The Impact of Paris Agreement Climate Pledges on Firms' Production Decisions

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Abstract

Since the UN officially recognized climate change in 1992, climate pledges have played a leading role in spurring global action to limit climate change's devastating consequences. Countries are currently bound by pledges under the 2015 Paris Agreement, which aims to limit global warming to below 2°C, and preferably below 1.5°C, relative to pre-industrial levels. Given the centrality of such pledges to global climate plans and the large role of firms in driving climate change, it is essential to understand if Paris Agreement pledges are reducing firm-level environmental intensities of production. In this study, production intensities are defined as firms' monetized environmental impacts divided by their sales revenues for a given year.

This study performs difference-in-difference and linear probability regressions to examine the impact of Paris Agreement pledge strengths on firm-level production intensities over time, and to examine what factors predict countries' decisions to sign stronger Paris Agreement pledges. Results suggest that on average, firms in countries with strong pledges reduced their environmental intensities 3.6 to 9.9 cents more after the Paris Agreement compared to firms in countries with weak pledges. Results also suggest that higher GDP, lower greenhouse gas emissions, and stronger environmental performance at the time of signing are positively associated with a country's decision to make a strong climate pledge, while the relationship between governance and a country's pledge decision varies depending on the data specification, such as the use of weighting by firm size.

Overall, this study's results are consistent with previous research suggesting that pledges do influence firms' behavior, but that pledges will be insufficient on their own to combat climate change. Going forward, it will be important for policymakers to consider policy alternatives or supplemental actions to international climate agreements to limit global temperature increases in line with Paris Agreement goals.

INDEX WORDS: Paris Agreement, climate change, climate agreement, climate pledge, production intensity, emissions

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Chapter 1

Introduction

It is a well-established scientific fact that human actions are driving climate change, resulting in long-term shifts in temperatures and weather patterns with devastating consequences.[1] Since the late 1800s, burning fossil fuels and other industrial activities have contributed to a 1.1°C increase in Earth's temperature by releasing greenhouse gases (GHGs) that trap heat in the atmosphere.[1] In United Nations (UN) reports, thousands of scientists and government reviewers argue that humans must curtail their emissions to limit global temperature rises to no more than 1.5°C compared to pre-industrial levels by the end of the century to avoid the most severe impacts of climate change, including droughts, floods, fires, and sharp declines in biodiversity.[1]

Countries around the world have committed to formal treaties on climate change, the major form of international negotiation on climate issues. The most recent such treaty was the Paris Agreement in 2015, which aims to limit global warming to the levels cited in the UN reports—below 2°C, and preferably below 1.5°C, relative to pre-industrial levels.[2] While country-level pledges are crucial to addressing climate change, such pledges must translate to changes at the firm level. Since 1998, just 100 firms have been responsible for 70% of global GHG emissions.[3]

Previous research on the impact of country-level climate pledges has generally focused on country-level outcomes, such as countries' CO_2 emissions, rather than on firm-level outcomes. The research on corporate responses to country-level actions

has often focused on specific countries, industries, or individual firms, rather than examining responses on a global scale. Extant research on environmental impacts also tends to focus exclusively on one type of emissions, such as CO_2 or water pollution, rather than including a more encompassing measure of environmental impacts. In part, this is because it is difficult to find data on individual firms' environmental impacts, and existing data often suffers from a lack of accuracy and standardization. [4, 5, 6]

This study aims to address these gaps in the literature by examining the impact of countries' Paris Agreement pledges on individual firms' pollution production decisions. It most notably expands the literature by using an outcome variable measuring firms' environmental intensities' of production, rather than simply emissions. Production intensity data, developed by Harvard Business School, is defined as firms' monetized environmental impacts divided by their sales revenues for a given year.[7] Using production intensity as the outcome variable enables this study to isolate changes to firms' production methods. In contrast, emissions, the traditional outcome measure, does not allow researchers to isolate whether reductions in emissions are due to changes in production decisions or to simply lowering output. This research study also expands the literature by examining changes in corporate behavior rather than country behavior, by examining corporate behavior on a global scale rather than a local scale, and by examining a more general measure of environmental impacts that includes data on environmental outputs ranging from carbon emissions to water usage.

The data used in this study are from Harvard Business School, the Universal Ecological Fund, Germanwatch, and the World Bank. The dataset containing the major outcome variable of interest, a firm's environmental intensity of production, is a novel dataset from Harvard Business School that provides monetized, firm-level

environmental impact estimates from 2010 to 2019, with impacts based on a variety of environmental outputs.[7, 8] Data on climate pledge strength comes from Watson et al (2019)'s report, "The Truth Behind the Climate Pledges," published by the Universal Ecological Fund. Data on environmental policies and regulatory governance come from Germanwatch's Climate Change Performance Index (CCPI) and the World Bank's Worldwide Governance Indicators. Control variables including GDP, GHG emissions, and population come from the World Bank.

This study exploits variation in the strength of countries' Paris Agreement pledges to examine the impact of country-level climate pledges on firm-level production intensities, and to examine what factors predict countries' decisions to sign stronger pledges. First, difference-in-difference regressions are used to measure the impact of Paris Agreement pledge strengths on firm-level production intensities. This analysis compares the results of models that are either aggregated at the firm or country level. Countries are grouped based on whether their Paris Agreement pledges are sufficient or insufficient to meet their climate goals according to Watson et al. (2019).[9] Next, linear probability models are used to test for endogeneity of climate pledge strength, in this case, the idea that countries' GHG emissions, GDPs, and existing climate policies and governance regimes impacted their decisions to make a stronger or weaker climate pledge in 2015.

Results from the difference-in-difference models suggest that on average, firms in countries with strong pledges reduced their environmental intensities 3.6 to 9.9 cents after the Paris Agreement compared to firms in countries with weak pledges. Meanwhile, results from the linear probability models suggest that higher GDP, lower GHG emissions, and stronger environmental performance at the time of signing are positively associated with a country's decision to make a strong climate pledge, while the effect of governance varies depending on the data specification. Governance is posi-

tively associated with the decision to make a strong climate pledge in the full dataset, but is negatively associated with the decision to make a strong climate pledge in the dataset removing countries without at least one firm with complete data. Difference-in-difference results are similarly sensitive to the data specification. Significant results are observed for data specifications where firms are weighted by sales revenues but not for specifications where firms are weighted equally, indicating that large firms are more responsive to Paris Agreement pledges than smaller firms. Effect sizes are small, even for analyses weighted by firm size. Thus, this study's results are consistent with previous research suggesting that pledges do influence firms' behavior, but that such efforts will likely be insufficient on their own to combat climate change. Going forward, it will be important for policymakers to consider policy alternatives or supplemental actions to international climate agreements to limit global temperature increases to below 2°C, and preferably below 1.5°C, relative to pre-industrial levels.

Chapter 2

Background

International negotiations have formed the basis of global collaboration to address environmental issues since even before the UN officially recognized climate change in 1992.[10] Countries around the world adopted the Montreal Protocol in 1987 to limit the consumption and production of ozone-depleting substances. The protocol, which was universally ratified, was heralded as a great success, as it enabled countries to phase out 98% of ozone-depleting substances relative to 1990 levels.[11]

At the first summit in Rio de Janeiro after the UN officially recognized climate change, country representatives created the UN Framework Convention on Climate Change (UNFCCC) to acknowledge the gravity of climate change and humans' role in causing it. UNFCCC became active as of 1994, requiring ratifying countries to attend frequent meetings called the Conference of the Parties (COP). Since then, major global climate treaties formed at COP meetings have included the Kyoto Protocol from COP3, the Copenhagen Accord from COP15, and the Paris Agreement from COP21. The Paris Agreement, the focus of this thesis, is viewed as the most significant global climate agreement in history. Unlike the Kyoto and Copenhagen agreements, it requires both developed and developing countries to set emissions reductions targets called nationally determined contributions (NDCs). The Paris Agreement's overall goal is to limit global temperature rises to below 2°C, and ideally below 1.5°C, relative to pre-industrial levels.[2, 10]

As of June 2022, 194 parties—193 countries plus the European Union—have joined the Paris Agreement.[12] To prevent global warming from climbing above the Agreement's goal of 1.5°C, these parties need to collectively reduce their total emissions 45% by the year 2030 and reach net zero emissions by 2050.[13] A key part of parties' plans to reach their emissions targets, both current and future, is stronger environmental regulations. The UN's Intergovernmental Panel on Climate Change estimates that in 2020, 53% of global emissions were covered by climate laws in 56 countries, indicating the global prevalence of such laws.[14] However, countries are not the only notable climate actors; recent literature indicates a growing role for non-state and subnational actors like corporations.[14] In the last few years, over 30% of the world's largest publicly traded firms by revenue have pledged to achieve net-zero emissions by 2050, but these firm-level pledges are limited in scope and their success is hard to assess due to a lack of pledge standardization.[15, 16]

Under the Paris Agreement, each country chooses its own emissions reduction targets and participates in a non-punitive review process examining its progress towards meeting these targets.[10] This structure enables countries to adopt a wide variety of individualized targets and means to achieve them, in line with their own unique emissions levels, national policies, and government structures. In addition to shaping pledge targets, countries' individual characteristics may also influence the efficacy of these targets. In this study, I examine the impact of Paris Agreement pledge strengths on firm-level production intensities, accounting for unique country-level policies and governance.

Chapter 3

Literature Review

Past scholarship indicates mixed success of previous climate pledges and provides a general consensus that such pledges will be insufficient to address the climate crisis on their own.[17, 18, 19, 20] However, research has not yet identified effects of the Paris Agreement, has generally focused on country-level effects rather than firm-level, and has often only examined emissions (particularly GHG emissions) as the primary outcome variable. Current research is also lacking on how pledges impact firm-level production decisions, the role of climate policies as a mechanism for this impact, and the role of governance as a necessary condition. This study will add to the climate pledge literature by: (1) exploring preliminary evidence of the Paris Agreement's effect on firm-level decisions on a global scale, (2) studying environmental intensities of production rather than a general measure of emissions as the outcome variable, and (3) investigating the roles of both policies and governance in reductions in environmental intensities of production.

3.1 Climate Pledges

Since the UN officially recognized climate change in 1992, climate pledges have played a leading role in spurring global action to limit climate change's devastating consequences.[10] Countries are currently bound by pledges and updated NDCs under the Paris Agreement of 2015, which aims to limit global warming to below 2°C, and

preferably below 1.5°C, relative to pre-industrial levels.[2] Given the centrality of such pledges to global climate plans and the large role of corporations in driving climate change, it is important to understand the role Paris Agreement pledges play in reducing firm-level environmental intensities of production.

Research indicates mixed success of past climate pledges on reducing emissions, leaving an open question regarding the predicted effectiveness of the Paris Agreement.[17, 18, 19, 20] Some researchers argue Paris pledges' voluntary and non-punitive nature will render them too weak to be effective, while others argue it will render them more effective by enabling countries the flexibility to adapt their pledges to their unique national circumstances and political contexts.[21, 22, 23] Either way, the Paris Agreement's value is not yet clear, and more research is needed to understand its effects.[17, 19]

Studies on previous climate pledges, including the Kyoto Protocol and the Copenhagen Accord, have found mixed, and generally muted, effects on key climate outcomes. Using a panel dataset of 186 countries, Tenreyro and de Silva (2021) studied countries' compliance with their pledged targets in the Kyoto, Copenhagen, and Paris agreements, and the impact of those pledges and country-specific climate laws and policies on countries' CO_2 emissions and economic outcomes. To do so, the authors relied on regressions using country and year fixed effects and inverse probability weights to account for possible endogeneity in the decision to sign a climate-pledge, as they predicted countries with low emissions might find it easier to sign a climate agreement than countries with high emissions. Overall, the authors found mixed compliance with pledge targets but did find evidence that countries that signed the Kyoto Protocol and/or the Copenhagen Accord experienced significant emissions reductions relative to non-signatories. Effects from the Paris Agreement were not yet evident in their data, which only covers through the year 2018.[17]

Rogelj et al. (2010) calculated probabilistic estimates for the climate consequences of countries' Copenhagen Accord pledges, including global temperature increase and atmospheric CO_2 and CO_2-equivalent concentrations, and evaluated those predicted consequences against the Accord's climate-related objectives. They found that given the ambition of the current pledges and the lack of common goals, the pledges would be unlikely to meet the Copenhagen Accord's goals of limiting global warming to below 2°C, and ideally below 1.5°C.[18]

While the effect of past climate pledges is generally known, particularly on a country-wide basis, the overall impact of the Paris Agreement on global emissions is still an outstanding question. Given that the Agreement was signed in 2015, there may not have been enough time yet for significant effects to show up in country-level research, the level at which pledge impacts have generally been studied thus far.[17, 19] The open question, which researchers are beginning to explore in empirical studies and predictive research, is whether the pledges will have any impact on country and firm-level emissions, and whether such impacts will be sufficient to meet Paris Agreement goals.

Many researchers speculate that like the Kyoto and Copenhagen Agreements, pledges under the Paris Agreement will reduce emissions to some degree, but not nearly enough to limit global warming to below Paris Agreement goals of 2°C.[9, 24, 25] Examining 186 countries' pledges, Watson et al (2019) found that only 36 countries, or 19%, have sufficient pledges to reduce GHGs by 50% by 2030, in line with Paris Agreement goals. At least 130 nations, including four of the top five countries with the largest emissions, are falling short of their necessary goals.[9] Nauels et al (2019), Robiou du Pont and Meinshausen (2018), and Barrett and Dannenberg (2016) similarly find evidence of the insufficiency of Paris pledges in their predictive research. Nauels et al (2019) and Robiou du Pont and Meinshausen (2018) used economic

modelling and found that current pledges would be insufficient to reverse trends in long-term sea level rises and global warming levels exceeding Paris Agreement goals.[24, 25] Barrett and Dannenberg (2016) used a lab experiment to simulate the effect of a review process on targets, pledges, and contributions. They found that a review process like that of the Paris Agreement, which reviews pledges but offers no retribution for unmet ones, may impact countries' targets and pledge strengths but not their ultimate contributions to emissions reductions.[21]

Not all researchers are as skeptical about the Paris Agreement's potential for environmental impact, arguing that its structure may not pose a threat to pledges' credibility as Barrett and Dannenberg (2016) claim, and that non-state actors like investors and corporations may internalize pledges and choose to take action to address climate change on their own, without the need for government action. Victor et al (2022) used binary probit regressions to examine interviews with climate policy experts assessing whether they considered more ambitious pledges to be more credible. In contrast to Barrett and Dannenberg, Victor et al (2022) argued that pledges permitted under the Paris Agreement's voluntary and non-punitive review process may be more effective than the alternative because it allows countries to incorporate country-specific circumstances into their pledges, making them more credible. In their assessment, the largest determinant of countries' credibility in their climate pledges was the quality of their political institutions.[23] In a different study, Tørstad and Wiborg (2021) used ordinary least squares (OLS) regressions to examine the impact of ambiguity on the ambition levels of countries' NDCs. They found that ambiguity leads to lower ambition in NDCs overall, but that this lack of ambition does not necessarily undermine compliance under the Paris Agreement's pledge-and-review. When faced with ambiguity, countries may pledge more prudent targets, leading to higher compliance rates. Instead of pledging unrealistically high targets, the authors argued that coun-

tries formulate targets they can comply with and have leeway to raise their ambition levels during future pledges.[22]

Beyond state action, researchers argue that the Paris pledges may be able to impact emissions levels through the indirect effect of triggering and legitimizing corporate action. While the ultimate impact of corporate pledges is still in need of research, it is clear that there has been a large increase in the number of corporate pledges since the Paris Agreement.[15, 20] Palea and Drogo (2020) used a series of OLS regressions to examine the relationship between corporate carbon risk[1] and the cost of debt for a sample of firms from the Eurozone for 2010-2018. They found that higher carbon emissions are associated with a higher cost of debt financing, indicating that lenders are incorporating carbon risk in their investment decisions, which may in turn impact corporations' decisions to engage in carbon-risk carrying activities. The Paris Agreement also appeared to be a turning point for lenders' decisions as they began to internalize policymakers' commitments to limiting climate change.[26]

While corporate pledges may contribute to meaningful improvements in corporations' environmental footprints, there is reason to suspect such pledges may be insufficient to meaningfully address climate change. In an analysis of a Japanese manufacturing firm that launched its own climate pledge in response to the Paris Agreement, Warzywoda et al (2022) found that modest corporate targets can lead to reductions in carbon emissions, but that corporations must take much larger steps to reach their ambitious net-zero targets.[27] In another study, Arnold and Toledano (2021) analyzed climate pledges from 35 firms across seven industries and found that firms are not doing nearly enough to reach their pledges, with shortcomings ranging

[1]The authors use carbon intensity as an indicator of corporate carbon risk. Carbon intensity is computed as the ratio between Scope 1 and Scope 2 emissions and net sales.

from a lack of short-term ambitions to actively lobbying against policies that would catalyze decarbonization.[16]

3.2 Environmental Policy

Strong environmental policy at the national level is necessary to achieve the pledges and NDCs that countries agreed to under the Paris Agreement. In the years since the Agreement was adopted in 2015, many countries have planned or implemented domestic climate policies including taxes, tariffs, or standards to help reduce their environmental impacts.[28] While there is a general consensus on the importance of environmental policies, there is a large degree of variation in their effectiveness due to the nature of the enacted policies and the context in which they are employed. As with pledges, policy effects have been studied at both the country- and firm-level.

At the country level, Tenreyro and de Silva (2021) used a regression with country and year fixed-effects to study the impact of the number of climate-related laws, the number of climate-related policies, the presence of a national carbon tax, and the presence of a national emissions trading scheme (ETS) on country-level fossil CO_2 emissions. The authors found that the number of climate-related policies did not have a significant association with emissions, but that the number of laws passed, the presence of a national carbon tax, and the presence of a national ETS were all significantly associated with reductions in fossil CO_2 emissions. The authors also found that having a carbon tax or ETS carried a much larger magnitude of effect that enacting another law or policy.[17]

At the firm level, researchers have generally found similar results indicating the positive effect of national climate policies on emissions, though this success may be limited by the global nature of certain corporations. Shapiro and Walker (2018) exam-

ined factors contributing to the decline in air pollution emissions from U.S. manufacturing between 1990 and 2008, which fell 60% despite a substantial increase in manufacturing output. The authors first decomposed changes in manufacturing due to the total scale of manufacturing output, the composition of products produced, and the pollution intensity of a given set of products. Second, they used stylized economic models to examine firms' choice of pollution emissions given a tax on emissions. In these economic models, firms' production and pollution abatement decisions depended on the environmental regulations they faced, along with their individual productivity and trade costs. Shapiro and Walker found that the implicit pollution tax from their models more than doubled for most pollutants between 1990 and 2008, driving manufacturer's decisions to reduce emissions.[29]

In a much older study, Kagan et al (2003) similarly found that stricter regulatory requirements and greater political pressures have contributed to large improvements in manufacturers' environmental performance over time. In this study, the authors' research expanded beyond just the United States; in addition to examining pulp and paper manufacturing mills in the states of Washington and Georgia, Kagan et al also examined mills in Australia, New Zealand, and British Columbia. Unlike in future studies, including Tenreyro and de Silva (2021), Kagan et al attribute the success of environmental regulations to social pressures from communities and activists and the culture of corporate management involved in creating and implementing them—rather than to the rules themselves.[30]

While much extant scholarship highlights the positive impact of strong domestic environmental policies on reducing firms' pollution levels, some research reveals that such policies may have limited impact if there are not global policy improvements. Ben-David et al (2021) studied 1,970 large public firms headquartered in 48 countries and their CO_2 emissions in 218 countries from 2008 to 2015 using fixed effects models

controlling for industry and year. They found that on net, firms reduced their overall global CO_2 emissions in response to stricter domestic environmental policies, but there was evidence that firms relocated some of their pollution abroad.[31]

3.3 Governance

Past research indicates that strong national governance is necessary to ensure successful policy implementation to achieve climate pledge goals. Strong national governance reflects a country's ability to effectively select, monitor, and replace governments; formulate and implement sound policies; and garner citizen and state respect for public institutions.[32, 33] Such governance is needed for countries to achieve their Paris Agreement goals, as research has shown that the largest determinant of the credibility of countries' climate pledges is the quality of their national political institutions.[23]

Previous research on governance focuses on the impact of governance on country-level emissions, rather than firm-level environmental intensities, which is the subject of this study. The research is clear on the importance of governance for environmental outcomes of pledges and policy, but indicates that its effects are non-uniform. Improvements in governance tend to reduce emissions in high-income countries and increase emissions in low-income countries.

In a predictive modeling analysis of factors that explain differences in high-income OECD countries' per capita GHG emissions, Calbick and Gunton (2014) found that energy prices, economic output per capita, and environmental governance explained around 81% of the observed variation in high-income OECD countries' per capita GHG emissions. Taken alone, energy prices explained 55% of the variation in per capita GHG emissions, while economic output per capita explained 19% and envi-

ronmental governance explained 7%. The researchers also found that more affluent populations tend to generate greater GHG emissions, and that rising energy prices and environmental governance levels both tend to reduce GHG emissions.[34] A different study by Ronaghi et al. (2020) found a similar positive impact of governance on emissions reductions in OECD countries.[35]

Studies of poor or middle-income nations observe the opposite effect of governance on emissions. Sarkodie et al (2020) examined the relationship between governance and GHG emissions, among other factors, in countries in Sub-Saharan Africa using regressions controlling for country-level fixed effects. They found that increasing governance exacerbates emissions in these countries, as do foreign direct investment and income. The authors hypothesized that the increased emissions could be attributed to expanding production levels at the expense of the climate. In low-income countries, governance is used to relax environmental policies and regulations to favor foreign direct investment and economic expansion rather than to combat climate change.[36]

Gök and Sodhi (2021)'s study of the impact of governance on environmental quality measures observed interactive effects of governance and income level that explain the different findings observed in the studies discussed above. Using observations of 115 countries clustered as high, middle, and low income for the years 2000 to 2015, Gök and Sodhi found that improvements in governance increased environmental quality in high income countries, but decreased environmental quality in middle- and low-income countries. Thus, improvements in governance may have enabled high-income countries to achieve environmental quality improvements without changing their environment-oriented policies and governance practices, while middle- and low-income countries would have needed to restructure their governance system to prioritize environmental outcomes over economic ones to improve their environmental quality.[33]

Chapter 4

Data and Methods

This study uses data from Harvard Business School, the Universal Ecological Fund, Germanwatch, and the World Bank to explore how countries' Paris Agreement climate pledges affect firms' production decisions. The research relies on two sets of analyses: difference-in-difference models examining the impact of Paris Agreement pledges on firm-level production intensities, and linear probability models examining the determinants of countries' decisions to make a strong or weak pledge. These analyses enable me to examine several pathways in my theory of change, shown in Figure 4.1 below.

4.1 Data

The novel dataset created in this study contains firm-level emissions for 2,401 firms in 61 countries over the period from 2010 to 2019. Of these 2,401 firms, 489 firms in 34

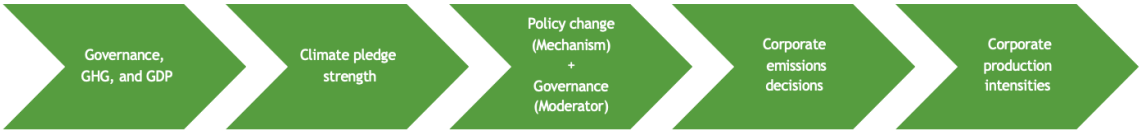


Figure 4.1: Theory of change.

countries have complete data for all years. Descriptive statistics for this study's key variables of interest can be found in Tables 4.1 and 4.2. Table 4.1 compares descriptive statistics for the unweighted data subsets aggregated at the firm-level, while Table 4.2 compares these datasets aggregated at the country-level with weighting by firm sales revenue. As Tables 4.1 and 4.2 reveal, there are significant differences between the dataset with all firms included and the dataset with only firms that are not missing data. For both the unweighted and the weighted subsets, the dataset containing all firms has higher environmental intensity levels and more representation of firms in countries with weak pledges, on average, than the dataset containing only firms with non-missing data.

This study's main outcome variable, environmental intensity, is derived from Harvard Business School's impact-weighted accounts dataset and is calculated as the monetized environmental impact of a firm's operations during a specific year divided by its sales revenue in that year.[7, 8] For ease of analysis, I report this value as a proportion rather than as a percent, and reverse the sign. In my dataset, firms with larger, positive values for environmental intensity produce more environmental damages per dollar of sales revenue.

While Harvard Business School's dataset provides information across a broad enough time period to study changes in the trajectory of firms' production intensities before and after the Paris Agreement, it also provides a number of analytical challenges. Many firms lack complete data for all years, results may be sensitive to weighting by firm revenues, and some firms have negative values for environmental intensity, signifying these firms produce net environmental benefits to society rather than damages. According to the dataset authors, nearly all cases of negative environmental intensities are caused by one of the following scenarios: 1) the firm engaged in significant carbon offset efforts in a given year, or 2) the firm had a large volume of

Table 4.1: Descriptive statistics for unweighted data subsets.

Variable	N	(1) All Mean/(SE)	N	(2) Non-Missing Mean/(SE)	(1) - (2) Pairwise t-test Mean difference
Environmental intensity	13491	0.113	4890	0.099	0.014***
		(0.002)		(0.003)	
Strong pledge	24010	0.593	4890	0.763	-0.170***
		(0.003)		(0.006)	
Government effectiveness	24010	1.229	4890	1.443	-0.214***
		(0.004)		(0.007)	
Climate Change Performance Index	23304	52.110	4856	52.396	-0.286
		(0.076)		(0.172)	
Policy level	4616	2.479	968	2.341	0.138***
		(0.018)		(0.038)	
Natural log of GHG emissions (kt of CO2 equivalent)	23050	13.636	4840	13.522	0.114***
		(0.010)		(0.019)	
Natural log of GDP per capita (USD)	24010	10.364	4890	10.575	-0.211***
		(0.006)		(0.009)	
Natural log of population	24010	18.124	4890	18.080	0.044**
		(0.009)		(0.016)	

Standard errors in parentheses
$*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$

Note: Data are panel data covering the period 2010 to 2019.

Table 4.2: Descriptive statistics for weighted data subsets.

Variable	N	(1) All Mean/(SE)	N	(2) Non-Missing Mean/(SE)	(1) - (2) Pairwise t-test Mean difference
Environmental intensity	504	0.177	340	0.125	0.052***
		(0.012)		(0.010)	
Strong pledge	610	0.525	340	0.706	-0.181***
		(0.020)		(0.025)	
Government effectiveness	610	0.770	340	1.112	-0.342***
		(0.032)		(0.039)	
Climate Change Performance Index	468	53.965	318	55.293	-1.328*
		(0.463)		(0.535)	
Policy level	92	2.522	62	2.710	-0.188
		(0.120)		(0.137)	
Natural log of GHG emissions (kt of CO2 equivalent)	590	12.089	330	12.343	-0.254**
		(0.063)		(0.075)	
Natural log of GDP per capita (USD)	610	9.852	340	10.199	-0.347***
		(0.045)		(0.054)	
Natural log of population	610	16.831	340	17.096	-0.265**
		(0.068)		(0.081)	

Standard errors in parentheses
$*$ $p < 0.05$, $**$ $p < 0.01$, $***$ $p < 0.001$

Note: Data are panel data covering the period 2010 to 2019.

nitrogen oxide (NOx) or sulfur oxide (SOx) emissions. Due to the high costs imposed by global warming relative to other environmental costs, the harmful effects of NOx and SOx are currently significantly outweighed by their cooling effects, and are thus treated as resulting in net environmental benefits in this dataset.[1] To address these quirks, this study performs several iterations of results with and without firms with missing data, with and without weighting by firm revenues, and with and without firms with negative environmental intensities.

The explanatory variables in this study—country-level climate pledges, environmental policies, and governance—are obtained from the Universal Ecological Fund, Germanwatch, and the World Bank, respectively. Watson et al (2019)'s report, "The Truth Behind the Climate Pledges," published by the Universal Ecological Fund, provides an assessment of the overall strength of countries' Paris Agreement pledges in 2015, categorizing them as sufficient, partially sufficient, partially insufficient, or insufficient based on their ability to reduce GHG emissions by 50% by 2030, in line with Paris Agreement goals. [9] In this analysis, countries' pledges are rated as strong (1) or weak (0) based on Watson et al's classifications. Countries have strong pledges if they have a partially sufficient or a sufficient pledge, and weak pledges if they have no pledge, an insufficient pledge, or a partially insufficient pledge.

To assess the strength of countries' overall climate performance, this study relies on data from Germanwatch's CCPI, which provides overall CCPI scores for countries from 2010 to 2019. The CCPI is a weighted index measure based on countries' GHG emissions (40%), renewable energy use (20%), energy use (20%), and climate policies (20%), and its values range from 0 to 100, with 100 being the best possible score.

[1]The researchers' treatment of NOx and SOx is supported by other researchers and the UN's Intergovernmental Panel on Climate Change.[37]

It is created based on performance ratings from questionnaires given to around 350 climate change experts in the countries being evaluated.[38]

The World Bank's Worldwide Governance Indicators are used to assess the impact of country-level governance on firms' production intensities. These indicators provide data at the country-level across all years of this study (2010 to 2019) for the following six categories: Voice and Accountability, Political Stability and Absence of Violence/Terrorism, Government Effectiveness, Regulatory Quality, Rule of Law, and Control of Corruption.[32] This analysis relies on the government effectiveness indicator, which reflects perceptions of the quality of public services, the quality of civil service and its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.[32] Its values range from -2.5 (weak) to 2.5 (strong). Data for the control variables used in the study—GDP (measured in USD as of September 2022), GHG emissions (kt of CO_2 equivalent), and population—also come from the World Bank. [39, 40, 41]

The main analyses in this study rely on four data specifications accounting for different levels of aggregation and accompanying weighting, and treatment of firms with missing data.

- All Un-W: Data aggregated at the firm-level, giving equal weight to each firm.
- No Miss Un-W: Data aggregated at the firm-level, giving equal weight to each firm. No Miss Un-W is a subset of All Un-W that contains only firms with complete data for all years.
- All W: Data aggregated at the country-level, weighting firms by their sales revenues.

- No Miss W: Data aggregated at the country-level, weighting firms by their sales revenues. No Miss W is a subset of All W that contains only firms with complete data for all years.

Auxiliary analyses provided in the appendix report results for subsets of these main specifications removing firms with negative environmental intensities (i.e., firms that provide environmental benefits that outweigh their damages). The first set removes individual firm-year observations with negative intensities, while the second set removes all observations for firms with negative intensities for any year.

It is particularly important to examine if results hold across data specifications in this study given the significant differences between groups observed in Tables 4.1 and 4.2. Such differences are also apparent in Figure 4.2, which reveals that data aggregated at the country-level with weighting is more concentrated at higher intensities and revenues than data aggregated at the firm-level without weighting.

4.2 Methods

To examine the impact of countries' Paris Agreement pledges on firm-level environmental performance, this study relies on two sets of models. The first set of models examines changes in firm-level environmental intensity paths over 2010 to 2019, testing whether the Paris Agreement served as a turning point for firms' production intensities. The second set of models examines determinants of countries' Paris Agreement pledge strengths. Each set of analyses is run using the different data specifications described above, with checks to see if models are robust to model specifications such as the inclusion of fixed effects.

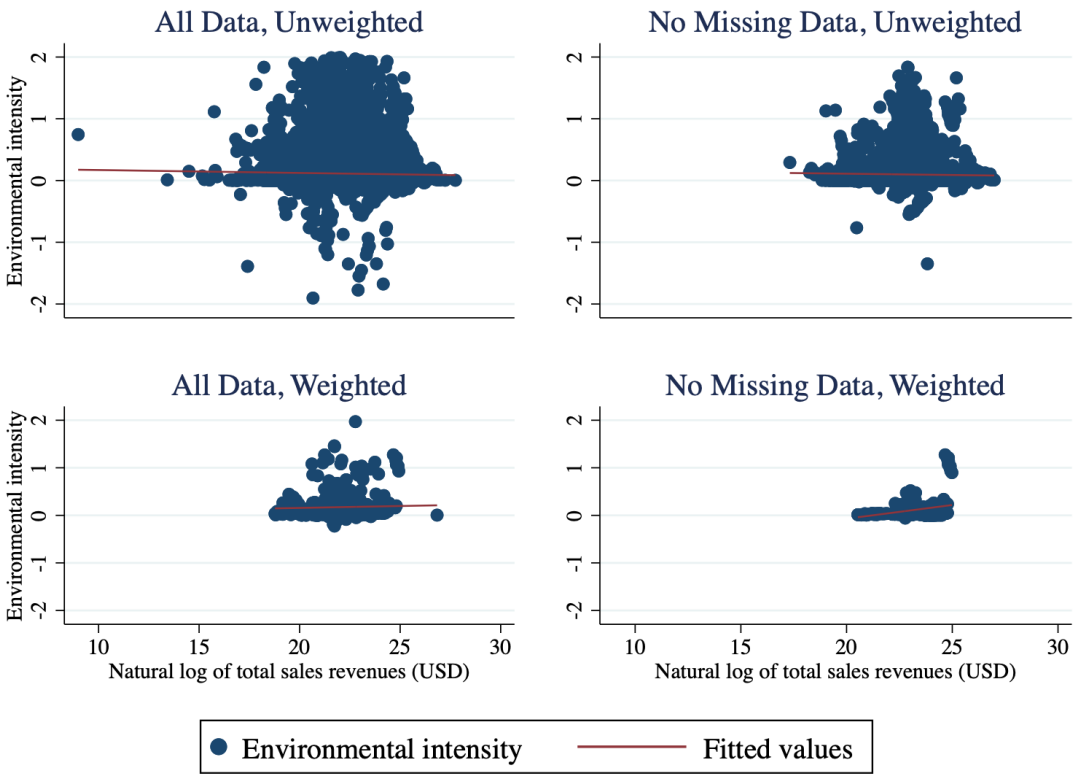


Figure 4.2: Comparison of environmental intensity and sales revenues (USD) for different data specifications.

4.2.1 Impact of Countries' Paris Agreement Climate Pledges on Firm-Level Production Intensities

Using data on firm-level environmental intensities from 2010 to 2019, this study first tests whether countries with stronger climate pledges under the Paris Agreement experienced different trajectories in firm-level environmental intensities after the Paris Agreement, relative to countries with weaker climate pledges.

The baseline model is a difference-in-difference regression. For each firm i in country c in region r in time t, firm-level environmental intensities are estimated as:

$$intensity_{i,c,r,t} = \beta_0 + \beta_1(post)_t + \beta_2(strong)_c + \beta_3(postXstrong)_{c,t} + \beta_4 X_{i,c,t} + \epsilon_{i,c,t} + \epsilon_r \tag{1}$$

In this model, β_3 is the difference-in-difference estimate, X is a vector of covariates (governance, GDP, and population), and ϵ_r represents clustering at the regional level. Standard errors are clustered at the regional level to reflect that pledge strengths are clustered at the regional level (see Figures 4.3 and 4.4).

This baseline model is also run with company-level fixed effects α_c to account for the fact that firms may have idiosyncratic features beyond those controlled for in the model that impact their production intensities, as well as annual fixed effects α_t to adjust for time trends. For each firm i in country c in time t, firm-level environmental intensities are estimated as:

$$intensity_{i,c,t} = \beta_0 + \beta_3(postXstrong)_{c,t} + \beta_4 X_{i,c,t} + \alpha_c + \alpha_t + \epsilon_{i,c,t} \tag{2}$$

Equations (1) and (2) are calculated using the four data specifications described in the Data section above. In specifications with country-level data, country-level fixed effects are used in place of company-level fixed effects.

4.2.2 Determinants of Countries' Paris Agreement Pledge Strengths

Tenreyro and de Silva (2021) hypothesized that countries with low levels of emissions may find it easier to sign a climate agreement than countries with high levels of emissions at the time of signing, leading to reverse-causality between pledge agreements and country-level emissions. [17] While their study examines the decisions to sign a pledge, rather than pledge strength—the focus of this study—the same logic applies. In this study, I hypothesize that more effective governance, higher GDP, lower GHG emissions, and stronger environmental performance at the time of signing will be positively correlated with a country's decision to sign a stronger Paris Agreement pledge.

To test this hypothesis, I use data from 2015, the year of Paris Agreement adoption, to run the following linear probability model at the country-level for each country c in region r:

$$pledge_{c,r} = \beta_0 + \beta_1 governance_c + \beta_2 GDP_c + \beta_3 GHG_c + \epsilon_c + \epsilon_r \tag{3}$$

Here, pledge strength is a binary outcome, with 1 representing a strong pledge and 0 representing a weak pledge, and ϵ_r represents clustering at the regional level.

Equation (3) is also tested using CCPI as the only explanatory variable. For 2015, CCPI scores are comprised of country-level emissions (30% weighting), emissions development (30% weighting), renewable energy (10% weighting), efficiency (10% weighting), and policy (20% weighting).[38] I am unable to include climate policy directly in this model, as climate policy data is not provided separately from overall CCPI for the year 2015.

For each country c in region r, climate pledge strength is estimated using the following linear probability model:

$$pledge_{c,r} = \beta_0 + \beta_1 CCPI_c + \epsilon_c + \epsilon_r \tag{4}$$

where ϵ_r represents clustering at the regional level.

Equations (3) and (4) are calculated using countries that appear in the All W and No Miss W data specifications discussed in the Data section above.

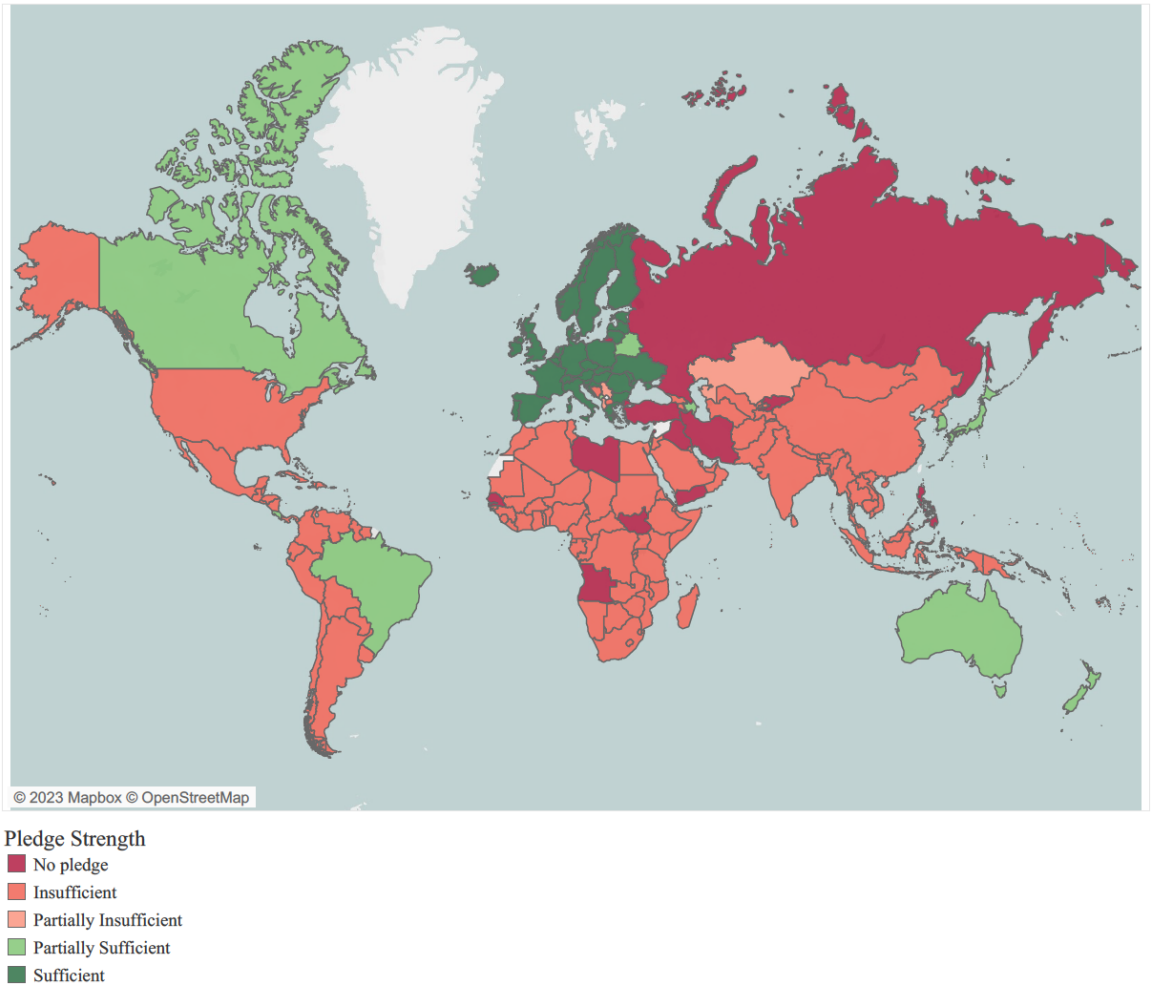
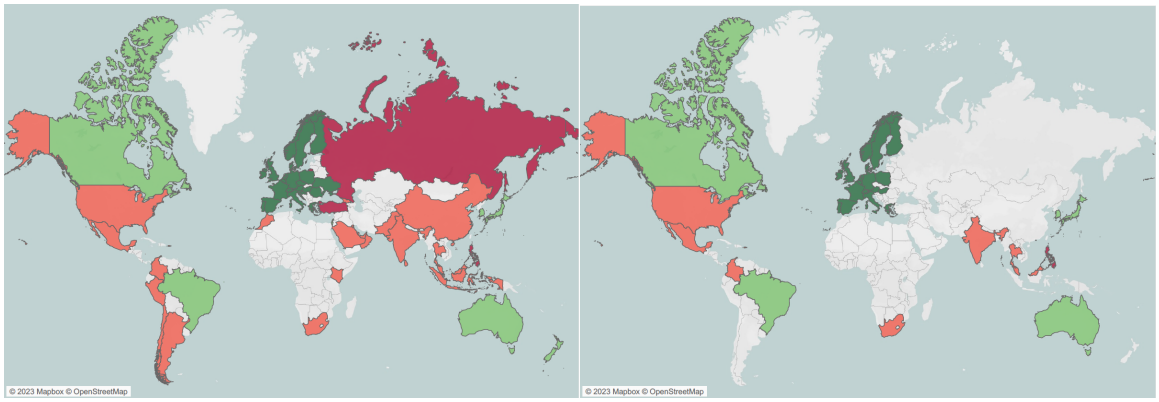


Figure 4.3: Paris pledge agreement strength for all countries.



(a) All Data **(b)** No Missing Data

Figure 4.4: Paris pledge agreement strength for analyzed countries.
Note: See Figure 4.3 for legend.

Chapter 5

Results

This study relies on two sets of models to estimate the impact of countries' Paris Agreement pledges on firm-level environmental performance. The first set uses difference-in-difference models to examine the impact of countries' pledges on firm-level production intensities, while the second set uses linear probability models to examine determinants of countries' pledge strengths.

This study finds that, on average, firms in countries with strong pledges reduced their environmental intensities 3.6 to 9.9 cents after the Paris Agreement compared to firms in countries with weak pledges. This result, though, is sensitive to data specifications; significant results are found for data specifications where firms are weighted by sales revenues but not for specifications where firms are weighted equally, indicating the large firms are more responsive to Paris Agreement pledges than smaller firms. It also finds that higher GDP, lower GHG emissions, and stronger environmental performance at the time of signing are positively associated with a country's decision to make a strong climate pledge, while the effect of governance varies depending on the data specification. Governance is positively correlated with the decision to make a strong climate pledge in the full dataset, but is negatively correlated with the decision to make a strong climate pledge in the dataset removing countries without at least one firm without missing data.

5.0.1 Impact of Countries' Paris Agreement Climate Pledges on Firm-Level Production Intensities

Using difference-in-difference regressions, I first test whether countries with stronger Paris Agreement pledges experienced greater reductions in firm-level environmental intensities after the Paris Agreement, relative to countries with weaker climate pledges. The Paris Agreement was adopted in December 2015 and entered into force on November 2016. [2] In this study's difference-in-difference regressions, 2016 is treated as the last year of the pre-intervention period, while 2017 is treated as the beginning of the post-intervention period.

To estimate causal effects in a difference-in-difference model, several assumptions must hold, including that the intervention is unrelated to the outcome at baseline, that treatment and control groups have parallel trends in outcomes before the intervention, and that the composition of the comparison groups is stable over time. [42] Researchers must also believe that the treatment is the only factor that could be influencing the observed differences in outcomes between treatment groups.

The regressions contained in this report violate several of the difference-in-difference assumptions for causality. First, as the second set of regressions discussed below indicates, there is reason to believe that a country's choice to make a strong or weak Paris Agreement pledge is endogenous. Countries with lower levels of GHG emissions, more effective governments, and stronger environmental performance at the time of signing are more likely to make stronger climate pledges than other countries. Second, Figure 5.1 provides evidence that countries with strong pledges experienced different trajectories in environmental intensity prior to the Paris Agreement than countries with weak pledges. Third, there many be factors influencing observed differences in outcomes beyond the Paris Agreement, such as differences

in trends in consumer preferences for climate-friendly products. Thus, the results described below are indicative of a correlation between study variables, but should not be considered causal.

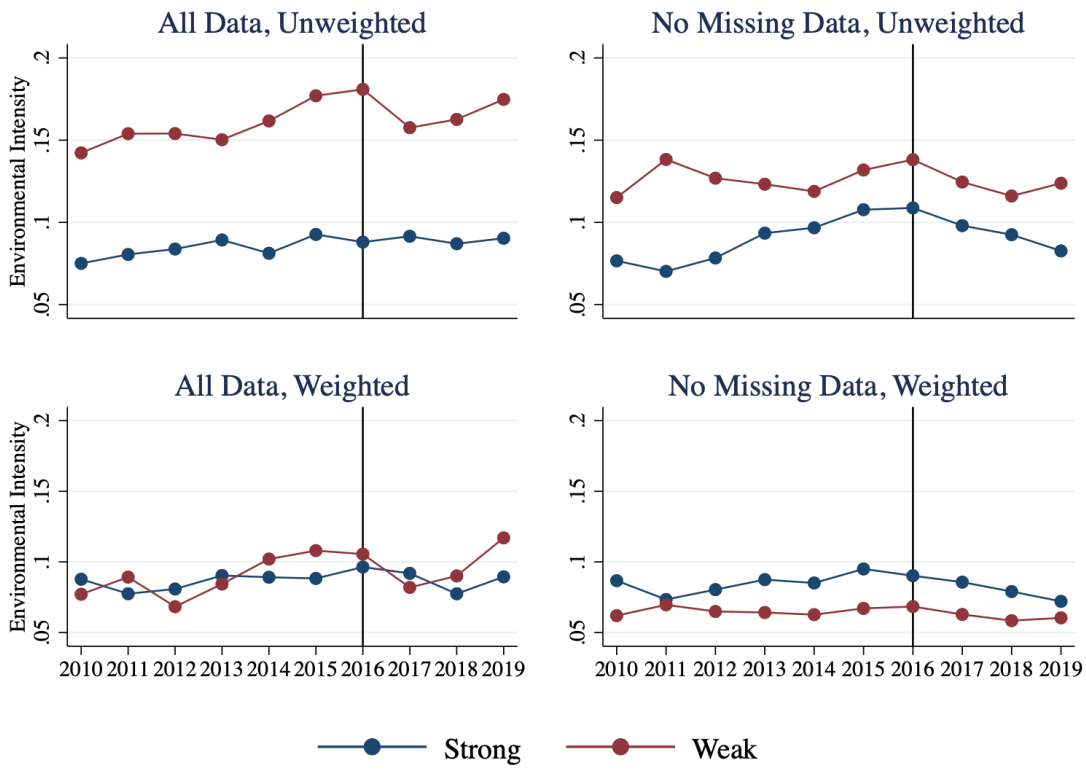


Figure 5.1: Difference in environmental intensities by pledge strength.

Note: The Paris Agreement was adopted in December 2015 and entered into force on November 2016. In this study's difference-in-difference analyses, 2016 is considered the last year of the "pre" period, and 2017 is the beginning of the "post" period.

Tables 5.1 to 5.4 contain results for difference-in-difference regressions run on the main data specifications, as described in the Data section. Appendix Tables A.1 to A.8 contain results for the same regressions run on data specifications including only firms with positive environmental intensities, with different methods for removing firms with negative intensities.

For each data specification, I run four sets of regressions:

1. A version without controls or fixed effects
2. A version with controls and without fixed effects
3. A version without controls and with fixed effects for year and company/country
4. A version with controls and fixed effects for year and company/country

The coefficient of interest in each regression is "Post 2016 x strong pledge," which measures the change in environmental intensity after the Paris Agreement for firms in countries with strong pledges, relative to firms in countries with weak pledges. Across Tables 5.1 to 5.4, the coefficient of interest is small in magnitude and not statistically significant for both the unweighted data specifications aggregated at the firm-level. The coefficients tell a different story for the weighted data specifications aggregated at the country-level. For the All W specification, firms in countries with stronger pledges see 7.1 to 9.9 cents less in environmental harm for every dollar of sales after the Paris Agreement, relative to firms in countries with weak pledges. For the No Miss W specification, firms in countries with stronger pledges also see lower levels of environmental intensities, but at a much smaller magnitude. Reductions for firms in countries with strong pledges range from 3.6 to 3.9 cents higher than those of firms in countries with weak pledges. Findings are similar for the auxiliary regressions seen in Appendix Tables A.1 to A.8. While only the results for the regressions including fixed effects are statistically significant at the 5% level, the other results are still meaningfully large and approach significance.

Despite a lack of significance for the coefficient on the term "Post 2016 x strong pledge" in the unweighted regressions, these regressions do have a significant coefficient on the term "Strong pledge" (see Tables 5.1 and 5.2). On average, firms in

countries with strong pledges have 7.7 cents lower environmental intensities in the All Un-W group and 3.7 cents lower intensities in the No Miss Un-W group compared to firms in countries with weak pledges.

Table 5.1: Difference-in-difference estimates of change in environmental intensity by pledge strength. (Version without controls or fixed effects.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016	0.00324	-0.00600	0.0463	0.0260
	(0.0137)	(0.00732)	(0.0377)	(0.0147)
Strong pledge	-0.0772**	-0.0372*	0.00147	-0.000668
	(0.0145)	(0.0143)	(0.0413)	(0.0201)
Post 2016 x strong pledge	0.00152	0.00680	-0.0907	-0.0368
	(0.0145)	(0.00959)	(0.0449)	(0.0150)
Constant	0.162***	0.127***	0.177***	0.126***
	(0.0105)	(0.0167)	(0.0245)	(0.0163)
Observations	13491	4890	504	340
R^2	0.017	0.005	0.009	0.002
Fixed Effects	NA	NA	NA	NA
Cluster	Region	Region	Region	Region

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.2: Difference-in-difference estimates of change in environmental intensity by pledge strength. (Version with controls and without fixed effects.)

	(1) All Un-W	(2) No Miss Un-W	(3) All W	(4) No Miss W
Post 2016	0.00222	-0.00614	0.0462	0.0257
	(0.0129)	(0.00783)	(0.0293)	(0.0188)
Strong pledge	-0.0716***	-0.0433**	0.0482	-0.0678
	(0.00911)	(0.00865)	(0.0360)	(0.0726)
Post 2016 x strong pledge	0.00147	0.00613	-0.0988	-0.0390
	(0.0144)	(0.00947)	(0.0420)	(0.0160)
Government effectiveness	-0.0116	-0.0316	-0.0552	-0.0709
	(0.0397)	(0.0252)	(0.0748)	(0.0676)
Natural log of GDP per capita (USD)	-0.0114	0.0107	-0.0192	0.0402
	(0.0247)	(0.0186)	(0.0451)	(0.0627)
Natural log of population	-0.00638	-0.0139	-0.0283	-0.0577*
	(0.00356)	(0.00776)	(0.0217)	(0.0198)
Constant	0.409	0.317	0.873	0.829*
	(0.250)	(0.294)	(0.410)	(0.256)
Observations	13491	4890	504	340
R^2	0.020	0.011	0.047	0.196
Fixed Effects	NA	NA	NA	NA
Cluster	Region	Region	Region	Region

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.3: Difference-in-difference estimates of change in environmental intensity by pledge strength. (Version without controls and with fixed effects for year and company/country.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016 x strong pledge	-0.00353	0.00680	-0.0866**	-0.0368**
	(0.00429)	(0.00599)	(0.0298)	(0.0118)
Constant	0.113***	0.0973***	0.190***	0.133***
	(0.00127)	(0.00180)	(0.00861)	(0.00351)
Observations	13098	4890	502	340
R^2	0.888	0.879	0.702	0.951
Fixed Effects	Company, Year	Company, Year	Country, Year	Country, Year

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5.4: Difference-in-difference estimates of change in environmental intensity by pledge strength. (Version with controls and fixed effects for year and company/country.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016 x strong pledge	-0.00578	-0.000732	-0.0710*	-0.0358**
	(0.00490)	(0.00687)	(0.0315)	(0.0129)
Government effectiveness	0.0195	0.0198	-0.0549	0.0178
	(0.0107)	(0.0141)	(0.0630)	(0.0248)
Natural log of GDP per capita (USD)	-0.0841***	-0.0959***	-0.174*	-0.0415
	(0.0121)	(0.0159)	(0.0728)	(0.0303)
Natural log of population	0.361***	0.246**	0.945**	0.149
	(0.0745)	(0.0886)	(0.336)	(0.148)
Constant	-5.563***	-3.357*	-14.16*	-2.013
	(1.358)	(1.613)	(5.819)	(2.544)
Observations	13098	4890	502	340
R^2	0.888	0.880	0.714	0.951
Fixed Effects	Company, Year	Company, Year	Country, Year	Country, Year

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Overall, the difference-in-difference regressions for unweighted data specifications do not yield significant results, while regressions for weighted specification do. In contrast to the unweighted regressions, the weighted regressions indicate that firms in countries with strong pledges significantly reduced their production intensities after the Paris Agreement relative to firms in countries with weak pledges. These results reveal that larger firms are more responsive to Paris Agreement pledges than smaller firms. In the weighted regressions, firms with larger sales revenues are weighted more heavily than firms with smaller revenues, and are thus driving the reductions in environmental intensities observed in the weighted regressions. This is consistent with research suggesting that a small number of the world's largest firms are responsible for the bulk of global emissions.[3]

The dynamic of significant results in weighted regressions but not unweighted regressions can be seen in Figure 5.2 and Table 5.5. In Figure 5.2, the weighted regressions show reductions in fitted values after 2016 for firms in countries with strong pledges.[1] These reductions are larger for the specification with all data compared to the subset with only firms without missing data. In Table 5.5, it is evident that firms' environmental intensities remain fairly stable across the pre and post periods for the unweighted groups but not for the weighted groups. In the weighted groups, firms in countries with weak pledges see large increases in mean intensities across periods while firms in countries with strong pledges see large decreases in intensities. Both Figure 5.2 and Table 5.5 also reveal that the larger firms driving the results for the weighted group also have greater environmental intensities, on average, than smaller firms. Thus, the large firms that see the greatest reductions in intensities after the Paris Agreement are also the ones in greatest need of those reductions.

[1]Higher fitted values indicate greater environmental damages per dollar of sales revenues (e.g., a value of 0.15 would mean that for every dollar of sales revenue, a firm causes 15 cents of environmental damages).

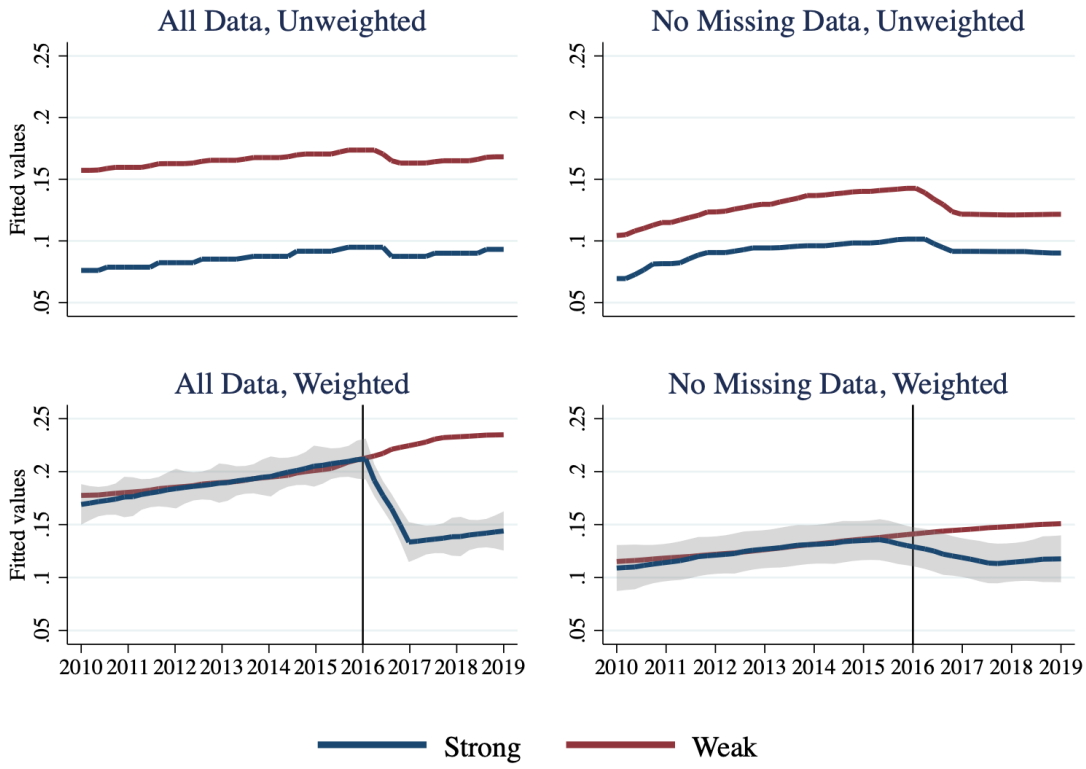


Figure 5.2: Fitted values for difference in environmental intensities by pledge strength using difference-in-difference regression with controls and year fixed effects.

Note: The Paris Agreement was adopted in December 2015 and entered into force on November 2016. In this study's difference-in-difference analyses, 2016 is considered the last year of the "pre" period, and 2017 is the beginning of the "post" period.

Table 5.5: Mean environmental intensity of production across pre-2016 and post-2016 periods, by pledge strength.

	All Un-W		No Miss Un-W		All W		No Miss W	
Environmental Intensity	**Weak Pledge**	**Strong Pledge**	**Weak Pledge**	**Strong Pledge**	**Weak Pledge**	**Strong Pledge**	**Weak Pledge**	**Strong Pledge**
Pre-2016	0.162	0.085	0.127	0.090	0.177	0.179	0.126	0.125
Post-2016	0.165	0.090	0.121	0.091	0.224	0.134	0.152	0.114
Difference	0.003	0.005	-0.006	0.001	0.047	-0.045	0.026	-0.011

5.0.2 Determinants of Countries' Paris Agreement Pledge Strengths

The next analysis runs two linear probability models using country-level data to test the hypothesis that countries with strong Paris Agreement pledges are likely to have more effective governance, higher GDP, lower GHG emissions, and stronger environmental performance at the time of signing than countries with weak pledges. The first model examines the relationship between a country's decision to sign a strong climate pledge and their measures of government effectiveness, GDP, and GHG emissions. The second model examines the relationship between a country's decision to sign a strong climate pledge and its overall climate performance, measuring using CCPI.

Both models are run on two datasets: a full dataset containing all analyzed countries, and a subset containing only countries with at least one firm with complete data for 2010 to 2019. The results for these analyses are reported in Table 5.6. As hypothesized, higher GDP, lower GHG emissions, and stronger environmental performance at the time of signing are positively associated with the probability of a country's decision to make a strong climate pledge. The last variable, governance, confirms or rejects the hypothesis based on the employed dataset. While governance is positively correlated with the decision to make a strong climate pledge in the full dataset, it is negatively correlated with the decision to make a strong climate pledge in the dataset removing countries without at least one firm with complete data.

In the first set of regressions (columns (1) and (2) in Table 5.6), higher GDP is associated with a higher probability of making a strong climate pledge, while higher GHG emissions are associated with a lower probability of making a strong climate pledge as predicted. A 10% increase in GDP per capita is associated with a 3.2 percentage point increase in the probability of making a strong climate pledge for the

full dataset, and a 4.8 percentage point increase for the dataset with only firms with non-missing data. For GHG emissions per capita, a 10% increase is associated with a 2.9 percentage point decrease in the probability of making a strong climate pledge for the full dataset, and a 1.8 percentage point decrease for the dataset with only firms with non-missing data.

In contrast to GDP and GHG, the relationship between government effectiveness and pledge strength differs by data specification. A one unit increase in government effectiveness, the equivalent of moving from India's level of government effectiveness to Portugal's, is associated with a 10 percentage point increase in the probability of making a strong climate pledge for the dataset comprised of all analyzed countries, and a 22 percentage point decrease in the probability of making a strong climate pledge for the data subset comprised of only countries with at least one firm with complete data for all years. The large difference in estimated effect sizes and directions may be explained by the fact that countries in the No Miss W dataset have much higher levels of governance and less variation in governance than countries in the All W data specification (see Table 4.2). Singapore and the U.S., which have high levels of governance but made weak climate pledges, also have a larger influence on results in the No Miss W dataset and may be driving the negative relationship between governance and pledge strength observed in the regression using this dataset.

The second set of regressions (columns (3) and (4) in Table 5.6) reveals that a country's aggregate climate change performance, expressed as CCPI scores—an aggregate measure of country-level emissions, emissions development, renewable energy, efficiency, and policy—is an important predictor of its decision to make a strong climate pledge. A 10 unit increase in CCPI, the equivalent of moving from Romania's level of performance to Finland's, is associated with a 17.3 percentage point increase in the probability of making a strong climate pledge for the full dataset, and a 11.3

percentage point increase for the data subset containing only firms with non-missing data.

Table 5.6: Linear probability estimates for factors contributing to the decision to make a strong climate pledge.

	(1)	(2)	(3)	(4)
	All W	No Miss W	All W	No Miss W
Government effectiveness	0.100	-0.221		
	(0.0941)	(0.194)		
Natural log of GDP per capita (USD)	0.320*	0.484*		
	(0.101)	(0.151)		
Natural log of GHG emissions per capita (kt of CO2 equivalent)	-0.288	-0.176		
	(0.136)	(0.0999)		
Climate Change Performance Index			0.0173	0.0113
			(0.00830)	(0.00550)
Constant	-4.041*	-4.760*	-0.301	0.109
	(1.486)	(1.503)	(0.343)	(0.225)
Observations	59	33	47	32
R^2	0.404	0.441	0.120	0.058
Cluster	Region	Region	Region	Region

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Chapter 6

Conclusion

In December 2015, countries across the globe signed the Paris Agreement, committing them to climate pledges with the goal of collectively reducing their emissions enough to limit global temperature rises to no more than 2°C, and preferably below 1.5°C, relative to pre-industrial levels in order to avoid the most severe impacts of climate change.[2] To meet their targets, countries need to collectively reduce their total emissions 45% by the year 2030 and reach net zero emissions by 2050.[13] Given that corporations are the primary emissions producers, it is necessary to understand if, and how, the Paris Agreement is impacting corporate behavior. This study expands the climate pledge literature by using a series of analyses to examine the impact of countries' Paris Agreement pledges on firms' pollution production decisions, as measured by their environmental intensities of production.

The first analysis uses difference-in-difference regressions to measure the impact of Paris Agreement pledge strengths on firm-level environmental production intensities, and finds that, on average, firms in countries with strong pledges reduced their environmental intensities 3.6 to 9.9 cents after the Paris Agreement compared to firms in countries with weak pledges. This result is sensitive to data specifications; significant results are found for data specifications where firms are weighted by sales revenues but not for specifications where firms are weighted equally. This finding reveals that larger firms are more responsive to country-level climate pledges than smaller firms,

which is important given that the data indicates that larger firms also tend to produce more environmental damages per dollar of revenue than smaller firms.

The second analysis uses linear probability models to test how countries' government effectiveness levels, GDPs, GHG emissions, and overall climate performance impacted their decisions to make a stronger or weaker climate pledge in 2015. I find that higher GDP, lower GHG emissions, and stronger environmental performance at the time of signing are predictive of a country's decision to make a strong climate pledge, with the effect of governance dependent on the data specification. Governance is positively correlated with the decision to make a strong climate pledge in the full dataset, but is negatively correlated with the decision to make a strong climate pledge in the dataset removing countries without at least one firm with complete data. Differences between datasets are likely the result of the greater influence of Singapore and the U.S. in the second dataset, which both have high levels of governance but made weak climate pledges.

This study provides suggestive evidence that Paris Agreement pledges are successfully influencing large firms to reduce their emissions, but are failing to influence smaller ones. It also reveals small effect sizes, even for analyses weighting by firm size. To avoid the worst impact of climate change, firms will need to reduce their environmental impacts by more than a few cents per dollar of sales revenues. This study's results are consistent with previous research suggesting that pledges do influence firms' behavior, but that pledges will be insufficient on their own to combat climate change. It is important for policymakers to consider policy alternatives or supplemental actions to international climate agreements to limit climate change, especially for smaller firms who may lack the knowledge, resources, or capacity to reduce their environmental intensities without an economic incentive to do so. UN projections indicate that global temperatures will reach 3.2°C above pre-industrial average by

the end of the century based on countries' current commitments—far exceeding Paris Agreement targets of below 2°C, and preferably below 1.5°C.[1]

6.1 Limitations and Suggestions for Future Research

This study has several limitations that impact the scope of the analyses performed and introduce potential concerns for external validity.

This study's primary limitation is the large amount of missing data in the datasets used for its analysis. The full dataset contains firm-level emissions for 2,401 firms in 61 countries over the period from 2010 to 2019, but only 489 firms in 34 countries have complete data for all years. The results are sensitive to this lack of data, as findings in both sets of analyses differ depending on whether firms with missing data are included or excluded. In addition to the missing data for the firms included in the analysis, the source for the firms and countries in my analysis, Harvard Business School's impact-weighted accounts dataset, is not comprehensive of firms, and thus the firms contained in the dataset may not be representative of all firms. This study's results may have limited external validity depending on how representative the firms it examines are in relation to the global market.

This study's second limitation is that it lacks data on updated Paris Agreement pledges, and on long-term impacts of these pledges. The analyses in this study rely on Watson et al (2019)'s assessment of countries' original pledges from 2015. This data does not account for countries' updates to their NDCs since the original agreement in 2015. At COP26 in Glasgow in 2021, countries offered enhanced or new NDCs, which researchers Ou et al (2021) found to be more ambitious than countries' original 2015 pledges.[43] Similarly, the main outcome variable in the analyses, firm-level production intensity, is only available through 2019 in the Harvard Business School dataset. This

means differences in environmental intensity by pledge strength can only be observed over the first few years after the Paris Agreement. Long-term effects will not be visible in the results. This study should be updated over the coming years to account for enhanced NDCs and to examine the impact of pledge strength on firms' production intensities over a longer time horizon than just the first few years since the Paris Agreement.

Finally, while this study examines data on country-level climate commitments in the form of Paris Agreement pledges, it does not examine the impact of firm-level climate commitments on firm-level production intensities. It also does not examine the impact of country- or firm-level policy change on firm-level production intensities. Firm-level climate commitments and country- or firm-level policy changes could all be important mechanisms for the impact of pledge strength on firm-level production intensities, and should be explored in future research.

Appendix

Auxiliary Difference-in-Difference Regression Results

Table A.1: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firm-year observations with environmental damages. (Version without controls or fixed effects.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016	0.00593	-0.00930	0.0486	0.0346
	(0.0148)	(0.00824)	(0.0395)	(0.0149)
Strong pledge	-0.0809**	-0.0505**	0.0138	-0.00542
	(0.0165)	(0.0124)	(0.0415)	(0.0207)
Post 2016 x strong pledge	-0.000962	0.00893	-0.0981	-0.0474*
	(0.0159)	(0.00964)	(0.0476)	(0.0149)
Constant	0.172***	0.144***	0.181***	0.134***
	(0.0108)	(0.0137)	(0.0234)	(0.0181)
Observations	13131	4778	501	340
R^2	0.021	0.009	0.009	0.005
Fixed Effects	NA	NA	NA	NA
Cluster	Region	Region	Region	Region

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.2: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firm-year observations with environmental damages. (Version with controls and without fixed effects.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016	0.00416	-0.0103	0.0488	0.0336
	(0.0139)	(0.00860)	(0.0317)	(0.0161)
Strong pledge	-0.0738***	-0.0548**	0.0655	-0.0718
	(0.00998)	(0.00808)	(0.0414)	(0.0758)
Post 2016 x strong pledge	-0.000716	0.00897	-0.103	-0.0495*
	(0.0163)	(0.00944)	(0.0455)	(0.0141)
Government effectiveness	-0.0210	-0.0368	-0.0597	-0.0791
	(0.0431)	(0.0304)	(0.0778)	(0.0690)
Natural log of GDP per capita (USD)	-0.00541	0.0170	-0.0203	0.0463
	(0.0249)	(0.0210)	(0.0442)	(0.0637)
Natural log of population	-0.00658	-0.0126	-0.0291	-0.0558*
	(0.00397)	(0.00730)	(0.0201)	(0.0204)
Constant	0.372	0.249	0.903	0.751*
	(0.256)	(0.306)	(0.386)	(0.267)
Observations	13131	4778	501	340
R^2	0.024	0.015	0.049	0.193
Fixed Effects	NA	NA	NA	NA
Cluster	Region	Region	Region	Region

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.3: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firm-year observations with environmental damages. (Version without controls and with fixed effects for year and company/country.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016 x strong pledge	-0.0000183	0.0115*	-0.0999***	-0.0474***
	(0.00376)	(0.00563)	(0.0297)	(0.0115)
Constant	0.120***	0.102***	0.202***	0.140***
	(0.00112)	(0.00170)	(0.00846)	(0.00343)
Observations	12751	4777	499	340
R^2	0.913	0.894	0.713	0.954
Fixed Effects	Company, Year	Company, Year	Country, Year	Country, Year

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.4: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firm-year observations with environmental damages. (Version with controls and fixed effects for year and company/country.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016 x strong pledge	-0.00403	0.00363	-0.0851**	-0.0494***
	(0.00430)	(0.00645)	(0.0315)	(0.0126)
Government effectiveness	0.0104	0.0192	-0.0570	-0.0150
	(0.00943)	(0.0132)	(0.0625)	(0.0244)
Natural log of GDP per capita (USD)	-0.0872***	-0.0903***	-0.174*	-0.0159
	(0.0106)	(0.0149)	(0.0721)	(0.0297)
Natural log of population	0.318***	0.191*	0.898**	0.0192
	(0.0658)	(0.0828)	(0.339)	(0.145)
Constant	-4.737***	-2.413	-13.35*	-0.00825
	(1.200)	(1.506)	(5.878)	(2.496)
Observations	12751	4777	499	340
R^2	0.913	0.896	0.724	0.954
Fixed Effects	Company, Year	Company, Year	Country, Year	Country, Year

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.5: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firms with environmental damages for all observed years. (Version without controls or fixed effects.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016	0.00735	-0.00477	0.0469	0.0227
	(0.0160)	(0.00550)	(0.0398)	(0.0165)
Strong pledge	-0.0792**	-0.0450	0.00623	-0.0286
	(0.0190)	(0.0206)	(0.0429)	(0.0294)
Post 2016 x strong pledge	-0.00136	0.00521	-0.0945	-0.0345
	(0.0164)	(0.00679)	(0.0469)	(0.0163)
Constant	0.171***	0.140**	0.188***	0.155**
	(0.0140)	(0.0215)	(0.0268)	(0.0299)
Observations	12649	4540	497	340
R^2	0.020	0.007	0.008	0.010
Fixed Effects	NA	NA	NA	NA
Cluster	Region	Region	Region	Region

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.6: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firms with environmental damages for all observed years. (Version with controls and without fixed effects.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016	0.00553	-0.00404	0.0458	0.0215
	(0.0150)	(0.00613)	(0.0313)	(0.0209)
Strong pledge	-0.0716***	-0.0500**	0.0580	-0.0907
	(0.0105)	(0.00884)	(0.0350)	(0.0857)
Post 2016 x strong pledge	-0.00129	0.00362	-0.0996	-0.0368
	(0.0168)	(0.00649)	(0.0433)	(0.0172)
Government effectiveness	-0.0205	-0.0321	-0.0613	-0.0852
	(0.0428)	(0.0304)	(0.0761)	(0.0676)
Natural log of GDP per capita (USD)	-0.00962	0.00518	-0.0213	0.0478
	(0.0244)	(0.0208)	(0.0455)	(0.0623)
Natural log of population	-0.00802	-0.0159	-0.0321	-0.0548
	(0.00410)	(0.00798)	(0.0201)	(0.0216)
Constant	0.440	0.423	0.974*	0.743*
	(0.252)	(0.313)	(0.341)	(0.269)
Observations	12649	4540	497	340
R^2	0.025	0.016	0.050	0.186
Fixed Effects	NA	NA	NA	NA
Cluster	Region	Region	Region	Region

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.7: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firms with environmental damages for all observed years. (Version without controls and with fixed effects for year and company/country.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016 x strong pledge	-0.00282	0.00521	-0.0909**	-0.0345**
	(0.00382)	(0.00564)	(0.0312)	(0.0113)
Constant	0.120***	0.104***	0.204***	0.142***
	(0.00114)	(0.00170)	(0.00890)	(0.00335)
Observations	12280	4540	495	340
R^2	0.913	0.899	0.704	0.958
Fixed Effects	Company, Year	Company, Year	Country, Year	Country, Year

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A.8: Difference-in-difference estimates of change in environmental intensity by pledge strength, including only firms with environmental damages for all observed years. (Version with controls and fixed effects for year and company/country.)

	(1)	(2)	(3)	(4)
	All Un-W	No Miss Un-W	All W	No Miss W
Post 2016 x strong pledge	-0.00697	-0.00392	-0.0796*	-0.0334**
	(0.00438)	(0.00646)	(0.0332)	(0.0123)
Government effectiveness	0.00830	0.0113	-0.0658	0.0148
	(0.00961)	(0.0132)	(0.0656)	(0.0238)
Natural log of GDP per capita (USD)	-0.0871***	-0.0917***	-0.175*	-0.0199
	(0.0107)	(0.0148)	(0.0756)	(0.0290)
Natural log of population	0.311***	0.175*	0.791*	0.0789
	(0.0670)	(0.0822)	(0.355)	(0.141)
Constant	-4.606***	-2.096	-11.53	-1.020
	(1.222)	(1.495)	(6.171)	(2.434)
Observations	12280	4540	495	340
R^2	0.913	0.900	0.714	0.958
Fixed Effects	Company, Year	Company, Year	Country, Year	Country, Year

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

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