in-difference approach.

Implemented in 2005 as a strict tool to reduce pollution, the European Union Emission Trading System (EU ETS) is the world's first and major international trading system, which covers over three-quarters of international carbon trading. Eighteen European countries (out of the 27 countries in our sample) are among those that employed the cap-and-trade program set by the European Union. Using the EU ETS as a natural experiment, we run a difference-in-difference (DiD hereafter) model to compare the effects of EU ETS on treated firms and the control group. This analysis confirms our earlier findings.

The EU emission trading system regulation was enacted to mitigate the impact of climate change by reducing greenhouse gas emissions in a cost-effective way. The goal of the EU ETS is to reduce carbon emissions cost effectively and to spur the growth and development of new low-carbon technologies. When regulated firms are faced with a higher price of emissions relative to all the other costs of production, we then expect them to make operational changes and investments to reduce their emissions. This cap-and-trade program allows companies to emit a certain amount of greenhouse gas every year. If a company makes more emissions than its allowance at the end of the year, it has to either buy the extra level from another company or pay the fine. This assigned cap will decrease in time to reduce the total level of greenhouse gas emission. This market-based emission program will give firms the flexibility to work towards reducing the total level of emission.

Following Calel and Dechezlepretre (2016), we use the launch of EU ETS as a quasinatural experiment and conduct a DiD analysis. As illustrated in Figure 1, there is a parallel trend between the two groups from 1990 to 2005, the time frame prior to the launch of the program. During this time, the treated countries (those who adopted the EU ETS) have had a lower average cost of bank loans. This trend clearly changes after 2005. First, there is a huge spike in 2006, and then the average cost of loans remains higher for the treated group for rest of the sample period except for the last year when the cost of loans for both treated and control groups becomes virtually the same.

[Figure 1 here]

DiD results are reported in Table 4. Our findings in this table show that firms in countries that adopted the emission trading system pay larger spreads on their loans relative to firms in countries that did not adopt the program. The coefficients on *Treated*Post* are positive and highly significant in all specifications. While this result confirms our earlier findings, interestingly, the magnitude of the effect and its statistical significance is larger than those reported in Table 3.[14]

[Table 4 here]

4.3. EPS and other loan features

Our results up to this point provide evidence that lenders view stringent environmental regulations as a risk factor and therefore charge a higher spread on loans issued to firms that are

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[14] While these environmental regulations are imposed on firms by governments and in that sense can be viewed as exogenous to companies, an argument can be made that firms in countries that make their environmental regulations more stringent might be fundamentally different from others. Therefore, we may face selection bias. To address this concern, in the spirit of propensity score matching, we conduct our analysis on a matched sample. Using a set of observable covariates, we matched firms located in countries with EPS scores in the top 30th and 20th percentiles with firms in countries at the bottom 30th and 20th percentiles of EPS distribution. Conducting the analysis on the matched sample, we confirm our earlier finding that stronger environmental regulation is associated with higher cost of bank loans (results reported in Appendix C).

exposed to such regulations. However, as pointed out in prior research (Dennis et al., 2000; Goss and Roberts, 2011; among others) in addition to directly increasing the cost of loans, lenders have the option to change other contractual features of their loans to reflect and mitigate the risk associated with their borrowers. In this subsection, we focus on these contractual features of loans and test our second hypothesis and its variations.

Table 5 reports the results. Our regression Model (1) is augmented in each specification by replacing the dependent variable, *Ln(Spread)*, with a new one to test our hypotheses. In the first column, we run a logit model where the dependent variable is a dummy that is equal to one if the issued loan is secured and zero otherwise. The coefficient on EPS is positive and statistically significant ($\beta = 0.556$; *t*-stat = 2.22), indicating that an increase in the stringency of environmental regulations makes the issuance of secured loans more likely. Specifically, a one standard deviation increase in EPS leads to about a 7.6% increase in the likelihood of issuance of a secured loan (based on the marginal value of EPS coefficient at the mean). In the second column, we test our prediction about the increase in the up-front fees. The dependent variable in this model is *Ln(upfront fees)*. The positive and statistically significant coefficient on EPS ($\beta = 0.222$; *t*-stat = 2.68) implies that lenders charge their borrowers a higher up-front fee if the firm is exposed to a more stringent environmental regulation. A one standard deviation increase in EPS raises the up-front fees by about 25%. Results in Specification (3) are also consistent with our hypothesis. In this model, the dependent variable is the natural log of loan maturity. The coefficient on EPS is negative ($\beta = -0.042$; *t*-stat = -1.45). This result suggests that a one standard deviation increase in EPS shortens the loan maturity by approximately 4%, though statistically insignificant.

[Table 5 here]

The result of the last column, however, is inconsistent with our prediction. In Model 4, we test whether lenders write more covenants on their loans if their borrower is exposed to stringent environmental regulations. The independent variable in this model is the total number of covenants written on a given loan. We find no link between loan covenants and the stringency of environmental regulation. The EPS coefficient is highly insignificant and has the wrong sign. As discussed by Chava et al. (2010), according to the contracting efficiency hypothesis developed by Smith and Warner (1979), covenants are included if (1) there is an agency risk for lenders from shareholders or from managerial entrenchment, and (2) mitigating the risk through other mechanisms is costlier. Thus, as a plausible explanation for this insignificant result, we argue that it is likely that in the case of environmental regulation, lenders are able to reduce the risk more effectively and at a lower cost through other mechanisms, such as issuing secured loans, increasing up-front fees, and reducing maturity; consequently they find no reason to mitigate this risk by including more covenants.[15]

4.4. Why are lenders concerned about environmental regulations?

Our results thus far show that to compensate for the risk stemming from a borrower who is facing more stringent environmental regulation, lenders not only charge a higher spread on loans, but also adjust other contractual features of their loans accordingly. However, these results provide no explanation for the mechanism through which these regulations affect lenders. As we discussed in Section 2, there are several reasons why lenders would view the stringency of environmental regulations as a risk factor. In this section, we test the veracity of our hypotheses related to the mechanism that environmental regulations affect lenders.

[15] In addition to total covenants, we also used general covenants, financial covenants, and their log transformations. In all specifications, the coefficient on EPS was highly insignificant.

The key to understanding the mechanism with which environmental regulation affects lenders is that a more stringent regulation increases firms' environmental liability. While these liabilities are mainly categorized as "nonfinancial issues" and are usually kept off balance sheets (Chang et al., 2018), they are increasingly viewed as financial issues and reported in annual financial reports of a rapidly growing number of firms (KPMG Report, 2017). Moreover, these liabilities are legally binding, would drain firm's cash flows, and could potentially lead to bankruptcy (Chang et al., 2018). Prior research also provides consistent evidence that these liabilities could have serious financial implications for a firm (Barth and McNichols, 1994; Graham et al., 2001; Bauer and Hann, 2010; Schneider, 2011; Clarkson et al., 2011; Li et al., 2014). Similarly, anecdotal evidence highlights the significance of environmental liabilities: BP was charged $42 billion for its oil spill in the Gulf of Mexico. Chevron and Volkswagen were fined $9.5 billion in 2011 and $14.7 billion in 2016, respectively, for their environmental violations. Moreover, increased environmental liabilities resulting from more stringent environmental regulations can directly affect lenders through other means, such as increasing litigation risk and compliance costs to their borrowers (which increases the borrower's credit risk); through lender litigation laws, which directly expose the lenders to litigation risk; and finally through lender reputation risk, which emanates from lending to a borrower with environmental concerns (Chava, 2014). Thus, we argue that if for all or one of the aforementioned reasons a sufficiently large number of lenders avoid a borrowing firm, this firm would have fewer participants in its loan syndicate and as demonstrated in prior research (Merton, 1987; Heinkel et al., 2001; Chava, 2014), would have to pay a higher spread on its loan. Our result confirms this prediction.

Specifically, in the first model of Table 6, we test the above hypothesis (H_3) that firms facing more stringent environmental regulations have fewer participant in their loan syndicates and provide evidence consistent with this hypothesis. We use an augmented version of Regression Model (1) where the dependent variable is the number of participants in a firm's loan syndicate. The coefficient on EPS is negative and statistically significant (β = -0.922; *t*-stat = -2.08). For an average firm in our sample that has about nine participants in its loan syndicate, this coefficient is equivalent to approximately an 11% drop in loan syndicate participation.

[Table 6 here]

Further, in the second model of Table 6 we test H_5, where we hypothesize a negative relation between leverage and the stringency of environmental regulations. In Model (2) we follow the literature on capital structure and regress leverage (defined as debt-to-asset ratio; see Appendix A) on a set of known determinants and EPS. The coefficient on EPS is negative and statistically significant (β = -0.032; *t*-stat = -3.02). This result implies that for a one standard deviation increase in EPS, firms' leverage decreases by about 3%. For an average firm in our sample that has a leverage ratio of 32%, a 3-percentage point decrease represents approximately a 10% change in leverage. This finding is consistent with the main result in Chang et al. (2018). They demonstrate that environmental liabilities and leverage have several features in common and that environmental liabilities can intensify business risk. Then they also show that firms with higher environmental liabilities have lower leverage ratios and take that as evidence that environmental liabilities can substitute for financial leverage. Similarly, our finding also implies that firms that face more stringent environmental regulations that increase their environmental liabilities maintain lower leverage, suggesting the same substitution effect. This finding is particularly important because leverage is one of the main inputs to Merton's (1974) distance-to-default formula that determines default probability. Merton's distance-to-default model implies that default probability increases in leverage. The fact that firms maintain lower leverage when facing more stringent environmental regulations establishes more confidence that the observed increase in the cost of bank loans and other adjustments to contractual features of loans are driven by environmentally sensitive lending practices by banks that screen out borrowers exposed to such environmental regulation risk.

As discussed above, more stringent environmental regulations could directly affect lenders through increasing compliance costs of their borrowers, which would adversely affect borrowers' credit risks. In the third model of Table 6, we explore this idea and report our finding. We use cost of goods sold (COGS) as a proxy for firms' compliance costs and regress its natural log on EPS and a set of other control variables. The coefficient on EPS is positive and statistically significant ($\beta = 0.349$; *t*-stat = 2.10). This result suggests that firms facing more stringent environmental regulations have higher compliance costs. Specifically, for a one standard deviation increase in EPS, COGS increases by about 42%. This increase in compliance costs could be attributed to updating the waste management system that is typically required to meet the new mandate of a stiffer regulation.

4.5. Subsample analysis

Collectively, results in the previous subsections suggest that lenders charge a higher spread on their loans and adjust its other features to reflect the environmental regulation risk associated with their borrowers. This is evident in lower participation of lenders in loan syndicates and higher compliance costs for borrowers. Furthermore, maintaining lower leverage by firms facing more stringent environmental regulations not only shows that increased environmental liabilities resulting from these regulations is viewed as a risk factor very much like debt, but also alleviates the concern that the observed increase in spreads and other adjustments to different loan features are driven by firms' default risks. In this subsection, conducting a series of subsample analyses, we provide more evidence related to the mechanism from the cross-section. Specifically, we test H_4, H_6, and H_7 and report the results in Table 7.

[Table 7 here]

Using the median of the Kaplan-Zingales (1997) measure of financial constraint, we split our sample into high and low financially constrained firms. Chang et al. (2018) show that firms with better environmental profiles have larger debt capacity and better access to bank loans. By raising the regulatory threshold, more stringent environmental regulations effectively undermines firms' environmental profiles across the board. Those firms that are marginally in compliance with the existing regulations are no longer be in compliance after the stronger regulations go into effect. Therefore, their environmental liabilities increase while their debt capacity decreases. This adverse effect of stronger environmental regulations should be more pronounced for financially constrained firms that already have low or limited debt capacity. Our evidence in Columns (1) and (2) in Table 7 is consistent with this prediction. Conditioning the sample on the financial constraint index, we find that the results are mainly driven by financially constrained firms. The EPS coefficient is positive and statistically significant ($\beta = 0.210$; *t*-stat = 4.62) for these firms, whereas the effect is insignificant for firms with low financial constraints. Specifically, a one standard deviation increase in EPS leads to a 23% rise in loan spread, which translates into an increase of about 40 bps in the cost of bank loans for an average in our sample.

Next, we condition our sample on environmental litigation risk. Firms are categorized into high and low environmental litigation risk based on their industries.[16] In addition to undercutting firms' environmental profiles and their debt capacity, stronger environmental regulations subject

[16] A list of industries with the highest and lowest environmental litigation cases from 1980 to 2016 in the U.S. is provided in Appendix D.

borrowers to litigation risks. Lenders themselves are also directly exposed to litigation risk due to lender liability laws. Thus, we expect that the adverse effect of stringent environmental regulations on the cost of bank loans is stronger for firms that due to the nature of their line of business and industry are more susceptible to this litigation risk. Our results in Columns (3) and (4) confirm this conjecture. We show that our results are predominantly driven by firms that belong to industries with high environmental litigation risk. For these firms, the EPS coefficient is positive and highly significant (β = 0.175; *t*-stat = 4.35), whereas for firms in low litigation risk industries, this coefficient is insignificant.

In the last two columns, we compare the impact of stronger environmental regulations on loan spread between bank-based and market-based economies. The classification of countries is based on Demirguc-Kunt and Levine (2001). For the countries that are not in this classification, we use the classification introduced by Levine (2002). As we show earlier, if switching to another source of external financing is difficult for a borrower, the firm would have fewer lenders participating in its loan syndicate, which leads to higher loan spreads. The orientation of the economy has implications for this result. Finding an alternative source of external financing is more difficult for firms in bank-based economies relative to those in market-based economies. In bank-based economies, the main source of external financing is bank loans, and obtaining financing through capital markets is less viable. Firms in these economies mainly depend on banks for financing. Thus, we expect that the adverse effect of stronger environmental regulations is more pronounced for firms in bank-based economies. Consistent with this prediction, we find that our results are much stronger for companies in bank-based economies. We show that increasing the stringency of environmental regulations by one standard deviation leads to about a 49% increase in loan spreads for firms in bank-based economies (β = 0.401; *t*-stat = 3.75), whereas for firms in market-based economies where they can switch to another source of financing relatively easily, this impact is about 10%.

4.6. Further discussion: Environmental regulation and firms' innovation

Overall, in relation to cost of debt, our results provide an unfavorable view for environmental regulations. This raises an important question. Given its adverse impact on cost of debt, does a more stringent environmental regulation also adversely affect firms' competitiveness and stifle innovation? Proponents of the Porter Hypothesis (Porter and van der Linde, 1995) argue that environmental regulations can spur innovation. Theoretical models (Kennedy, 1994; Simpson and Bradford, 1996; Xepapadeas and Zeeuw, 1999; Ambec and Barla, 2002; Greaker, 2003; Mohr, 2002; Feichtinger et al., 2005) and empirical evidence (Berman and Bui, 2001; Alpay et al., 2002; Brunnermeier and Cohen, 2003; Lanoie et al., 2008; Lanoie et al., 2011) belonging to this school of thought generally provide a positive link between the stringency of environmental regulations and firms' innovation. Critics of the Porter Hypothesis, on the other hand, point to studies that show either a very weak, negative, or no link between environmental regulations and innovation (Gollop and Roberts, 1983; Palmer et al., 1995; Jaffe et al., 1995; Jaffe and Palmer, 1997; Gray and Shadbegian, 1998). We explore this question and show that consistent with the Porter Hypothesis, stronger environmental regulations stimulate firms' innovation.

To measure firms' innovation, we use the patent applications reported by the Patent Network Dataverse, managed by Harvard University. The database includes a patent's applicant name, date, location, and class number for both U.S. and non-U.S. corporations for 26 years from 1975 to 2010. We conduct fuzzy matching, merging two databases by company names and locations to link unique patent numbers with GVKEY, Global Compustat. For any ambiguous company names, we match manually. After cleaning up, we classify patents as environment-related (or green) patents based on the primary class numbers. (See Carrión-Flores and Innes, 2010; Popp and Newell, 2012; Amore and Bennedson, 2016.) We then count the number of granted green, nongreen, and total patent applications as proxies of environmental, nonenvironmental, and total innovation, respectively. We also use the number of patent citations (green, nongreen, and total) and R&D as another measures of innovation. Each measure is then regressed on EPS and a set of control variables. We find that environmental regulation is positively linked to all innovation measures. The coefficients on EPS in Table 8 are positive and statistically significant in all models, suggesting that stronger environmental regulations stimulate innovation. Results indicate that these innovations include both green- and nongreen-related technologies. Specifically, a one standard deviation increase in EPS is associated with an increase of about 10% in successful green patent applications, 15% in nongreen patent applications, and 10% in R&D expenditures. A conservative interpretation of this result is that while we show more stringent environmental regulations increase the cost of bank loans, we find no evidence that the regulations also adversely affect innovation.

[Table 8 here]

Nevertheless, in Table 9 we show that banks are more interested in firms' green innovation. We use the log-transformed of the cumulative number of green and nongreen patents from year *t* - *N* where *N* is equal to 1, 3, and 5; that is, the cumulative green and nongreen patents since last year, last three years, and last five years, respectively. Similar to Model (1), we then regress the cost of bank loans, *Ln(Spread)*, on these two variables along with other controls. Results show that while both cumulative green and nongreen innovations have the correct sign indicating a reduction in the cost of bank loans, only the green innovation is statistically significant (at 10%). This result is consistent with our earlier evidence and prior findings in the literature about banks' higher sensitivity to environmental issues.

[Table 9 here]

5. Conclusion

In this paper, we study the impact of the stringency of environmental regulations on the cost of bank loans in an international setting. Using bank loan data for 27 countries over a 25-year period, from January 1990 to December 2014, we find that lenders charge a higher interest on the loans issued to firms facing such regulations. Moreover, in addition to higher loan spreads, consistent with prior research, we find that lenders also adjust other contractual features of their loans. Loans issued to firms facing more stringent environmental regulations not only have higher spreads, but are also more likely to be secured, are associated with higher up-front fees, and have shorter maturity.

Further, we show that firms facing stiffer environmental regulations have fewer banks participating in their loan syndicates; incur higher operating expenses reflecting increased compliance costs; and maintain lower leverage, which alleviates the concern that the observed increase in spreads and other adjustments to different loan features are driven by firms' default risk. Our subsample analysis also paints the same picture. We find that the adverse impact of these regulations on loan spreads is more pronounced for firms in industries that are more susceptible to environmental litigation risk, for financially constrained firms, and for firms in bank-based economies. Overall, these results suggest that environmentally sensitive lending practices by banks has a significant adverse impact on the cost of bank loans and other contractual features of loans.

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Table 1

Sample Distribution by Country

Country Name	Obs.	EPS	Spread
Australia	96	2.57	247.97
Belgium	28	1.41	156.07
Brazil	176	0.45	217.91
Canada	1,268	1.93	211.4
China	273	1.24	157.39
Denmark	27	2.64	176.11
Finland	67	1.56	39.80
France	267	1.72	124.41
Germany	209	2.41	151.78
Greece	122	1.82	146.34
Hungary	27	1.16	115.64
India	236	0.95	200.64
Indonesia	25	0.74	328.72
Ireland	90	1.43	214.46
Italy	61	1.73	90.92
Japan	67	1.98	79.92
Netherlands	251	2.19	156.21
Norway	117	1.72	166.12
Poland	30	1.21	79.00
Russia	230	0.62	245.81
South Africa	83	0.65	175.42
South Korea	203	2.78	138.56
Spain	147	2.26	116.77
Sweden	129	1.85	79.18
Switzerland	197	2.34	107.44
Turkey	30	1.09	254.21
United Kingdom	1,891	1.83	172.11
Total	6,347	1.77	173.08

This table shows the average EPS and bank-loan spread by country.

Table 2
Descriptive Statistics

	Obs.	Mean	Median	p25	p75	s.d.
Spread	6,347	170.45	130.40	55.00	250.00	142.41
EPS	6,347	1.77	1.58	0.81	2.58	1.02
Firm Size	6,345	0.12	$0.4e^{-4}$	$0.8e^{-5}$	$0.1e^{-3}$	0.22
Operating Profit	6,305	0.08	0.07	0.04	0.11	0.07
Leverage	6,337	0.32	0.30	0.19	0.43	0.19
Loan Amount	6,334	2.33	0.20	0.08	0.55	36.84
Maturity	6,114	53.00	60.00	36.00	60.00	29.34
GDP	6,332	7.81	7.34	7.10	7.61	1.82
Term Loan	6,347	0.43	0.00	0.00	1.00	0.49
Political Stability	5,854	0.53	0.79	0.25	1.00	0.70
Anti-Corruption	5,854	1.40	1.86	0.99	2.12	0.99
Ln (Gpat)$_{[t-1,t]}$	4,353	0.12	0.00	0.00	0.00	0.54
Ln (Gpat)$_{[t-3,t]}$	4,353	0.21	0.00	0.00	0.00	0.76
Ln (Gpat)$_{[t-5,t]}$	4,353	0.27	0.00	0.00	0.00	0.88
Ln (NGpat)$_{[t-1,t]}$	4,353	0.24	0.00	0.00	0.00	0.90
Ln (NGpat)$_{[t-3,t]}$	4,353	0.40	0.00	0.00	0.00	1.18
Ln (NGpat)$_{[t-5,t]}$	4,353	0.48	0.00	0.00	0.00	1.31

This table presents descriptive statistics for the sample used in the analysis based on the variables from 32 countries from 1990 to 2014. *Spread* is the interest rate that borrowers pay on their loan facility, and it is measured by the All-in-Spread-Drawn variable from Dealscan. *EPS* is the score ranging from 0 to 6 and measures the level of environmental policy stringency from each sample country. *Firm Size* is the book value of total assets in U.S. dollars expressed in hundreds of millions. *Operating Profit* is the return on total assets calculated as *EBIT/Assets*. *Leverage* is the long-term debt of the borrower scaled by assets (Debt/Assets). *Loan Amount* is the size of loans in billions of dollars. *Maturity* is the number of months that represent the duration of the loan. *GDP* is the natural logarithm of a country's real GDP. *Term Loan* refers to an installment loan in which the funds are typically drawn down all at once. *Ln (Gpat)*$_{[t-N,t]}$ (or *Ln(NGpat)*$_{[t-N,t]}$) is the cumulative number of green (nongreen) patents from year t - N (N = 1, 3, and 5) to year t and log-transformed. Variable definitions and their sources are reported in Appendix A.

Table 3
Environmental Policy Stringency and Cost of Bank Loan

	Dependent Variable: Ln(Spread)					
	(1)	(2)	(3)	(4)	(5)	(6)
EPS	0.105**	0.132***	0.124***	0.099**	0.147***	0.127***
	(2.480)	(3.220)	(2.900)	(2.440)	(3.740)	(2.700)
Borrower Characteristics						
Firm Size		0.125**			0.102*	0.208***
		(2.280)			(1.730)	(3.790)
Operating Profit		-1.739***			-1.711***	-0.822***
		(-9.390)			(-9.040)	(-3.140)
Leverage		0.636***			0.641***	0.621***
		(8.170)			(8.320)	(5.650)
Loan Characteristics						
Loan Amount			-0.000		0.000	-0.002***
			(-0.770)		(0.070)	(-2.620)
Loan Maturity			0.098***		0.101***	0.085***
			(4.270)		(4.590)	(3.960)
Term Loan			0.469***		0.299**	-0.035
			(3.790)		(2.380)	(-0.330)
Country Characteristics						
GDP				0.120	0.194	-0.122
				(0.560)	(0.840)	(-0.530)
Political Stability				-0.293***	-0.292***	-0.192*
				(-3.150)	(-3.020)	(-1.740)
Anti-Corruption				-0.353***	-0.337***	-0.294**
				(-3.130)	(-2.910)	(-2.200)
Constant	4.711***	4.486***	3.769***	5.370***	3.889**	6.106***
	(38.820)	(32.280)	(16.030)	(3.340)	(2.230)	(3.590)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	No
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	No	No	No	No	No	Yes
Loan Type & Purpose FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,347	6,299	6,101	5,851	5,618	5,618
Adj. R^2	0.517	0.548	0.526	0.487	0.534	0.790

This table presents our OLS regression results where the dependent variable is *Ln(Spread)*, the natural logarithm of *Spread*. *EPS* is the score ranging from 0 to 6 where the higher the number, the more stringent regulations are in a country. Definitions of all control variables are provided in Appendix A. Year, industry, country, loan type, and loan purpose dummies are included but not reported for brevity. Numbers in parentheses are *t*-statistics. Standard errors are clustered by year and country. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 4
Difference-in-Differences

	Dependent Variable: Ln(Spread)				
	(1)	(2)	(3)	(4)	(5)
Treated	-0.293***	-0.252**	-0.304***	-0.393***	-0.387***
	(-2.660)	(-2.140)	(-2.750)	(-3.060)	(-2.860)
Post	0.629***	0.796***	0.669***	0.312**	0.388***
	(4.850)	(5.430)	(3.680)	(2.430)	(2.870)
Treated*Post	0.348***	0.334***	0.361***	0.284***	0.313***
	(6.100)	(5.750)	(6.130)	(4.140)	(4.500)
Borrower Characteristics					
Firm Size		0.119**			0.108*
		(2.150)			(1.720)
Operating Profit		-1.734***			-1.714***
		(-9.200)			(-8.870)
Leverage		0.598***			0.607***
		(7.870)			(7.980)
Loan Characteristics					
Loan Amount			-0.000		-0.000
			(-0.870)		(-0.080)
Loan Maturity			0.100***		0.104***
			(4.370)		(4.730)
Term Loan			0.413***		0.250*
			(3.070)		(1.800)
Country Characteristics					
GDP				0.135	0.166
				(0.620)	(0.690)
Political Stability				-0.156	-0.144
				(-1.580)	(-1.410)
Anti-Corruption				-0.249**	-0.214*
				(-2.180)	(-1.800)
Constant	4.938***	4.733***	4.075***	4.888***	3.787**
	(34.200)	(29.830)	(15.300)	(3.100)	(2.160)
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
Loan Type & Purpose FE	Yes	Yes	Yes	Yes	Yes
Observations	6,347	6,299	6,101	5,851	5,618
Adj. R^2	0.522	0.552	0.531	0.489	0.545

This table presents the results of the difference-in-difference regressions that examine the effect of a change in environmental regulations climate action in European countries on cost of bank loans. The dependent variable in all models is *Ln(Spread)*. *Treated*Post* is an interaction term showing the effects adopting the Emission Trading System on firms' cost of loans in countries that adopted the program in 2005. All control variables are defined in Appendix A. Year, industry, country, loan type, and loan purpose dummies are included but omitted for brevity. Numbers in parentheses are *t*-statistics computed using standard errors that are clustered at the year-country level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 5
EPS and Other Contractual Feature of a Loan

	(1) Secured Loans	(2) Ln(Upfront Fees)	(3) Ln(Maturity)	(4) Covenant-Index
EPS	0.556**	0.222***	-0.042	-0.053
	(2.220)	(2.680)	(-1.450)	(-0.480)
Borrower Characteristics				
Firm Size	4.377	0.155***	-0.021	-0.056
	(0.360)	(5.800)	(-0.380)	(-0.690)
Operating Profit	-5.068***	-1.322***	-0.059	-0.759
	(-3.650)	(-3.920)	(-0.360)	(-1.080)
Leverage	2.581***	0.509***	0.158***	0.055
	(4.910)	(3.420)	(2.940)	(0.270)
Loan Characteristics				
Loan Amount	-0.100	0.001	-0.000	0.000
	(-1.330)	(1.010)	(-0.880)	(0.410)
Loan Maturity	0.586***	0.224***		0.066
	(3.970)	(4.880)		(0.890)
Term Loan	1.386	0.539***	0.113	0.786*
	(1.190)	(3.490)	(1.440)	(1.810)
Country Characteristics				
GDP	0.524	0.502	-0.100	0.780*
	(0.250)	(1.450)	(-0.720)	(1.860)
Political Stability	0.051	-0.288**	-0.018	0.082
	(0.080)	(-2.000)	(-0.260)	(0.230)
Anti-Corruption	-0.582	-0.371*	-0.137*	-0.916***
	(-0.730)	(-1.720)	(-1.670)	(-2.640)
Constant	-3.978	0.251	5.071***	-5.211*
	(-0.270)	(0.090)	(4.760)	(-1.650)
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Loan Type & Purpose FE	Yes	Yes	Yes	Yes
Observations	1,932	2,119	5,618	5,618
(Pseudo or Adj.) R^2	0.305	0.472	0.380	0.126

This table presents regression of other loan features on the EPS score ranging from 0 to 6 where the higher the number, the more stringent regulations are. In the first model, dependent variable is an indicator if the loan is secured. In the second model, dependent variable is the natural log of upfront fees. In the third model, dependent variable is natural log of loan maturity. In the last model, the dependent variable is the total number of covenants that a loan contract has at the time of origination. More information on these variables and other control variables are provided in Appendix A. Year, industry, country, loan type, and loan purpose dummies are included but not reported for brevity. Numbers in the parentheses are *t*-statistics. Standard errors are clustered by year-country. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 6
Potential Channels

Model (1)	Number of Loan Syndicate Participants	Model (2)	Leverage	Model (3)	Ln(COGS)
EPS	-0.922**	EPS	-0.032***	EPS	0.349**
	(-2.080)		(-3.020)		(2.100)
Borrower Characteristics		Firm Size	-0.241	Firm Size	1.469***
Firm Size	-1.016***		(-1.240)		(5.140)
	(-2.680)	Operating Profit	-0.235***	Operating Profit	-0.009
Operating Profit	6.659***		(-3.050)		(-0.020)
	(2.760)	Market/Book	0.002*	Leverage	-0.077
Leverage	-0.846		(1.930)		(-0.200)
	(-0.950)	Sales	0.000	Market/Book	-0.001
Loan Characteristics			(1.180)		(-0.210)
Loan Amount	0.010	R&D	-0.273***	R&D	-1.920
	(1.340)		(-3.050)		(-0.960)
Loan Maturity	0.168	FCF	-0.002	Nemployee	0.795***
	(0.640)		(-0.680)		(23.790)
Term Loan	-3.404***	Dividend	0.001	Country Exchange Rate	-1.858***
	(-3.190)		(0.070)		(-9.290)
Constant	8.699*	Constant	0.561***	Constant	7.101***
	(1.920)		(12.670)		(13.310)
Year FE	Yes				
Industry FE	Yes	Year FE	Yes	Year FE	Yes
Country FE	Yes	Industry FE	Yes	Industry FE	Yes
Loan Type & Purpose FE	Yes	Country FE	Yes	Country FE	Yes
Observations	5,909	Observations	3,527	Observations	1,580
Adj. R^2	0.162	Adj. R^2	0.157	Adj. R^2	0.863

This table reports the regression results analyzing the potential channels through which EPS affects loan spreads. Dependent variables are the *number of participants in a loan syndicate*, *leverage*, and *log of cost of goods* in Models (1), (2), and (3), respectively. All control variables, their sources, and definitions are described in Appendix A. All models include loan type and purpose dummies, year, industry, and country fixed effects. Numbers in parentheses are *t*-statistics. Standard errors are clustered by country-year. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 7
Subsample Analyses

	Financial Constraint		Environmental Litigation		Bank- vs Market-Based	
	High	Low	High	Low	Bank-Based	Mkt-Based
EPS	0.210***	0.041	0.175***	-0.026	0.401***	0.098**
	(4.620)	(0.760)	(4.350)	(-0.340)	(3.750)	(2.270)
Borrower Characteristics						
Firm Size	0.128***	-0.654**	0.103*	-7.267*	0.263***	-0.034
	(2.620)	(-2.360)	(1.780)	(-1.940)	(6.910)	(-1.150)
Operating Profit	-1.389***	-2.157***	-1.782***	-1.318***	-1.349***	-1.854***
	(-5.660)	(-5.840)	(-7.400)	(-3.420)	(-3.690)	(-8.500)
Leverage	0.632***	0.640***	0.678***	0.530***	0.935***	0.552***
	(7.040)	(4.700)	(7.300)	(4.360)	(5.930)	(6.840)
Loan Characteristics						
Loan Amount	0.000	-0.002	0.000	-0.027**	0.000	-0.001
	(0.100)	(-1.340)	(0.220)	(-2.580)	(0.330)	(-0.470)
Loan Maturity	0.087***	0.126***	0.118***	0.068*	0.121***	0.111***
	(3.350)	(3.610)	(4.780)	(1.660)	(2.830)	(4.830)
Term Loan	0.707***	0.143	0.354***	-0.208*	0.758***	0.145
	(3.000)	(1.080)	(2.640)	(-1.790)	(4.540)	(1.030)
Country Characteristics						
Ln (GDP)	-0.004	0.761*	0.218	0.044	0.144	-1.075*
	(-0.020)	(1.920)	(0.960)	(0.100)	(0.670)	(-1.920)
Political Stability	-0.270**	-0.187	-0.335***	-0.045	-0.447***	-0.154
	(-2.580)	(-1.310)	(-3.210)	(-0.270)	(-2.870)	(-1.310)
Anti-Corruption	-0.188	-0.387**	-0.334***	-0.387**	-0.464*	-0.685***
	(-1.510)	(-2.020)	(-2.680)	(-2.050)	(-1.920)	(-5.230)
Constant	4.407**	-0.347	3.467**	6.445**	1.996	14.051***
	(2.480)	(-0.120)	(1.990)	(2.030)	(1.310)	(3.410)
Observations	3,345	2,273	4,250	1,368	1,741	3,825
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Loan Type & Purpose FE	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.571	0.538	0.542	0.550	0.596	0.524

This table reports the results for subsample analysis. In all models, the dependent variable is *Ln(Spread).* In the first two columns, we use KZ index (Kaplan-Zingales Index (1997)) to split samples into firms with high and low financial constraints. The next two columns compare the effect of environmental regulation on the cost of loans in industries with high and low environmental litigation risk (Manufacturing, Mining, and Transportation and Public Utility). Columns 5 and 6 compare the impact of stronger environmental regulation on loan spreads between bank-based and market-based economies. Classification of countries is based on Demirguc-Kunt and Levine (2001). For the countries that are not in that classification, we use the classification introduced by Levine (2002). All control variables are defined in Appendix A. Year, industry, country, loan type, and loan purpose dummies are included but not reported for brevity. Numbers in parentheses are *t*-statistics computed using standard errors that are clustered at the country-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 8
Impact of EPS on Innovation

	(1) Total Patent	(2) Green Patent	(3) Nongreen Patent	(4) Patent Citation	(5) Green Citation	(6) Nongreen Citation	(7) R&D
EPS	0.138**	0.093**	0.141**	0.169**	0.099**	0.172**	0.098**
	(2.250)	(2.450)	(2.430)	(2.260)	(2.190)	(2.370)	(2.020)
Firm Size	-0.038	-0.011	-0.033	-0.002	-0.035	0.000	-0.039
	(-0.510)	(-0.220)	(-0.440)	(-0.030)	(-0.950)	(0.000)	(-1.070)
Operating Profit	0.372	0.029	0.350	0.483	0.034	0.442	-0.401
	(1.190)	(0.170)	(1.170)	(1.340)	(0.150)	(1.280)	(-1.330)
Market/Book	-0.001	0.000	-0.001	-0.000	0.000	0.000	0.001
	(-0.260)	(0.060)	(-0.310)	(-0.030)	(0.200)	(0.030)	(1.300)
Tangibility	0.322***	0.205***	0.293***	0.271**	0.152**	0.255**	0.044
	(3.420)	(3.940)	(3.220)	(2.540)	(2.110)	(2.560)	(0.880)
R&D	0.068	0.011	0.073	0.064	0.004	0.069	--
	(1.270)	(0.370)	(1.380)	(1.270)	(0.120)	(1.410)	--
HHI	-0.151	-0.129**	-0.130	-0.310***	-0.178**	-0.311***	-0.106**
	(-1.510)	(-2.490)	(-1.360)	(-2.630)	(-2.480)	(-2.700)	(-2.040)
GDP	0.275	0.315**	0.260	0.771***	0.570***	0.715***	0.246
	(1.360)	(2.450)	(1.34)	(2.850)	(3.320)	(2.750)	(1.220)
Constant	-1.563	-1.770**	-1.593	-3.205*	-2.955***	-2.912*	-1.573
	(-1.230)	(-2.200)	(-1.310)	(-1.760)	(-2.690)	(-1.660)	(-1.250)
Observations	3,760	3,760	3,760	3,760	3,760	3,760	3,760
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.335	0.275	0.325	0.315	0.230	0.307	0.0433

This table reports the regression results analyzing the impact of EPS on firm innovation. Dependent variables for Models (1) to (7) are the log of total number of patents; Green Patents, Nongreen Patents, Total Patent Citations, Green Patent Citations, Nongreen Patent Citations, and R&D, respectively. Control variables are described in Appendix A. All models include year, industry, and country fixed effects. Numbers in parentheses are *t*-statistics. Standard errors are clustered by country-year. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

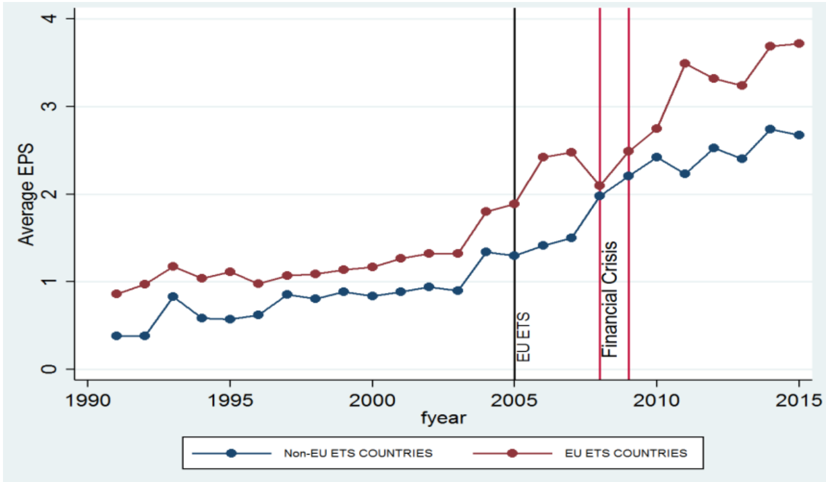
Table 9

Effect of Green Innovation on Bank Loan Spread

Dependent Variable: Ln(Spread)	$N = 1$	$N = 3$	$N = 5$
Ln (GPat$_{[t-N,t]}$)	-0.083*	-0.091*	-0.095*
	(-1.670)	(-1.800)	(-1.810)
Ln (NGpat $_{[t-N,t]}$)	-0.035	-0.032	-0.030
	(-1.200)	(-1.100)	(-1.010)
Borrower Characteristics			
Firm Size	0.089	0.090	0.090
	(1.510)	(1.520)	(1.510)
Operating Profit	-1.670***	-1.670***	-1.672***
	(-8.810)	(-8.780)	(-8.800)
Leverage	0.598***	0.599***	0.599***
	(7.950)	(7.950)	(7.940)
Loan Characteristics			
Loan Amount	0.000	0.000	0.000
	(0.300)	(0.310)	(0.310)
Loan Maturity	0.101***	0.101***	0.101***
	(4.530)	(4.580)	(4.570)
Term Loan	0.264*	0.265*	0.265*
	(1.850)	(1.860)	(1.870)
Country Characteristics			
GDP	0.020	0.024	0.024
	(0.080)	(0.100)	(0.100)
Political Stability	-0.289***	-0.289***	-0.288***
	(-2.760)	(-2.750)	(-2.740)
Anti-Corruption	-0.351***	-0.350***	-0.351***
	(-2.840)	(-2.830)	(-2.830)
Constant	4.961***	4.922***	4.921***
	(2.83)	(2.810)	(2.81)
Observations	5,618	5,618	5,618
Year FE	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes
Country FE	Yes	Yes	Yes
Adj. R^2	0.511	0.511	0.511

This table reports the regression results where dependent variable is *Ln(Spread)*. *Ln (Gpat)*$_{[t-N,t]}$ (or *Ln(NGpat)*$_{[t-N,t]}$) is the cumulative number of green (nongreen) patents from year *t* - *N* (N = 1, 3, and 5) to year *t* and log-transformed by adding 1 (Furman, Porter, and Stern, 2002). All other control variables are defined in Appendix A. Year, industry, country, loan type, and loan purpose dummies are included but not reported for brevity. Numbers in parentheses are *t*-statistics computed using standard errors that are clustered at the country-year level. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A. EPS Score Between European and Non-European Firms



Panel B. Average Loan Spread Between European and Non-European Firms

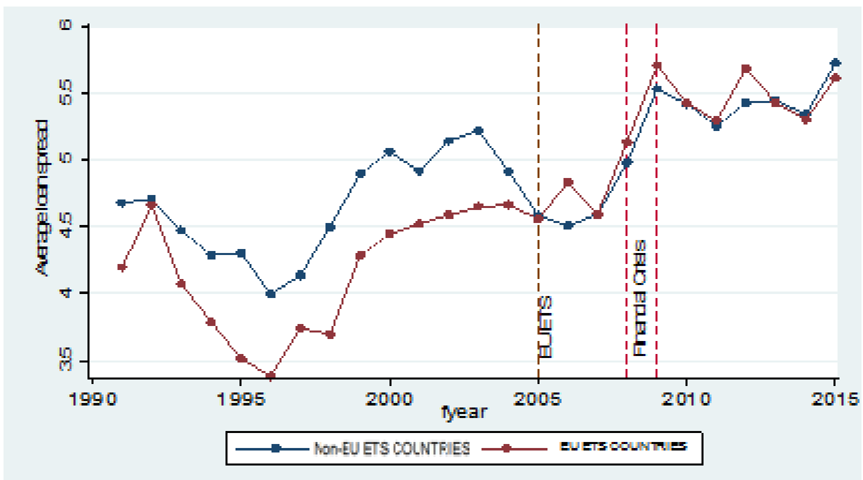


Fig. 1. Time-Series EPS and Bank Loan Spreads. This figure describes time varying EPS scores and average bank loan spreads between European and non-European firms.

Appendix A. Definitions of Variables

Variables Description	Data Source
EPS: EPS Index constructed from OECD, which shows the level of environmental policy stringency in countries and ranges from 0 to with 6 indicates the most stringent laws.	OECD
Spread: The interest rate that the borrower pays on its loan facility and it is measured by All-in-Spread-Drawn variable from DealScan.	Dealscan
Covenant Index: Total number of covenant terms in loan facility.	Dealscan
Loan Amount: Loan facility amount in billions of U.S. dollars	Dealscan
Term Loan: Installment loan in which the funds are typically drawn down all at once.	Dealscan
Maturity: Represents the duration of the loan in number of months.	Dealscan
Secured Loans: Indicator variable equals 1 if the loan is secured and 0 otherwise.	Dealscan
Upfront Fee: A fee paid by borrower once the loan is closed.	Dealscan
Firm Size: Book value of total assets in U.S. dollars expressed in hundreds of millions	Global Compustat
Operating Profit: Defined as EBIT/Assets; return on total assets, and measures the effectiveness of company in using its assets in order to generate earnings before interests and taxes. [ebit/at]	Global Compustat
Leverage: Debt/Assets is the debt ratio and indicates the level of assets that companies generated using debts.	Global Compustat
Market/Book: Firm value representing by the ratio of its market and book value	Global Compustat
HHI: Herfindahl index based on sales in a given industry, first two digits of SIC code	Global Compustat
Sales Growth: Annual sales' growth rate (($sale_t/sale_{t-1}$) - 1)	Global Compustat
Firm Age: The natural logarithm of the number of years since the firm was included in the Compustat database	Global Compustat
Dividend: Dummy variable equals 1 if firm pays dividend in year *t*, 0 otherwise.	Global Compustat
R&D: Research and development normalized by total asset [xrd/at]	Global Compustat
Cash: Firm cash holdings scaled by total asset	Global Compustat
FCF: Sum of operating and investing cash flow scaled by total asset	Global Compustat
Nemployee: Natural logarithm of the number of firms' employees	Global Compustat
Country Exchange Rate: Country exchange rates to $U.S.	Global Compustat
Tangibility: Ratio of fixed assets to book assets [ppent/at]	Global Compustat
GDP: Represents real GDP of a country in a specific year transformed in logarithm function.	WorldBank
KZ Index: Measure of firms' financial constraints, represents the level of firms' reliance on external financing.	Kaplan and Zingales (1997)
Political Stability: Measures level of government stability and safety and ranges from -2.5 (weak) to 2.5 (strong).	Kaufmann, Kraay, Mastruzzi (2010)
Anticorruption: Measures the level of public power efforts for private gains, including different forms of corruptions; it ranges from -2.5 (weak) to 2.5 (strong).	Kaufmann, Kraay, Mastruzzi (2010)
Ln (GPat[*t-N,t*]): $Ln\ (Gpat)_{[t-N,t]}$ is the cumulative number of green (nongreen) patents from year *t* - *N* (*N* = 1, 3, 5, and 7) to year *t* and log-transformed by adding 1. The following patent class numbers are classified as green patents: Wind Energy (242, 073, 180, 440, 340, 343, 422, 280, 104, 374), Solid Waste Prevention (137, 435, 165, 119, 210, 205, 405, 065), Water Pollution (405, 203, 210), Recycling (264, 201, 229, 460, 526, 106, 205, 425, 060, 075, 099, 100, 162, 164, 198, 210, 216, 266, 422, 431, 432, 502, 523, 525, 902), Alternative Energy (204, 062, 228, 248, 425, 049, 428, 242, 222, 708, 976), Alternative Energy Sources (062, 425, 222), Geothermal Energy (060, 436), Air Pollution Control (123, 060, 110, 422, 015, 044, 423), Solid Waste Disposal (241, 239, 523, 588, 137, 122, 976, 405), and Solid Waste Control (060, 137, 976, 239, 165, 241, 075, 422, 266, 118, 119, 435, 210, 405, 034, 122, 423, 205, 209, 065, 099, 162, 106, 203, 431) (Carrión-Flores and Innes, 2010)	/dataverse/patent

Appendix B. Environmental Policy Stringency Index by Country

Country: Year	Australia	Belgium	Brazil	Canada	China	Denmark	Finland	France	Germany	Greece	Hungary	Ireland	India	Indonesia
1990	0.50	0.67	—	0.38	0.25	0.90	0.83	0.71	1.21	0.65	0.35	0.52	0.40	0.38
1991	0.50	0.67	—	0.38	0.44	1.58	1.00	0.71	2.13	0.73	0.48	0.48	0.40	0.38
1992	0.50	0.71	—	0.71	0.52	2.13	1.25	0.71	1.88	0.77	0.52	0.52	0.40	0.38
1993	0.75	0.77	—	0.50	0.52	2.23	1.31	0.77	1.94	1.02	0.52	0.58	0.40	0.38
1994	0.50	0.77	—	0.50	0.52	2.23	1.27	0.81	1.90	1.48	0.52	0.58	0.40	0.38
1995	0.50	0.77	0.42	0.50	0.52	1.98	1.27	0.81	1.81	1.73	0.52	0.58	0.46	0.44
1996	0.46	0.77	0.42	0.46	0.52	1.98	1.52	1.23	1.85	1.69	0.52	0.73	0.46	0.44
1997	0.46	0.77	0.42	0.65	0.52	1.98	1.77	1.15	1.94	1.69	0.52	0.73	0.46	0.44
1998	0.77	0.77	0.42	0.65	0.52	2.56	1.52	1.23	1.98	1.69	0.56	0.77	0.46	0.44
1999	1.02	0.77	0.42	0.65	0.52	2.40	1.52	1.31	1.98	1.69	0.52	0.77	0.46	0.44
2000	0.98	0.85	0.42	0.90	0.52	2.60	1.60	1.40	2.06	1.52	0.85	0.85	0.56	0.44
2001	1.09	1.10	0.54	0.90	0.52	2.74	1.35	1.56	2.06	1.52	1.69	0.81	0.56	0.44
2002	1.21	1.21	0.63	0.90	0.65	2.11	1.98	1.56	2.54	1.77	1.98	0.85	0.60	0.44
2003	1.21	1.17	0.58	1.58	0.85	2.09	2.48	1.56	2.54	1.77	2.13	1.42	0.60	0.44
2004	1.17	1.98	0.42	1.58	0.85	2.59	2.48	2.13	2.67	1.73	2.33	1.46	0.60	0.44
2005	1.55	2.45	0.42	1.54	0.85	3.13	2.44	2.71	3.05	1.84	2.63	1.88	0.67	0.44
2006	2.01	2.40	0.42	2.17	0.77	3.16	3.15	3.28	3.00	1.84	2.59	2.23	0.67	0.50
2007	2.01	2.20	0.42	3.27	0.77	2.83	2.82	2.86	2.67	1.92	2.30	1.71	0.63	0.50
2008	2.26	2.34	0.42	3.31	0.81	2.96	3.08	2.90	2.64	1.83	2.55	2.05	0.63	0.50
2009	2.69	2.58	0.42	3.85	0.98	4.07	3.25	3.69	3.06	2.08	2.66	2.16	1.13	0.50
2010	2.50	2.60	0.42	3.35	1.10	4.03	3.21	3.15	3.02	2.33	2.77	2.22	1.20	1.17
2011	3.34	2.53	0.38	3.67	1.35	3.98	3.48	3.70	3.14	2.33	2.68	2.43	1.26	1.17
2012	3.72	2.47	0.38	3.42	2.04	3.85	3.43	3.57	2.92	2.13	2.63	2.05	1.30	1.17
2013	4.07	—	0.38	3.36	1.99	—	—	3.50	3.11	—	—	—	1.30	1.08
2014	2.67	—	0.38	3.28	2.10	—	—	3.54	3.07	—	—	—	1.28	1.08
2015	3.17	—	0.54	3.28	2.16	—	—	3.58	3.13	—	—	—	1.82	1.08

Country:	Italy	Japan	South Korea	South Africa	Netherlands	Norway	Poland	Russia	Spain	Sweden	Switzerland	Turkey	UK
Year													
1990	0.96	1.13	0.50	0.44	1.67	0.60	0.65	—	0.79	0.90	2.00	0.46	0.96
1991	1.00	1.13	0.63	0.44	1.42	1.15	0.79	—	0.96	0.69	2.00	0.21	0.96
1992	1.42	1.13	0.63	0.48	1.17	1.33	0.83	—	0.96	1.69	2.00	0.46	0.96
1993	1.48	1.13	0.69	0.48	1.23	1.19	0.88	0.33	1.02	1.25	2.06	0.46	1.02
1994	1.48	1.23	0.69	0.48	1.27	0.98	0.88	0.33	1.44	1.29	2.06	0.46	0.81
1995	1.48	1.31	0.69	0.48	1.27	1.02	0.88	0.33	1.44	1.04	2.06	0.50	0.81
1996	1.48	1.33	0.75	0.48	1.23	1.02	0.88	0.33	1.56	1.04	2.06	0.50	0.81
1997	1.56	1.33	0.75	0.48	1.52	1.06	0.88	0.52	1.56	1.04	2.06	0.50	0.81
1998	1.56	1.33	0.75	0.52	1.56	1.06	0.92	0.52	1.73	1.25	2.06	0.50	0.81
1999	1.56	1.52	0.81	0.48	1.52	1.02	0.92	0.52	2.06	1.21	2.06	0.50	0.81
2000	1.48	1.58	0.81	0.44	1.35	1.15	0.92	0.52	2.15	2.15	1.94	0.65	0.94
2001	1.35	1.58	1.10	0.44	1.74	1.10	1.19	0.52	2.19	2.06	1.94	0.65	0.94
2002	1.35	1.58	1.10	0.44	1.78	1.67	1.19	0.52	2.19	2.58	1.94	0.69	1.1
2003	1.42	1.65	2.02	0.44	2.20	1.42	1.19	0.65	2.19	2.43	1.94	0.69	1.73
2004	1.49	1.90	2.33	0.44	1.90	1.42	1.27	0.65	2.75	2.75	1.69	0.88	1.73
2005	2.22	1.67	2.90	0.40	2.80	1.88	2.13	0.65	2.96	2.71	2.38	0.83	2.23
2006	2.72	1.63	2.96	0.52	2.80	2.13	2.26	0.65	2.96	3.03	2.13	1.50	2.29
2007	2.34	1.69	2.96	0.52	2.64	2.05	2.08	0.65	2.75	2.70	2.13	1.50	1.95
2008	2.6	1.69	3.38	0.48	3.23	2.34	2.26	0.60	2.70	2.92	2.67	1.50	2.4
2009	2.73	1.73	3.52	1.52	3.69	3.19	2.96	0.60	3.00	3.34	3.19	1.54	2.58
2010	2.84	2.03	3.52	1.75	4.13	3.19	2.96	0.60	2.72	3.09	3.33	2.06	3.62
2011	2.79	2.96	3.44	1.71	3.51	3.19	2.96	0.60	2.85	3.23	3.29	2.21	3.47
2012	2.77	3.50	2.63	0.71	3.63	3.26	2.58	0.60	2.22	3.10	3.29	1.83	3.29
2013	3.21	3.08	2.70	0.71	—	—	—	0.85	—	—	—	1.92	3.77
2014	3.21	3.08	2.74	0.71	—	—	—	0.85	—	—	—	1.92	3.72
2015	3.28	3.17	3.07	0.71	—	—	—	0.92	—	—	—	1.92	3.83

Appendix C. EPS and Cost of Bank Loans Using Matched Sample

	Lspread	
	30% Threshold	20% threshold
EPS	0.590**	0.971**
	(2.340)	(2.500)
Matching Variables		
Cash	-0.052	-0.028
	(-0.140)	(-0.110)
FCF	-0.874*	-0.400
	(-1.730)	(-0.88)
Sales Growth	0.050	0.044
	(1.180)	(1.130)
Firm Size	-0.113***	-0.044*
	(-5.450)	(-1.730)
Leverage	0.641***	0.927***
	(4.040)	(5.240)
SIC-2 Digit	0.008**	0.019***
	(2.440)	(4.210)
Market/Book	-0.007	-0.004
	(-1.200)	(-0.880)
Firm Age	-0.087**	-0.027
	(-2.320)	(-0.590)
Dividend	-3.167**	-2.229
	(-2.540)	(-1.510)
R&D	-0.385	3.201*
	(-0.220)	(1.870)
Operating Profit	0.358	-0.535
	(0.630)	(-1.140)
Loan Characteristics		
Loan Amount	-0.108***	-0.147***
	(-4.490)	(-7.340)
Loan Maturity	0.159***	0.169***
	(3.670)	(3.380)
Term Loan	0.237	0.273**
	(1.350)	(2.050)
Country Characteristics		
GDP	1.460**	4.519***
	(2.020)	(3.690)
Political Stability	-0.009	-0.252
	(-0.060)	(-1.030)
Anti-Corruption	-0.486**	-0.732**
	(-2.220)	(-2.260)
Constant	-3.176	-24.497***
	(-0.660)	(-2.940)
Observations	2,840	1,528
Adj. R^2	0.6751	0.7210

While these environmental regulations are imposed on firms by governments and in that sense can be viewed as exogenous to companies, an argument can be made that firms in countries that make their environmental regulations more stringent might be fundamentally different from others, and therefore we may face selection bias. To address this concern, in the spirit of propensity score matching, we conduct our analysis on a matched sample. Using a set of observable covariates, we match firms located in countries with EPS scores in the top 30th and 20th percentiles with firms in countries at the bottom 30th and 20th percentiles of EPS distribution. Conducting the analysis on the matched sample, we confirm our earlier finding that stronger environmental regulation is associated with higher cost of bank loans (results reported in Appendix E). Matching variables include cash, FCF, sales growth, asset size, leverage, industry, market-to-book ratio, age of the company, dividend, R&D, and operating cash flow. We use a logit model for our matching and then use the matched sample to conduct our analysis and verify previous results. We also include all the matching variables to ensure that any potential pitfalls of our methodology are controlled for, similar to double estimation procedures in propensity score matching.

Appendix D: List of Industries With the Highest and Lowest Environmental Litigation Cases from 1980 to 2016 in the U.S.

SIC2	% of Total Env Litigation	Industry Name	Subindustry
49	19.11	Electric, Gas, & Sanitary Services	Transportation & Public Utilities
28	13.09	Chemical & Allied Products	Manufacturing
29	8.48	Petroleum & Coal Products	Manufacturing
37	6.70	Transportation Equipment	Manufacturing
13	5.65	Oil & Gas Extraction	Mining
36	5.59	Electronic & Other Electric Equipment	Manufacturing
35	5.47	Industrial Machinery & Equipment	Manufacturing
33	4.67	Primary Metal Industries	Manufacturing
38	3.81	Instruments & Related Products	Manufacturing
26	2.89	Paper & Allied Products	Manufacturing
10	2.21	Metal, Mining	Mining
40	1.78	Railroad Transportation	Transportation & Public Utilities
12	1.66	Coal Mining	Mining
99	1.66	Non-Classifiable Establishments	Nonclassifiable Establishments
48	1.66	Communications	Transportation & Public Utilities
34	1.41	Fabricated Metal Products	Manufacturing
67	1.17	Holding & Other Investment Offices	Finance, Insurance, & Real Estate
73	1.11	Business Services	Services
30	0.98	Rubber & Miscellaneous Plastics Products	Manufacturing
60	0.86	Depository Institutions	Finance, Insurance, & Real Estate
20	0.74	Food & Kindred Products	Manufacturing
14	0.74	Nonmetallic Minerals, Except Fuels	Mining
32	0.68	Stone, Clay, & Glass Products	Manufacturing
50	0.61	Wholesale Trade – Durable Goods	Retail Trade
53	0.49	General Merchandise Stores	Retail Trade
42	0.49	Trucking & Warehousing	Transportation & Public Utilities
25	0.43	Furniture & Fixtures	Manufacturing
44	0.43	Water Transportation	Transportation & Public Utilities
16	0.37	Heavy Construction, Except Building	Construction
63	0.37	Insurance Carriers	Finance, Insurance, & Real Estate
1	0.31	Agricultural Production – Crops	Agriculture, Forestry, & Fishing
15	0.31	General Building Contractors	Construction
51	0.31	Wholesale Trade – Nondurable Goods	Retail Trade
80	0.31	Health Services	Services
24	0.25	Furniture & Fixtures	Manufacturing
27	0.25	Printing & Publishing	Manufacturing
31	0.25	Leather & Leather Products	Manufacturing
39	0.25	Miscellaneous Manufacturing Industries	Manufacturing
54	0.25	Food Stores	Retail Trade
87	0.25	Engineering & Management Services	Services
23	0.18	Apparel & Other Textile Products	Manufacturing
58	0.18	Eating & Drinking Places	Retail Trade
59	0.18	Miscellaneous Retail	Retail Trade
2	0.12	Agricultural Production – Livestock	Agriculture, Forestry, & Fishing
17	0.12	Special Trade Contractors	Construction
61	0.12	Non-depository Institutions	Finance, Insurance, & Real Estate
62	0.12	Security & Commodity Brokers	Finance, Insurance, & Real Estate
55	0.12	Automative Dealers & Service Stations	Retail Trade
75	0.12	Auto Repair, Services, & Parking	Services
47	0.12	Transportation Services	Transportation & Public Utilities
65	0.06	Real Estate	Finance, Insurance, & Real Estate
22	0.06	Textile Mill Products	Manufacturing
52	0.06	Building Materials & Gardening Supplies	Retail Trade
56	0.06	Apparel & Accessory Stores	Retail Trade
70	0.06	Hotels & Other Lodging Places	Services
72	0.06	Personal Services	Services
79	0.06	Amusement & Recreation Services	Services
45	0.06	Transportation by Air	Transportation & Public Utilities
46	0.06	Pipelines, Except Natural Gas	Transportation & Public Utilities