Do Investors Reward Countries for Participating in Climate Agreements?

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Research Article

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Abstract

Yes. The reward is a decline in sovereign bond yields of countries that commit to reducing greenhouse gas emissions under a climate agreement. This decrease is likely due to climate-aware investors incentivizing governments for such climate-friendly decisions. Transition and regulatory climate risks are expected to increase after signing a climate agreement, so they cannot explain a decrease in yields. Exposures to physical climate risks play a role, but their effect is weaker than the incentive effect. Overall, our findings suggest that climate-aware investors are nudging governments to cooperate in international climate agreements.

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1 Introduction

Describing his Nobel prize-winning contributions, Nordhaus (2019) refers to climate change as ‘the ultimate challenge for economics’. He explains the well-known economic reasons why individual investors and consumers are unable to solve the problem of climate change via utility maximization and trading: markets fail to address climate change because our planet’s climate is a public good. This feature creates, perhaps, the most consequential global negative externality where market prices do not include information on how countries, investors, and consumers should optimally share the Earth’s climate. In the absence of informative market prices, dealing with such global externalities typically requires concerted action by major countries; one of the best ways we know to address global climate externalities is through international climate agreements (Nordhaus, 2019). For example, the Montreal Protocol is credited with successfully limiting the use of ozone-killing chlorofluorocarbons (Velders et al., 2007; Morgenstern et al., 2008).

Participating in a well-designed climate agreement is typically a decision by governments concerned about climate change and its impact on the welfare of current and future generations. However, various myopic concerns – political and economic – may influence government choices away from the welfare-maximizing choice. To nudge governments toward climate action, do investors reward governments for participating in climate agreements? In this paper, we study this question by analyzing whether investors provide market-based incentives to governments as rewards for participating in climate agreements.

The use of the fundamental force of financial incentives for shaping environmentally-friendly behavior has been documented for individuals and firms (Pastor et al., 2021a; Pedersen et al., 2021; Pastor et al., 2021b; Baker et al., 2020; Azar et al., 2021); but not for influencing governments’ climate policies. To assess whether there is evidence for such incentives, we study whether the costs of capital (sovereign yields) of participating countries decrease after two landmark climate agreements – the Kyoto Protocol and the
Paris Agreement, thereby rewarding governments for their commitment to reducing carbon emissions.

Well-aligned government incentives are crucial as addressing climate change externalities lies more within the government’s domain of managing the public good. Climate agreements help governments coordinate with each other on dimensions such as regulations, emission fines, carbon prices, and green technology. In addition, they help investors coordinate and incorporate climate considerations into asset prices by creating a pool of capital dedicated to financing climate-friendly governments and firms. For example, the United Nations convened the Net Zero Asset Managers alliance, to invest trillions of dollars of assets in accordance with the goals of the Paris Agreement.\(^1\) Thus, climate agreements can facilitate a financial market-based approach to internalizing climate-related global externalities (Hart and Zingales, 2017; Chowdhry et al., 2019; Baker et al., 2020).

A country’s sovereign bond yield is a natural asset for investors to choose when providing “climate aware” incentives to governments.\(^2\) Anecdotal evidence suggests that sovereign bond investors, such as central banks and sovereign wealth funds, use such climate change scenarios to determine the cost of capital for a sovereign bond. So, we focus our study on the sovereign bond.

With this motivation, we ask a novel empirical question: do sovereign yields change after climate agreements so that they reward countries for participating in the agreement? Using a difference-in-differences approach, we examine changes in sovereign yields of a cross-section of countries around the finalization of a climate agreement. Before and after this event, we compare the sovereign bond yields of countries making more significant climate commitments to those making weaker commitments.

The Kyoto Protocol was adopted in 1997 and introduced formally in February 2005.

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\(^1\)The Net Zero Asset Managers alliance supports investing aligned with the goal of net-zero greenhouse gas emissions by 2050 or sooner, in line with global efforts to limit warming to 1.5 degrees Celsius. As of 2021, it has 220 signatories with 57 trillion dollars in assets under management.

\(^2\)Sovereign bond yields are important considerations for governments as they affect governments’ ability to borrow and fund their respective countries’ (potentially greener) future growth. So, for governments undertaking a cost-benefit analysis of entering into climate agreements, it is fundamental to understand the impact of joining on their sovereign yields.
It places a higher burden on a subset of countries called Annex-I countries to reduce greenhouse gas (GHG) emissions, with significant penalties for missing emission reduction targets. For the Kyoto Protocol, we look at the difference between yields of sovereign bonds issued by Annex-I and Non Annex-I countries before and after the finalization of the agreement.

We find a significant decrease of approximately 14.0 basis points in Annex-I countries’ 10-year term spreads after ratifying the Kyoto Protocol. This decline, equivalent to 2.7 percent of the sample mean yield of 5.2 percent on a 10-year government bond, is economically significant, given the typical magnitudes of government debt: even a small decrease (increase) in yields implies considerable dollar savings (costs).

We also analyze the Paris Agreement adopted in 2015 by 192 countries, where countries pledged different GHG reduction targets. Due to the widespread adoption of the agreement, the difference between participating and non-participating countries is less well-defined for the Paris agreement. So instead, we look at the difference in sovereign bond yields between country groups with high and low goals to reduce GHG emissions. After countries sign and pledge GHG reduction targets under the Paris agreement, we again find a decrease in yields of sovereign bonds issued by countries with relatively intense reduction targets. The magnitude of this decline is about 2 basis points, implying that investors marginally reduced the cost of capital they require from countries willing to cooperate and do more to achieve climate goals.

We attribute the reduction in yields after climate agreements to investors rewarding countries that commit to reducing GHG emissions. This evidence is consistent with investor tastes for positive climate outcomes (Pastor et al., 2021a; Pedersen et al., 2021; Baker et al., 2020). As Pastor et al. (2021b) show, the taste motive allows two sovereign bonds, which are nearly identical in terms of risk, to trade at different prices because one is climate-friendly or ‘green’ and so climate-aware investors are willing to pay a premium price for it - the greenium. Our findings suggest that climate-aware preferences can influence the asset prices of much more liquid and heavily traded regular sovereign bonds, not just niche green sovereign bonds issued by select countries.
In addition to investor tastes, other forces influence the pricing of sovereign bonds around the finalization of climate agreements. For example, climate agreements imply changes in physical and regulatory climate risks. In our empirical analysis, we also analyze whether such alternative mechanisms subsume the effect of the tastes channel.

A successful climate agreement should lead to a global reduction in physical risks, but a country’s exposure to these physical risks is not directly related to its efforts in reducing carbon emissions (climate action involves externalities). Nevertheless, we allow for geographic differences in physical risk exposures to contribute to changes in sovereign yields for a country after becoming a signatory to a climate agreement. We measure physical risk exposures using projected temperature anomalies for a country under various emissions scenarios from World Bank’s Climate Change Knowledge Portal (CCKP). We find that the decline in yield is subdued for countries with the highest physical risk exposures.

This result shows that while climate-aware investors, on average, reward countries that commit more under a climate agreement, the net effect is concentrated in countries with lower physical climate risk exposures. This also suggests that investors are not substantially reducing the physical climate risks projection for high exposure countries after climate agreements are finalized. We conclude that the physical risk channel is not driving our results, and the tastes channel has stronger empirical support.

Other climate-related risks that change with climate agreements are transition risks and regulatory risks. Transition risks stem from disruption when transitioning to greener from dirtier technologies. Regulatory risks are associated with new penalties for firms based on their GHG emissions. The literature suggests that transition and regulatory climate risks have started materializing (Krueger et al., 2020; Stroebel and Wurgler, 2021; Bolton and Kacperczyk, 2022b) and are influencing asset prices for high-emissions firms: their stock returns (Bolton and Kacperczyk, 2021), options (Ilhan et al., 2021), and corporate bonds (Seltzer et al., 2020). After a climate agreement takes effect, transition and regulatory risks are expected to intensify, especially for countries participating in the agreements. An increase in transition and regulatory risks predicts
that risk-averse investors should demand higher sovereign bond yields to hold participating country sovereign bonds. However, we observe a decrease on average. So an increase in transition and regulatory risks do not seem to be driving our results either.

Long-run investors who perceive such consequential climate change risks should naturally try to hedge them, not just avoid them (Bansal and Yaron, 2004; Bansal et al., 2020; Baker et al., 2020). In other words, investors should not only underweight assets exposed to climate risks but also try to find hedging assets that give high payoffs when physical climate risks are particularly severe. Assets that hedge long-run climate-related risks should carry a premium; if long-run climate risks decrease, then this premium should decrease. We do not find significant evidence for the climate risk hedging incentive changing after climate agreements.

Overall, our findings suggest an important role for the climate tastes of investors rewarding cooperating countries. The evidence indicates that climate-aware preferences are becoming a positive and encouraging force in financial markets; they nudge governments to enact regulations that, in turn, nudge firms to reduce GHG emissions (Bolton and Kacperczyk, 2021; Ilhan et al., 2021; Seltzer et al., 2020; Bolton and Kacperczyk, 2022a). Together, the evidence suggests that governments and markets are starting to act as checks and balances for each other in global efforts to address climate change. To the best of our knowledge, this paper is the first to highlight how markets can be used to reward individual governments for globally beneficial behavior.

2 Data Description

The data on monthly 10-year sovereign bond yields are from the Refinitiv Datatabase. All data relating to the Kyoto Protocol (reduction targets and ratification dates) are from the website of the United Nations Framework Convention on Climate Change (UNFCCC). The pledged reduction targets’ data under the Paris Agreement are sourced from the Carbon Brief.

The Kyoto sample consists of 25 Annex-I countries, namely, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ire-
land, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Russia, Slovakia, Spain, Sweden, Switzerland, and the UK. Non Annex-I countries in the sample are Australia, Israel, Malaysia, Philippines, South Africa, South Korea, Tanzania, Thailand, and the US. The Kyoto sample period spans 60 months, starting in November 2000. As shown in Panel (a) of Exhibit 1, a 10-year government bond in our sample has an average yield of approximately 5.2 percent. The yield on a 10-year government bond averages lower for the Annex-I sample (4.7 percent) than the Non Annex-I sample (6.8 percent) because a majority of the Annex-I sample corresponds to developed countries.

[Insert Exhibit 1 Here]

For analyses focusing on the Paris agreement, we utilize Carbon Brief data that provide information on pledged reduction targets, target years, and reference years. This information is sourced from countries’ Intended Nationally Determined Contributions (INDCs). We standardize emission reduction targets based on 2005 as the reference year for all countries to minimize the effect of varying reference years across countries. Next, we divide these countries into high and low groups based on the yearly reduction required to reach the target level of emissions by the target year from 2014’s emission levels.

Specifically, high reduction target group includes Australia, Belgium, Canada, Czech Republic, Denmark, Finland, Germany, Iceland, Ireland, Lithuania, Luxembourg, Netherlands, Norway, Poland, Russia, Slovakia, Switzerland, the UK, and the USA. The low reduction target group includes Austria, Brazil, Chile, China, France, Hungary, India, Indonesia, Israel, Italy, Japan, Latvia, Malaysia, New Zealand, Portugal, Slovenia, Spain, and Sweden. In addition, five countries, Colombia, Philippines, South Africa, South Korea, Tanzania, and Thailand, use subjective reference level emissions. We cannot calculate the emissions reduction required per year for these countries. We allocate these countries to the low reduction target group. The sample period spans 33 months, starting
in February 2014 and ending in October 2016. The average yields for the overall sample, high and low reduction target countries are 3.3, 1.9, and 4.4 percent, respectively.

The country-level historical and projected temperature data over 95 years (2006 - 2100) are from the World Bank Group’s Climate Change Knowledge Portal (CCKP). The projected temperature data are from the Coupled Model Intercomparison Project - Phase 5 (CMIP5) ensemble under four representative concentration pathways (RCPs): RCP2.6, RCP4.5, RCP6.0, and RCP8.5. The annual CO₂ emissions data (available from the early 1800s to 2020) and fossil fuel consumption per capita data (1965-2019) are from Our World in Data. We source data on the GDP per capita, GDP growth, foreign reserves (net of gold) as a percentage of GDP, and inflation rate from the World Bank Group’s World Development Indicators (WDI) database. We use these variables are control variables in some tests. Our measure of risk-free rate is one month US Treasury Bill. These data are from Ken French’s website.

3 Empirical Results

3.1 Kyoto Protocol and Sovereign Bond Yields

3.1.1 Baseline

Towards the end of October 2004, the Kyoto Protocol’s future was unclear because it failed to meet the two conditions, which, en masse were necessary for its introduction. The Protocol required ratification by 55 nations, accounting for at least 55 percent of the world’s GHG emissions (based on 1990 emissions levels). According to some reports, in a somewhat surprising move, the European Union withdrew its objections to Russia joining the World Trade Organization (WTO) in exchange for Russia’s ratification of the Protocol. The Kyoto Protocol came into force 90 days after Russia’s ratification, meeting the two necessary conditions before it could come into effect on 16 February 2005.
First, we present our results non-parametrically by separating Annex-I and Non Annex-I countries in Panel (a) of Exhibit 2, which presents the mean yield on a 10-year government bond for two groups of countries. The aggregate trends illustrate how investors reward countries committed to reducing emissions under the Kyoto Protocol and provide support to our identification strategy. The trend in yields of Annex-I and Non Annex-I countries is similar before the EU countries ratified the Kyoto Protocol in May 2002. Second, there is a divergence in these trends after the EU countries’ ratification that cannot be attributed to preexisting differential trends. This divergence in yields due to the ratification of the Kyoto Protocol can be estimated as a double difference, i.e., the difference in yields of Annex-I and Non Annex-I countries after the ratification less the difference between the two before the event.

[Insert Exhibit 2 Here]

Next, we use the difference-in-differences (DiD) approach using countries’ staggered ratification of the Kyoto Protocol. In our sample, the first (Czech Republic) and last (Russia) ratification of the Kyoto Protocol took place in 2001:M11 and 2004:M11, respectively. Our sample period starts 12 months before Czech Republic’s ratification and ends 12 months after Russia’s ratification (including November 2004), implying a sample period length of 60 months, starting in November 2000. Our DiD specification takes the following form:

\[
y_{cmt} = \beta_0 + \beta_1 (\text{Annex-I}_c \times \text{Ratification}_{cmt}) + \Gamma' \text{Controls} + \text{Country}_c + \text{Time}_{mt} + u_{cmt}. \tag{1}
\]

In equation (1), subscripts \(c\), \(m\), and \(t\) represent the county, month, and year, respectively. \(y_{cmt}\) represents the yield on a 10-year government bond in excess of the 1-month US treasury bill rate. The coefficient of interest, \(\beta_1\), captures the change in yield on a sovereign bond issued by Annex-I countries relative to that for Non Annex-I coun-

with the 44.2 percent of 1990 emissions accounted for, by countries that have already ratified the treaty, Russia’s ratification of the Protocol fulfilled the requirements for the agreement to be legally binding for the Annex-I countries.
tries from before to after the ratification of the Kyoto Protocol. We present coefficient estimates in Panel (b) of Exhibit 2.

The results indicate that sovereign bonds of Annex-I countries exhibit a decline in yields after ratifying the Kyoto Protocol. In Model 1, we include lagged dependent (yield) as a control variable. Quantitatively, the economic size (-0.14) on the double interaction term implies a decline of approximately 14.0 basis points in yield on 10-year government bonds issued by Annex-I countries. This decline is equivalent to approximately 2.7 percent of the average yield in our sample.

In Model 2, we augment Model 1 with macroeconomic control variables, namely GDP per capita, GDP growth, foreign reserves (net of gold) as a percentage of GDP, and inflation rate. The key coefficient retains significance and implies a decline of 0.15 percent, representing 2.9 percent of our sample’s average yield on a 10-year government bond. Note that, in the presence of the lagged dependent variable, the macroeconomic control variables have a marginal impact on the key coefficient estimate and R-squared. Therefore, in the following sections, we present results with only lagged dependent as the only control variable.

In unreported results, we conduct two placebo tests. First, we exclude EU constituent countries to ensure that our results are not due to the introduction of the Euro in January 1999. Here, $\hat{\beta}_1$ continues to be economically meaningful and statistically significant. Second, we apply our methodology to random dates instead of the actual ratification date. As expected in a successful placebo test, we find that $\hat{\beta}_1$ lacks statistical and economic significance in this test. Overall, the evidence presented in Panel (a) and (b) of Exhibit 2 corroborates that tastes for climate-friendly investments and investor coordination are a potential channel through which investors reward Annex-I countries for participating in the Kyoto protocol.

### 3.1.2 Physical Risk

A country’s location and physical features are important determinants of its exposure to risks posed by increasing average global temperature. According to IPCC (2001,
2012), this salient aspect alters the physical risk profile of a region because an increase in average temperature leads to abnormally hot temperature occurrences that further exacerbate impending natural disasters (Meehl et al., 2000; Folland et al., 2001; Meehl, 2007; Islam and Singh, 2021). The physical risk exposure of sovereign bonds relates to the changing distribution and exacerbation of impending natural disasters in their respective geographies. A successful climate agreement should reduce the expected pace and magnitude of global warming.

To test whether a differential in countries’ physical risk exposures leads to a differential in their reward from climate-aware investors, we use projections of temperature data from the World Bank’s Climate Change Knowledge Portal (CCKP). We measure physical risk as proportional to a temperature anomaly variable defined as follows:

\[
\text{Temperature Anomaly}_{ct}^{p} = [T_{ct}^{p} - \bar{T}_{c51-80}] \quad t = 2006, \ldots, 2100
\]  

(2)

In equation (2), \(p\) indexes an emissions pathway, \(T_{ct}^{p}\) equals the temperature projected under pathway \(p\) for country \(c\) in year \(t\), and \(\bar{T}_{c51-80}\) represents the country-specific average temperature observed over the 30 year reference period, starting in 1951 and ending in 1980.\(^5\) Next, using the average values of \(\text{Temperature Anomaly}_{ct}^{p}\) over 95 year period, starting in 2006 and ending in 2100, we divide the countries into high- and low-groups based on their respective cross-sectional median values. We create a dummy variable that equals 1 for the high temperature anomaly group and 0 otherwise.

We investigate whether differences in physical risks between the high and low temperature anomaly groups influence the change in yields after committing to a climate agreement. We present results in Panel (c) of Exhibit 2. In Model 1, the dichotomous variable \(\text{Group1}\) equals 1 (0 otherwise) for the high temperature anomaly group of countries under the RCP2.6 emissions scenario. In Models 2, 3, and 4, the dichotomous variables \(\text{Group2}, \text{Group3}, \text{Group4}\) are defined analogously for under the RCP4.5, RCP6.0, and RCP8.5 emissions scenario, respectively. The results for participating in climate

\(^{5}\) \(\bar{T}_{c51-80} = \frac{1}{30} \sum_{t=1951}^{1980} \frac{1}{12} \sum_{m=1}^{12} T_{cmt}\). The reference period (1951-1980) is in line with that used by the Goddard Institute for Space Studies (GISS) Surface Temperature Analysis.
agreements are, on average, stronger for countries with less exposure to climate risk. For the most extreme scenario, the magnitude increases from about -0.14 in the baseline results in Panel (b) to -0.27 in Panel (c). The coefficients for the triple interaction terms are positive and statistically significant. The two coefficients imply that the decrease in yield for countries from the high temperature anomaly is offset due to their relatively high physical risk exposures. The results in Panel (c) of Exhibit 2 suggest that, even at the time of the Kyoto protocol, climate-aware investors were sophisticated in evaluating physical risks and adjusted the yields of Annex-I countries with high and low physical risk exposures differently.

3.1.3 The Hedging Incentive: Invest in Carbon Intensive Countries

The results in section 3.1.1 align with the notion that, when presented with a menu of investments, climate-aware investors are likely to pick more climate-friendly investments to encourage these countries or to coordinate to solve a global externality. Distinct from these motives is the climate risk hedging motive: investors averse to climate change risk may try to find investments that will give higher returns in times when climate change is particularly severe (even though this hedging motive might imply investments in high emission countries).

Sovereign bond prices depend on the underlying economic growth rates of a country, and these growth rates, in turn, are correlated with GHG emissions.\textsuperscript{6} Given such a correlation, the sovereign bonds of carbon-intensive economies may provide economical insurance in scenarios where GHG emissions are high and, thereby, climate change risk is high. Aversion to climate-related risks in this manner creates a ‘perverse’ individual investors’ incentive to continue to fund carbon-intensive projects and governments that exacerbate climate change risks (without large-scale cooperation among investors).

This section tests for any differential reward among Annex-I countries that exhibit varying carbon intensity. Specifically, for each country, we run a time-series regres-

\textsuperscript{6}In unreported results, we confirm a historically positive correlation between economic growth, and emissions and fossil fuel usage.
sion to estimate the sensitivity of its GDP per capita to various measures of carbon intensity. Based on the cross-sectional median value of these sensitivity estimates, we divide countries into the high (> median) and low (≤ median) groups. We test for the differential effect of the Kyoto Protocol on yield among Annex-I countries and present results in Panel (d) of Exhibit 2.

In Models 1, 2, 3, and 4, the variables Group1, Group2, Group3, and Group4 are dichotomous, equalling 1 (0 otherwise) for the high carbon intensity group based on: i) CO2e emissions per capita from all sectors, ii) CO2e emissions per capita from transport sector, iii) consumption per capita (in kilowatt-hours) of fossil fuels (all types), and iv) consumption per capita (in kilowatt-hours) of coal, respectively. We find that, on average, the sovereign yield on a 10-year government bond declined by 9 to 17 basis points for Annex-I countries that exhibit low carbon intensity. The negative or insignificant (or both) coefficients suggest the absence of significant difference between high and low carbon-intensive countries within the Annex-I sample. Moreover, the triple interaction term’s coefficient is positive in all but one instance. Overall, this form of hedging against long-run climate change risks does not subsume changes to sovereign yields due to the tastes effect.

3.2 The Paris Agreement and Sovereign Bond Yields

Compared to the Kyoto Protocol, the Paris Agreement was signed by a much larger number of countries. This widespread participation however came with a cost– the incentives provided to governments to actually reduce emissions in the future are weaker.

Under the Kyoto Protocol, a subset of countries is legally required to reduce their GHG emission levels. The protocol imposes these reduction requirements on a country that promises to meet them via ratifying it. In contrast, such requirements under the Paris Agreement are voluntary. Where there are no penalties for missing endogenous emission reduction targets under the Paris Agreement, countries missing their reduction targets in the first commitment period (2008-2012) are penalized with more intense
reduction targets in the second commitment period (2013-2020) under the Kyoto Protocol.

As investors are forward-looking, we expect such weaker incentives to produce smaller impacts on sovereign bond yields.

In our empirical analysis, we divide countries into two groups based on standardized reduction targets (see section 2 for details). As per this grouping, some climate-friendly countries such as France and Sweden appear in the low reduction target group. This simply reflects that they are already doing a good job on emissions and need comparatively lower commitments to keep up with the rest of the countries. Accordingly, they might be rewarded less for participating in the Paris Agreement. In contrast, countries like Australia and USA appear in the high reduction target group because they need to do more and are committing to do so. Such commitments, if credible, should be rewarded more by climate-aware investors.

Based on the country groups mentioned above, we run a regression specification of the following form:

\[
y_{cmt} = \beta_0 + \beta_1 (\text{High Reduction Target Group}_c \times \text{Post Paris}_{cmt}) + \Gamma' \text{Controls} + \text{Country}_c + \text{Time}_{mt} + u_{cmt}.\tag{3}
\]

In equation (3), High Reduction Target Group\(_c\) equals 1 if a country \(c\) is a constituent of high reduction target group and 0 otherwise; Post Paris\(_{cmt}\) equals 1 (0 otherwise) on or after a country submits its INDCs to UNFCCC. The first (last) submission in our sample is made by Switzerland (Malaysia) in February (November) 2015, and our sample period starts 12 months before the first submission and ends 12 months after (including November 2015) after the last submission. Our sample period spans 33 months, starting in February 2014 and ending in October 2016. The fixed effects serve the same purpose as in equation (1). We present baseline analysis in Panel (a) of Exhibit 3.

We find that the sovereign bond yields decline by 0.02 percent on average for coun-
tries with more intense emissions reduction targets under their INDCs. Despite differences in the structural features of the Kyoto Protocol and the Paris Agreement, the results in Panel (a) of Exhibit 3 suggest that investors’ tastes and coordination are important channels that impact sovereign yields in the same direction after both climate agreements.

[Insert Exhibit 3 Here]

Next, we repeat our tests for the differential effect among countries in high pledged target group that are heterogeneous in their exposures to physical risks. We present these results in Panel (b) of Exhibit 3. For each RCP scenario, we divide countries into high- and low- groups based on the cross-sectional median values of average temperature anomaly estimated over 84 year period, starting in 2017. We create a dummy variable that equals 1 for the high temperature anomaly group and 0 otherwise. Despite analyzing a more recent sample period, we continue to find that, among participating countries, a differential physical risk exposure RCP6.0 (late action) and RCP8.5 (no action) scenario translates into a differential in the average reward a country receives from investors for its willingness and efforts to mitigate climate change.

In Panel (c) of Exhibit 3, we analyze whether differences in hedging climate risks lead to our results. The double and triple interaction coefficients in most specifications carry a negative sign but lag statistical significance. This evidence suggests that countries that exhibit a higher carbon intensity are also the countries that need to make larger commitments. It is challenging to differentiate between countries with a greater commitment to climate agreements from those that are bigger polluters but most willing to improve. Moreover, compliance under the Paris Agreement is voluntary, weakening climate-aware investors’ motive to reward countries that make more strict commitments to reduce emissions.

There are some differences between our results for the Kyoto Protocol and Paris Agreement. The first relates to the economic significance of key coefficients in Panel
(b) of Exhibit 2 and Panel (a) of Exhibit 3. The second difference relates to the direction of the differential implied by the coefficients on triple interaction terms in Panel (d) of Exhibit 2 and Panel (c) of Exhibit 3. There are institutional differences, which may lead to such differences, between the Kyoto Protocol and the Paris Agreement.

Additionally, differences in econometric methodology for the two sets of analysis may have a substantial effect. In the case of the Kyoto Protocol, the Annex-I group of countries is identified, and only Annex-I countries are required to reduce their GHG emissions. In contrast, nearly all countries pledge to reduce GHG emissions under the Paris Agreement; thus, we make an empirical choice to distinguish among various countries based on the reduction targets and proposed years to achieve those targets. The cumulative effect of these factors may result in the differences mentioned above.

4 Conclusion

The ethical and environmental arguments for joining global climate agreements are well known. However, the financial and economic impacts after joining have not been well studied. One of the reasons is that the real economic benefits of climate agreements will accrue for decades after the signing and are very difficult to disentangle from other events that have transpired since. In contrast to this delayed evidence, we use the fundamental premise of finance that current market prices reflect future outcomes. Using the expectations of sophisticated market participants, we can infer the market’s expectation of the benefits of joining a climate agreement ‘immediately’. Of course, market expectations change rapidly, and optimism at the time of signing an agreement can subside as its shortcomings become more apparent. Nevertheless, this experiment evaluates how investors perceived the Kyoto Protocol and the Paris Agreement when they were finalized.

We study changes in sovereign bond yields of countries participating in climate agreements. We find that, after estimating long-run costs and benefits and the environmental value of climate agreements, climate-aware investors look favorably upon countries willing to participate in them. While investors discount carbon-intensive
countries, this discount is less than the premium investors pay for joining a climate agreement. We also find that the effect is weaker for the Paris Agreement than for the Kyoto protocol. We conjecture that this might be due to weaker incentives and commitments required by the Paris Agreement. However, we leave a more careful analysis of the effects of weaker incentives for future research.

Most policy arguments to participate in climate agreements appeal to long-run planetary outcomes for future generations. However, not all governments or citizens voting for them have climate as a top priority. We provide evidence that climate-agnostic countries should also carefully consider cooperating in climate agreements or face rising costs of capital on sovereign debt. This evidence also highlights the importance of climate-aware investing. Collectively, investors can nudge reluctant governments towards enacting climate regulation. Often regulation of firms is the main lever to reduce carbon emissions. Our evidence reinforces the markets’ important role in nudging governments to enact such regulations. It suggests that those investing their savings in climate-friendly strategies are not just transferring their profits to arbitragers: sovereign bond yields are hearing their voices and relaying their tastes to governments around the world.
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Figure 1: The figure presents the average yield on a 10-year government bond. In Panel (a), the sample corresponds to the Kyoto Protocol. The sample period is from 2000:M11 to 2005:M10. In Panel (b), the sample corresponds to the Paris Agreement. The sample period is from 2014:M2 to 2016:M10.
The Kyoto Protocol

(a) Time Series of Average Yield on 10-Year Government Bond (in %)

(b) DID - Baseline

(c) Triple DID - Physical Risk

(d) Triple DID - Hedging Incentive

Figure 2: In Panel (a), the figure presents the average of 10-Year government bonds for the Annex-I and Non Annex-I countries. The reference line corresponds to the EU’s ratification (2002:M5) of the Kyoto Protocol. In Panel (b), the figure plots the difference-in-differences coefficients with corresponding 95% confidence intervals. In Panel (c), the figure plots the relevant coefficient estimates from triple difference-in-differences models. The \textit{high temperature anomaly group} equals 1 (0 otherwise) for countries whose average temperature anomaly (estimated over 95 year period, starting in 2006) is above the cross-sectional median value under a given emissions scenario. In Panel (d), the figure plots the relevant coefficient estimates from triple difference-in-differences tests for the hedging incentive. The \textit{high carbon intensity group} equals 1 (0 otherwise) for countries whose GDP exhibits above cross-sectional median sensitivity to a given carbon intensity measure. The sample period is from 2000:M11 to 2005:M10. The standard errors are clustered along the time dimension and are robust to arbitrary autocorrelated disturbances for up to 12 lags.
Figure 3: In Panel (a), the figure plots the difference-in-differences coefficients with corresponding 95% confidence intervals. In Panel (b), the figure plots the relevant coefficient estimates from triple difference-in-differences models. The high temperature anomaly group equals 1 (0 otherwise) for countries whose average temperature anomaly (estimated over 84 year period, starting in 2017) is above the cross-sectional median value under a given emissions scenario. In Panel (c), the figure plots the relevant coefficient estimates from triple difference-in-differences tests for the hedging incentive. The high carbon intensity group equals 1 (0 otherwise) for countries whose GDP exhibits above cross-sectional median sensitivity to a given carbon intensity measure. The sample period is from 2014:M2 to 2016:M10. The standard errors are clustered along the time dimension and are robust to arbitrary auto-correlation for up to 12 lags.