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Green Bonds and the Inflation Reduction Act (IRA)

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Abstract

I study the impact of the Inflation Reduction Act (2022) on the cost of green bonds in the USA. In this study, I employ a difference-in-difference methodology to compare the cost of green bonds issued by US firms in USD after the implementation of IRA by taking green bonds issued by Non-US firms as a counterfactual. I find that after the implementation of IRA, the cost of green bonds in the USA decreased compared to that in other countries. Findings indicate that Governments can mitigate constraints on the cost and supply of climate financing through fiscal policy interventions that improve business environments for firms and spur the demand for cleaner fuels and products from individuals.

Keywords: Climate Finance, Green Bonds, Climate Policy, Policy Uncertainty

JEL Classification: H32, G12, E62

1 Introduction

Implementation of the Inflation Reduction Act(IRA) of 2022 is a watershed moment for the USA to reduce carbon emissions by around 40 percent by 2022, promote cleaner production and increase the share of renewable energy in the USA[1]. This act allocates around USD 369 billion through tax credits and incentives to firms and individuals for promoting the production of cleaner fuels, generation of cleaner electricity, adoption of clean vehicles, and investment in cleaner manufacturing technologies. Overall the objective of the IRA is

[1] See https://www.congress.gov/bill/117th-congress/house-bill/5376

to lower the cost of cleaner energy and create a market for cleaner fuels and technologies while ensuring energy security for the USA.

After implementing this act, firms involved in cleaner energy technology, the production of cleaner fuels and electricity, and the manufacturing of clean vehicles will benefit tremendously. Because tax credits and incentives offered under the IRA will reduce the production cost of cleaner fuels and electricity for the firms and the consumption cost for individuals and firms. With the implementation of IRA, the commercial and financial viability of firms involved in cleaner technologies and fuel will improve due to a reduction in the market and the cash-flow risk. IRA encourages individuals to shift to cleaner fuels and improve houses' energy efficiency, thereby incentivizing demand for cleaner technologies. Therefore, in terms of corporate finance, it is pertinent to understand the impact of IRA on the cost of debt instruments, especially instruments adopted for financing green projects. Reduction in the cost of debt allows the management of firms to adopt a lower hurdle rate to accept or reject green projects. Since managers are primarily conservative and risk-averse, a lower hurdle rate allows them to take up investment opportunities, which they otherwise have not taken up (Graham, 2022).

As the world continues to struggle to increase the flow of low-cost climate financing to achieve the target of the Paris Agreement, understanding factors that can reduce the cost of climate financing will help emerging markets and vulnerable countries attract low-cost finance. Due to the lack of commercial deployment and intermittent renewable energy generation, producing clean fuels and electricity is risky for investors (Hain et al., 2018). Lack of demand for low-carbon fuels and cleaner electricity can adversely affect the viability of green projects, as the hurdle rate is higher for such firms due to idiosyncratic risks (Jagannathan et al., 2016). Suppose governments can incentivize the market for cleaner fuels and products through fiscal policy measures. In that case, the financial viability of green projects will improve due to the stability of cash flows and reduced exposure to the market, credit, and climate risks.

In this context, I study the impact of implementing IRA on the cost of green bonds issued by US firms for undertaking green projects in the USA. I argue that fiscal policy measures such as tax credits and incentives will positively impact firms' financial viability. Production-based tax credits and incentives will reduce the cost of production, thereby increasing profitability. On the other hand, tax credits and incentives for individuals to consume cleaner fuels and products will create a demand for such products in the market, thereby increasing the future growth prospects of firms. For firms, the expected benefits of future profitability and growth with lesser risk should translate into a lower cost of capital. However, it is challenging to identify firms that will benefit from implementing IRA, as the conventional debt is not project specific. To identify a firm that will benefit from IRA, I argue that green bond issuing firms are more likely to benefit from IRA. Since investment raised through green bonds are deployed to only low carbon projects (Flammer, 2021), these projects are more likely to receive tax credits and incentives under IRA. Therefore, I argue that through green bonds, investors will identify potential beneficiaries of the IRA in the USA. Since beneficiaries are likely to be less risky after implemention of the IRA, firms can issue green bonds by offering lesser coupon rates, or investors may prefer to buy green bonds at a premium.

In this study, I adopt the Difference-in-Differences regression design to study if the coupon rate of green bonds issued by US firms in USD decreased after the implementation of the IRA in August 2022. In this case, the treatment group is green bonds issued in USD by firms with the country of incorporation as the USA. I take two counterfactual scenarios as control groups. The first control group is green bonds issued in Euro by Non-US firms. The second control group is all the green bonds except the bonds included in the treatment group. Based on the empirical analysis, I found that the cost of green bonds decreased significantly for the treatment group after implementing the IRA in the USA. For the first control group, the reduction in the coupon rate is 0.78%. While for the second control group, the reduction was around 1.03%. Findings suggest that the expectation of an improved business environment for firms negatively affects the cost of borrowing. Since financial markets are forward-looking, the market participant will price fiscal policy incentives and reduce policy uncertainty in advance, although firms will realize actual financial benefits in the future.

In this paper, I review the literature and present the research hypothesis in Section 2. In the section 3, I provide the data description and discuss the research methodology. In the section 4, I present result and analysis of regression estimates along with robustness checks. Section 5 concludes this paper.

2 Literature Review and Research Hypothesis

What drives down the cost of climate financing, especially the cost of financing instruments such as green bonds and loans designed to fund green transition worldwide? Considering the heterogeneity in the economic and risk profile of countries, the cost of climate finance and the quantum of climate finance also matter. Literature on climate finance primarily talks about two perspectives that say why the cost of green debt instruments should be lower than conventional debt instruments. First is the "Values perspective," and the second is the "Value perspective" (Starks, 2023)[2]. As per the Values perspective, some investors prefer to exclude certain socially irresponsible sectors and are willing to accept lesser returns for such investment choices as they derive utility from investing in socially responsible firms (Barber et al., 2021; Chava, 2014; Hartzmark & Sussman, 2019; Hong & Kacperczyk, 2009; Pástor et al., 2022; Riedl & Smeets, 2017). In contrast, the Value perspective suggests that the long-term sustainability of firms that invests in green transition improves, thereby reducing the risk for such firms. Accordingly, investors demand lesser returns from firms that invest in green transition as an investment in these firms acts as a hedge against the climate risk (Bolton & Kacperczyk, 2021a; Krüger, 2015; Pástor et al., 2022). Investors are primarily driven by financial motives and invest to earn risk-adjusted returns because risks affect firms' valuation due to the discount factor increase.

With the scale of climate financing required to achieve the target of the Paris Agreement

[2]See https://afajof.org/presidential-address-videos/ for the video of Prof. Laura Starks

by 2100, it is unrealistic to expect that entire financing would be provided by socially conscious investors with non-pecuniary preferences, who are willing to forego some returns. Considering the heterogeneity in the economic profile and financial development in various countries, it is still unclear whether the Values perspective dominates the Value perspective in climate financing or vice-versa. However, the value perspective, which is more in line with the traditional functioning of financial markets, says that mitigation of risks associated with green projects and investment opportunities can lower the cost of funding. And if investors view the green investment as less risky, they will provide lower-cost capital. Since debt is a critical mode of climate financing, it is pertinent to understand the cost dynamics of green bonds from the Value perspective.

Literature on green bonds extensively discusses differences in the pricing of green bonds compared to conventional bonds (Baker et al., 2022; Flammer, 2021; Hachenberg & Schiereck, 2018; Karpf & Mandel, 2017; Larcker & Watts, 2020; Pástor et al., 2022; Zerbib, 2019) and reaction in stock markets post-issuance of green bonds (Flammer, 2021; Tang & Zhang, 2020). Baker et al. (2022) found that municipal green bonds in the USA are sold at a premium at the issuance compared to conventional bonds. Pástor et al. (2022) also found that corporate green bonds in Germany yield lower than conventional bonds with similar characteristics. Zerbib (2019) found a very small difference in yields of both the type of bonds issued in USD and Euro, indicating the minimal impact of non-pecuniary utility preferences. Flammer (2021) and Larcker and Watts (2020) did not find any pricing differential in the yield of green bonds and conventional bonds. Karpf and Mandel (2017) even found that conventional bonds are traded at a premium compared to green bonds. Therefore, conflicting findings in the prior literature suggest that a bond labeled as green may not even have a cost advantage and fetch a premium at the time of issuance. The effect of non-pecuniary preferences on the yield of green bonds does not seem that prominent.

Another stream of research on green bonds looked at the dynamics of the stock market and equity investors. Tang and Zhang (2020) and Flammer (2021) found that stock prices move positively at the time of issuance of green bonds and ownership by long-term institutional investors surges post-issuance of green bonds. Flammer (2021) also found that firms that issued green bonds improved environmental performance post-issuance of green bonds. However, both studies did not find much evidence in support of the lower cost of debt financing by firms that have been issuing green bonds. Issuance of green bonds is more to do with signaling to investors about the firm's commitment to addressing environmental concerns (Flammer, 2021; Tang & Zhang, 2020).

Current literature on green bonds largely revolves around differences in pricing due to heterogeneity in the preferences of investors and behavior of the stock market and the firm's performance post-issuance of green bonds. How does government policy interventions affect the cost of green bonds have not been studied until now? Policy interventions that improve the business environment of firms involved in cleaner fuels and technologies can encourage more investment, enhance the growth rate of firms and reduce the risks such as market risk, credit risk, climate risks etc. At the same time, climate policy uncertainty might harm firm's profitability and cost of capital for firms. Prior literature on policy uncertainty suggests that policy uncertainty can harm stock prices, as uncertainty about profitability increases the discount rate and reduces the valuation of the firm (Pastor & Veronesi, 2012). Kang et al. (2014) have shown that firm-level certainty and economic policy uncertainty dampen firms' prospect of capital investment. Bradley et al. (2016) found that the presence of policy risks increases the cost of debt. In our context, firms will avoid investment in green projects and technologies if climate policy uncertainty is high. Jiang et al. (2020) found that firms with higher adjustment costs mitigate environmental concerns face a higher cost of capital due to climate policy uncertainty. Fiscal policies that provide tax credits and incentives to firms willing to undertake green projects and individuals to shift their consumption choices will reduce climate policy uncertainty. Since one of the purposes of the IRA is to create a market for clean fuels and products by removing supply-side and demand-side bottlenecks through tax credits and incentives, multiple risks associated with firms involved in such businesses should reduce in the future, and profitability and growth expectation should improve. Therefore, if we go by the Value perspective, such firms' capital costs should also decrease. Valuation should also improve due to reduced cash flow risk and discounting factors.

Even the current research on the pricing of climate risk supports the value perspective largely. Bolton and Kacperczyk (2021b) and Bolton and Kacperczyk (2021a) found that investors demand higher returns from firms with high carbon emissions since these firms are exposed to transition risk. Stellner et al. (2015) in a study on corporate bonds found that firms with superior corporate social responsibility in countries with high ESG performance attract lower z-spread on corporate bonds due to reduced credit risk. Seltzer et al. (2022) and Javadi and Masum (2021) have shown that firms with greater environmental concerns have been attracting adverse credit ratings, thereby affecting yield spread on the debt. Conversely, if a firm is working towards mitigating environmental concerns, firms should get less risky and attract lower spreads on debts. Even in options markets, put options of firms with environmental concerns are sold at a premium due to higher volatility and climate policy uncertainty Ilhan et al. (2021). Even the literature on municipal bond and real estate markets suggests that if the geographical location is exposed to adverse physical risk (such as sea level rise, flood etc.), municipal bonds and real estate are likely to be sold at a discount compared to unexposed or less exposed location (Baldauf et al., 2020; Bernstein et al., 2019; Goldsmith-Pinkham et al., 2022; Hallegatte et al., 2013; Murfin & Spiegel, 2020; Painter, 2020). This literature on climate risk suggests that firms with no or fewer environmental concerns are less risky. Therefore, irrespective of investors' preference, capital costs for such firms should go down.

Since firms issue green bonds with the sole purpose of investing in green projects, the cost of green bonds should go down after the implementation of IRA in the USA due to the improved risk profile of firms involved in the green transition and reduced climate policy uncertainty. In order to reduce carbon emissions, governments can facilitates green transition through timely and appropriate policy interventions. Inaction on the part of governments can delay the transition to greener and cleaner economic world order (Besley & Persson, 2022). In this study, I analyze whether the cost of green bonds went down after the implementation of IRA in the USA compared to green bonds issued in other countries where no such fiscal policy measure was implemented. This study can provide an empirical support to a different channel to reduce the cost of climate financing.

3 Data and Methodology

In order to study the impact of the implementation of the IRA on the cost of green bonds, I downloaded the data on green bonds from Refinitive Eikon database. The raw data set contained the data on 8229 green bonds. After removing green bonds issued by Governments, Municipalities, Multilateral Banks, and Other Government Affiliated institutions, the number of observations for green bonds issued by corporate entities went down to 6709. I adopt a difference-in-difference methodology to study the impact of the implementation of IRA on the cost of green bonds issued by firms of the USA in USD currency compared to green bonds issued in currencies other than USD. Since IRA came into effect in August 2022, I compare the coupon rate of green bonds issued in January 2022 to August 2022 (8 months) with green bonds issued from September 2022 to March 2023 (7 months). Accordingly, the total observations for the study came down to 1802. After removing observations with missing values and zero coupon bonds, the final observation for the baseline Difference-in-differences regression (without any control variables) came down to 1527. Since, after the implementation of the IRA, we have data for only seven months (September 2022 to March 2023), I have considered data on green bonds for only eight months before the implementation of the IRA to keep months almost the same.

The coupon rate of each bond is the dependent variable in the regression. The treatment group is green bonds issued by firms that are incorporated in the USA and have issued green bonds in currency USD since firms located in the USA are more likely to invest in green projects if they are issuing bonds in USD. These firms are going to benefit from the tax credit and incentives allowed after the implementation of the IRA. Counterfactual or Control group is green bonds issued by firms that have issued green bonds in a currency other than USD since these green bonds are less likely to be deployed in the USA. IRA will not benefit firms belonging to the control group because these firms are not likely to invest proceeds of green bonds in the USA. I assign the value 1 to the time dummy if bonds were issued post-implementation of IRA from September 2022 to March 2023 (7 months) and 0 otherwise. Since various characteristics of bonds also determine the cost of bonds, I also control for these characteristics. These characteristics include bond investment grading, tenor (in years), the amount issued (in millions), coupon type, coupon frequency, and premium (discount if the value is negative) at the of issuance. I also control if a bond is callable, putable, coverable, guaranteed, exchange-listed, ECB eligible, and sold through private placements. Summary statistics of the green bonds issued during the study period are shown in Table 1.

Summary statistics suggest that the average coupon rate increased after the implementation of IRA, which is in line with the trend of interest rate hikes announced globally by central banks. However, after the implementation of IRA, green bonds are being issued at premium compared to before, indicating higher demand for green bonds. The average tenor of green bonds increased to 6.52 years from 5.93 years post-implementation of the IRA. Share of investment-grade bonds increased to 95.16% from 91.86%. The average amount raised through green bonds increased to USD 350.17 million from USD 274.00 million.

Methodology

I adopt following Difference-in-Differences equation to estimate the impact of IRA on the coupon rate of green bonds issued in USA post Auguest 2022.

$$\begin{aligned} Coupon_{im} = \alpha + \beta Treated_i + \gamma AfterIRA_m + \delta Treated_i * AfterIRA_m + \theta X_{it} \\ + Currency_i * Month - Year + Industry_i + Month - Year + \epsilon_{im} \end{aligned} \quad (1)$$

'i' in the above equation is the green bond, and 'm' is the month the green bond was issued. $Coupon_{im}$ takes the bond coupon rate in percentage. $Treated_i$ equals 1 if the firms issuing the bond is located in USA and the currency of the bond is USD, otherwise, $Treated_i$ equals to 0. $AfterIRA_m$ equals to 1 if the green bond were issued after August 2022; otherwise, $AfterIRA_m$ equals to 0. X_{it} are the control variables related to bond characteristics. I also control for the time trend in unobserved economic changes in countries to saturate the model by including currency month year fixed effects. I proxy country by currency as interest changes and other policy changes by respective countries will be reflected through the country. Since the country of incorporation and country of issue of bonds can be different, and bonds can be issued in any other currency, taking the country of incorporation and month-year fixed effects will bias the estimate. I also control for industry-fixed effects represented by sic two-digit code to control for time-invariant industry characteristics. In equation (1), the coefficient of interest is δ, which is the Average Treatment Effect on the Treated (ATT). The negative and significant value of δ will indicate that after the implementation of IRA in the USA, the coupon rate for firms in the USA decreased compared to the coupon rate for firms that issued green bonds in currencies other than USD. It would indicate that climate policies that improve firms' business environment reduce climate financing costs. In an alternate regression, I only consider green bonds issued in USD and EURO to see if the results still hold.

I also checked for parallel trend assumptions in the data to ensure that average coupon rates in the treatment and control groups behaved almost similarly. Figure 1 shows the parallel treatment and control group trends. In Figure 1(a), the control group consists of green bonds issued in all currencies by Non-US firms. While in Figure 1(b), the control group consists of green bonds issued in EURO only. Both the figure show that coupon rates for the treatment and the control groups were largely moving in a parallel direction before the implementation of the IRA in August 2022.

4 Results and Analysis

This section presents empirical findings related to the change in coupon rate of green bonds issued based on the regression specification as per equation (1). First, I show Difference-in-differences results for green bonds issued in EURO as the control group. Then, I show the Difference-in-differences Estimation for green bonds issued by firms whose country of incorporation is outside the USA, and the currency of the bond can be anything. I also present robustness checks in the form of placebo and coefficient plots to show that before August 2022, there was no difference in the trend of coupon rate between the control group and treatment group.

Control Group as Bonds issued in EURO

Table 2 shows the result of the empirical analysis by only considering green bonds issued in EURO as the control group. Results in columns (1), (2) and (3) is without including any control variable. The only variation is at the level of fixed effects and clustering standard errors. While results in columns (4), (5), and (6) also include bond-level control variables to control for bond-level heterogeneity. Estimation with industry fixed effects (SIC 2 digit) level allows controlling for time-invariant heterogeneity in the industry structure. Month-year fixed effect captures the time-variant changes during the period of study. Due to the increase in global interest rates, the monthly economic scenario will vary. Since standard errors of bonds issued in the same currency are likely to be correlated and vary over time due to idiosyncratic variation in respective countries, I also cluster standard errors at the level of Bond Currency multiplied by Month-year. Since this model includes only two currencies (USD and Euro) for Estimation, the inclusion of the time trend of currencies or country of incorporation for firms will drop the interaction term of regression. That is why I have included only currency of bonds as fixed effect in the regression to control the country's time-invariant economic characteristics. Essentially in this regression, I proxy the economic characteristic of a country by the currency of that country.

Results of Difference-in-difference regression estimation show that the interaction term coefficient (Treated X AfterIRA) is negative and statistically significant, indicating that coupon rates for green bonds issued by US firms decreased compared to Non-US firms that issued bonds in Euro. If we consider the fully saturated model as per column(3) and column

(6), coupon rates went down by 1.23% and 0.78%, respectively, which is significant at 1% level. Our main specification in column(6) with all the control variables and fixed effects, with clustering of standard errors by time trend of currency of green bonds. Apart from various bond-specific characteristics that are decided ex-ante, I also controlled for market-determined premium(discount) at the time of issuance of bonds. If controlling for premium at issuance, a statistically significant decrease in the coupon rates in the USA compared to the control group indicates yield at issuance also went down. Results indicate that the cost of green bonds went down in the USA after the implementation of IRA, thereby supporting the hypothesis that policy interventions that improve business environments for firms involved in cleaner fuels and technologies can reduce the cost of capital for firms involved.

Control Group as All bonds

In this regression specification, I consider the control group as green bonds that do not belong treatment group. Since the treatment group consists of green bonds issued in USD by firms with the country of incorporation as the USA, I consider control groups as all the bonds that are not included in the treatment group. It means that the control group also includes bonds issued in the USA with the country of incorporation of the firms outside the USA, as these firms are not likely to deploy proceeds of green bonds in the USA and avail benefits of IRA. Table 3 shows the empirical analysis for this model specification. The result in columns (1) and (2) is without including any control variable. The only variation is at the level of fixed effects and standard clustering errors. While the result in columns (3), (4), and (5) also includes bond-level control variables to control for bond-level heterogeneity. Since the control group now consists of bonds issued in multiple currencies, I consider the monthly time trend of bond currency as fixed effects to control for time-varying unobserved heterogeneity in the economic situation of the country to which bond currency belongs to. I cluster standard errors at the level of the country of incorporation of firms, as due to domestic economic circumstances (such as credit ratings, climate policies etc.), standard error might be correlated.

Results of regression specification show that the coefficient of the interaction term (Treated X AfterIRA) is negative and statistically significant, indicating that coupon rates for green bonds issued by US firms in USD decreased compared to Non-US firms that issued bonds in all currencies. If we consider the fully saturated model as per column(2) and column (5), coupon rates went down by 0.74% and 1.031%, respectively, which is significant at 1% level. In this case, our main specification in column (5) with all the control variables and fixed effects, with clustering of standard errors by country of incorporation firms issuing green bonds. In this also, apart from various ex-ante features of green bonds, I control for market-determined premium at the issuance of green bonds to show that yield at the time issuance also went down for US firms compared to Non-US firms. Even after widening the control group, the results of this regression specification also support our hypothesis.

Robustness Checks

In order to validate the finding in the Table 2 and Table 3 and provide support for causal interpretation, I conduct a placebo test and plot the coefficient of the interaction term for the pre-treatment period.

Placebo Test

To test the robustness of our findings, I conduct the placebo test by taking observations for the pre-treatment period (January 2022 to August 2022). I introduced fake treatment (placebo) from May 2022 onward. So pre-treatment period is from January 2022 to April 2022 (4 months), and the post-treatment period is from May 2022 to August 2022. The regression model for the placebo test is given in equation (2).

$$Coupon_{im} = \alpha + \beta Treated_i + \gamma Placebo + \delta Treated_i * Placebo + Controls + FixedEffects + \epsilon_{im} \quad (2)$$

In this regression model (2), the coefficient of interest is δ. I expect this coefficient to be statistically insignificant, thereby indicating that no other factor in the pre-treatment period is driving the results of the main regression equation (1). Table 4 shows the results of the placebo test. Estimation in column (1) for the green bonds issued in Euro only with all control and fixed effects, similar to column (6) of Table 2. While Estimation in column (2) for the green bonds issued by Non-US firms in all currencies with all control and fixed effects is similar to column (5) of Table 3. In both columns, the coefficient of the interaction term (δ) is statistically insignificant. It shows that results in Table 2 and Table 3 are not driven by any other event that might have occurred in the pre-treatment period (January 2022 to August 2022) of the main regression.

Test of Parallel Trends through Coefficient Plot

To support the hypothesis that the reduction in the cost of green bonds is due to the implementation of IRA, I also plot the coefficient of the interaction term for each month in the pre-treatment period to show that coupon rates were not falling before the implementation of the IRA in the USA. If the interaction coefficient is insignificant, it would mean that reduction in coupon rates of the green bond in the post-treatment period is due to the implementation of the IRA.

Figure 2 show the coefficient plots for both control groups in the pre-treatment period. Figure 2a is for the control group as a green bond issued by firms other than the treatment group in all currencies. Figure 2b is for the control group green bond issued in Euro. Coefficient plots for both the control shows that the coefficient was insignificant for all the months except February 2022. However, the coefficient for February 2022 is positive and significant, indicating that some other economic phenomena, such as interest rate hikes by central banks, might be responsible. Otherwise, the coefficient was insignificant from March 2022 to August 2022. It means no trend in coupon rate reduction was noticed in the pre-treatment period. Therefore, Figure 2 supports the argument that implementation of IRA is causally correlated with the reduction in the coupon rate in the USA compared to other countries.

5 Conclusion

The empirical analysis in this paper suggests that the implementation of IRA in the USA is correlated with the reduction in the cost of green bonds in the USA, thereby supporting the main hypothesis of this paper. Findings support the view that climate financing can not get cheaper just because some investors value the environment and are willing to accept lower returns. If investors are primarily looking for risk-adjusted returns, we need some mechanism to reduce the risk associated with green investments to reduce the cost of climate financing. Fiscal policy incentives offered by the USA through the IRA are some of the measures to reduce risk and lower the cost of capital. However, one of the limitations of this study is limited external validity. Because the USA is a financial supper power, which allowed the government to roll out such a fiscal policy package, a financial package of this magnitude may not be possible in other countries due to fiscal constraints. Due to heterogeneity in economic profile and financial development in developed countries and emerging markets, a similar policy might not have similar impact. Another limitation is that the number of green bonds issued is less than those issued in the control group. A minor proportion of firms that IRA will befit were included in the treatment group. Also, many firms are banks and financial service firms that will, in turn, invest in green projects. The superior credit profile of banks might drive the reduction in coupon rates. Further research can focus on studying non-financial firms to get a better estimate of reduction in the cost of green bonds. However, we need some form of the financial support by global community to firms involved to mitigate risks associated with green projects and create demand for cleaner fuels, product and technologies.

References

Baker, M., Bergstresser, D., Serafeim, G., & Wurgler, J. (2022). The pricing and ownership of us green bonds. *Annual Review of Financial Economics*, *14*, 415–437.

Baldauf, M., Garlappi, L., & Yannelis, C. (2020). Does climate change affect real estate prices? only if you believe in it. *The Review of Financial Studies*, *33*(3), 1256–1295.

Barber, B. M., Morse, A., & Yasuda, A. (2021). Impact investing. *Journal of Financial Economics*, *139*(1), 162–185.

Bernstein, A., Gustafson, M. T., & Lewis, R. (2019). Disaster on the horizon: The price effect of sea level rise. *Journal of financial economics*, *134*(2), 253–272.

Besley, T., & Persson, T. (2022). The political economics of green transitions. *Quarterly Journal of Economics*.

Bolton, P., & Kacperczyk, M. (2021a). Do investors care about carbon risk? *Journal of financial economics*, *142*(2), 517–549.

Bolton, P., & Kacperczyk, M. (2021b). *Global pricing of carbon-transition risk* (tech. rep.). National Bureau of Economic Research.

Bradley, D., Pantzalis, C., & Yuan, X. (2016). Policy risk, corporate political strategies, and the cost of debt. *Journal of Corporate Finance*, *40*, 254–275.

Chava, S. (2014). Environmental externalities and cost of capital. *Management science*, *60*(9), 2223–2247.

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, *142*(2), 499–516.

Goldsmith-Pinkham, P., Gustafson, M. T., Lewis, R. C., & Schwert, M. (2022). *Sea level rise exposure and municipal bond yields* (tech. rep.). National Bureau of Economic Research.

Graham, J. R. (2022). Presidential address: Corporate finance and reality. *The Journal of Finance*, *77*(4), 1975–2049.

Hachenberg, B., & Schiereck, D. (2018). Are green bonds priced differently from conventional bonds? *Journal of Asset Management*, *19*, 371–383.

Hain, M., Schermeyer, H., Uhrig-Homburg, M., & Fichtner, W. (2018). Managing renewable energy production risk. *Journal of banking & finance*, *97*, 1–19.

Hallegatte, S., Green, C., Nicholls, R. J., & Corfee-Morlot, J. (2013). Future flood losses in major coastal cities. *Nature climate change*, *3*(9), 802–806.

Hartzmark, S. M., & Sussman, A. B. (2019). Do investors value sustainability? a natural experiment examining ranking and fund flows. *The Journal of Finance*, *74*(6), 2789–2837.

Hong, H., & Kacperczyk, M. (2009). The price of sin: The effects of social norms on markets. *Journal of financial economics*, *93*(1), 15–36.

Ilhan, E., Sautner, Z., & Vilkov, G. (2021). Carbon tail risk. *The Review of Financial Studies*, *34*(3), 1540–1571.

Jagannathan, R., Matsa, D. A., Meier, I., & Tarhan, V. (2016). Why do firms use high discount rates? *Journal of Financial Economics*, *120*(3), 445–463.

Javadi, S., & Masum, A.-A. (2021). The impact of climate change on the cost of bank loans. *Journal of Corporate Finance*, *69*, 102019.

Jiang, F., Li, W., & Qian, Y. (2020). Do costs of corporate loans rise with sea level? *Available at SSRN 4351883*.

Kang, W., Lee, K., & Ratti, R. A. (2014). Economic policy uncertainty and firm-level investment. *Journal of Macroeconomics*, *39*, 42–53.

Karpf, A., & Mandel, A. (2017). Does it pay to be green? *Available at SSRN 2923484*.

Krüger, P. (2015). Corporate goodness and shareholder wealth. *Journal of financial economics*, *115*(2), 304–329.

Larcker, D. F., & Watts, E. M. (2020). Where's the greenium? *Journal of Accounting and Economics*, *69*(2-3), 101312.

Murfin, J., & Spiegel, M. (2020). Is the risk of sea level rise capitalized in residential real estate? *The Review of Financial Studies*, *33*(3), 1217–1255.

Painter, M. (2020). An inconvenient cost: The effects of climate change on municipal bonds. *Journal of Financial Economics*, *135*(2), 468–482.

Pastor, L., & Veronesi, P. (2012). Uncertainty about government policy and stock prices. *The journal of Finance*, *67*(4), 1219–1264.

Pástor, L., Stambaugh, R. F., & Taylor, L. A. (2022). Dissecting green returns. *Journal of Financial Economics*, *146*(2), 403–424.

Riedl, A., & Smeets, P. (2017). Why do investors hold socially responsible mutual funds? *The Journal of Finance*, *72*(6), 2505–2550.

Seltzer, L. H., Starks, L., & Zhu, Q. (2022). *Climate regulatory risk and corporate bonds* (tech. rep.). National Bureau of Economic Research.

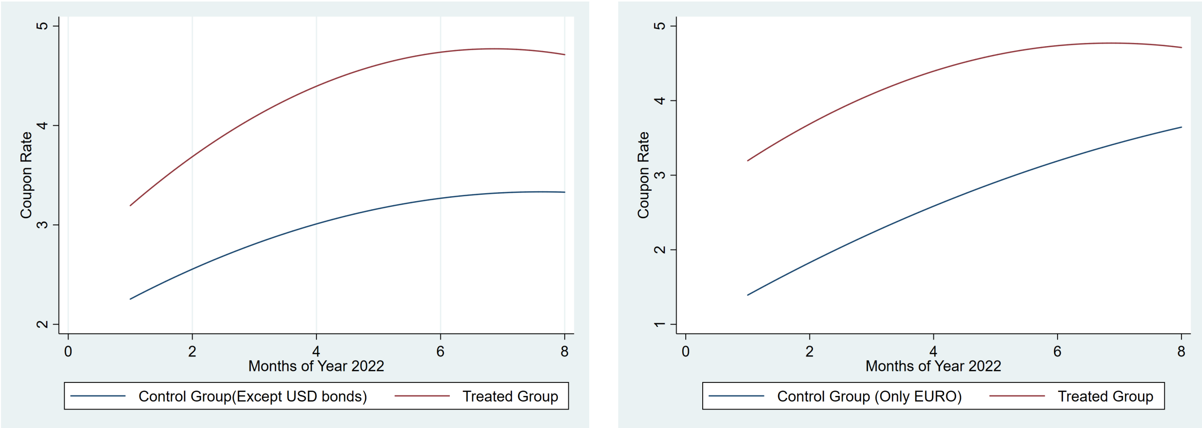
Starks, L. (2023). *Sustainable finance and e, s, g issues: Values versus value*. American Finance Association - 2023 Presidential Address Video. https://afajof.org/presidential-address-videos/

Stellner, C., Klein, C., & Zwergel, B. (2015). Corporate social responsibility and eurozone corporate bonds: The moderating role of country sustainability. *Journal of Banking & Finance*, *59*, 538–549.

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, *61*, 101427.

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*, *98*, 39–60.

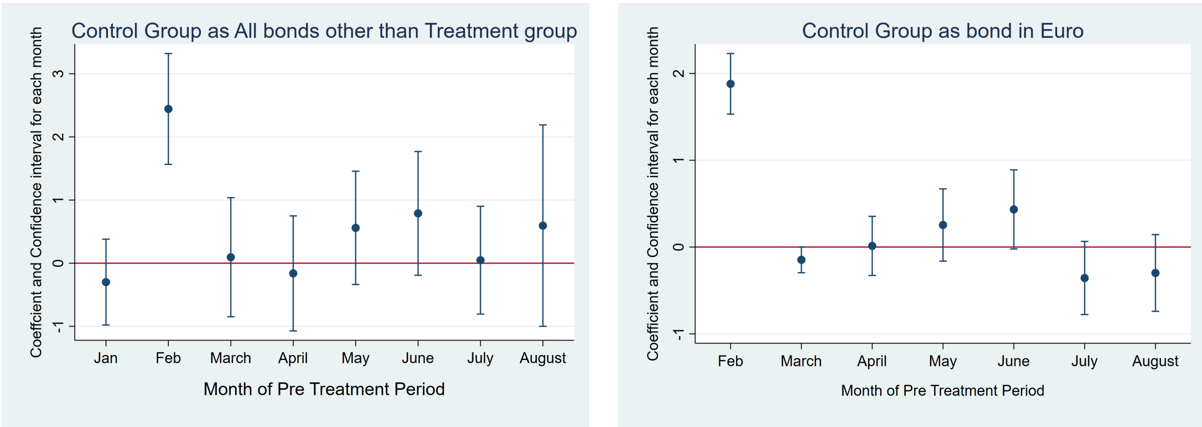
Figure 1: Parallel Trends before implementation of IRA (Graphs in the figure are quadratic fit representation of coupon rates)



(a) Control group as bonds in non USD

(b) Control group as bonds issued in EURO

Figure 2: Trend of Interaction Coefficient for the Treated Group compared to the the Control Group



(a) Control group as bonds issued by Non US firms

(b) Control group as bonds issued in EURO by firms

Table 1: Summary Statistics of Observation for Pre and Post treatment Periods

Variables	**N**	**Mean**	**SD**	**MIN**	**MAX**	**P50**
Bond Issued Before Implementation of IRA						
Coupon Rate	914	3.006586	1.730869	0.03	10.5	3
Tenor	898	5.936526	4.89071	2	31	5
Bond Grade	295	0.918644	0.273846	0	1	1
Amount Issued	914	274.0002	322.674	0.557126	2181.184	109.1227
If Coverable	914	0.0186	0.13518	0	1	0
If Callable	914	0.210066	0.407578	0	1	0
If Exchange listed	914	0.881838	0.322977	0	1	1
If Guranteed	882	0.120181	0.325358	0	1	0
If Inflation Protected	900	0	0	0	0	0
If Privately Placed	913	0.072289	0.259108	0	1	0
If ECB Eligible	914	0.142232	0.349479	0	1	0
If Putable	914	0.041576	0.199726	0	1	0
Premium at Issue	852	-0.09072	0.424642	-4	6.0122	0
Bond Issued After Implementation of IRA						
Coupon Rate	613	3.955851	1.82967	0.22	10.5	3.93
Tenor	604	6.521523	5.784511	2	31	5
Bond Grade	248	0.951613	0.215017	0	1	1
Amount Issued	613	350.1785	379.7337	1.070864	2181.184	156.7223
If Coverable	613	0.030995	0.173446	0	1	0
If Callable	613	0.296901	0.457265	0	1	0
If Exchange listed	613	0.8646	0.342429	0	1	1
If Guranteed	585	0.133333	0.340226	0	1	0
If Inflation Protected	605	0.004959	0.070301	0	1	0
If Privately Placed	613	0.053834	0.225873	0	1	0
If ECB Eligible	613	0.184339	0.388077	0	1	0
If Putable	613	0.032626	0.177802	0	1	0
Premium at Issue	568	1.226022	37.8254	-31.289	899.4	0

Table 2: Difference-in-Differences Estimate with Green Bonds issued in Euro as the Control Group

VARIABLES	(1) Coupon Rate	(2) Coupon Rate	(3) Coupon Rate	(4) Coupon Rate	(5) Coupon Rate	(6) Coupon Rate
Treated X AfterIRA	-1.213***	-0.957**	-1.213***	-0.787***	-0.450**	-0.787***
	(0.463)	(0.387)	(0.394)	(0.242)	(0.193)	(0.206)
Tenor				0.0338***	0.0165*	0.0338***
				(0.00878)	(0.00869)	(0.00820)
Bond Grade				-2.066***	-2.170***	-2.066***
				(0.218)	(0.508)	(0.489)
Amount Issued				-0.000289*	-0.000347**	-0.000289**
				(0.000157)	(0.000132)	(0.000140)
If Covered				-0.973***	-0.734***	-0.973***
				(0.181)	(0.167)	(0.196)
Coupon Frequency(Semi-Annually)				0.726	0.928	0.726
				(0.541)	(2.148)	(2.152)
If callable				0.284	0.242	0.284
				(0.173)	(0.161)	(0.168)
If Exchange Listed				-0.283	-0.280	-0.283
				(0.225)	(0.311)	(0.266)
Coupon Type- Fixed then Floating				-0.0595	0.0408	-0.0595
				(0.226)	(0.267)	(0.219)
Coupon Type - Plain Vanilla Fixed				-0.420*	-0.365	-0.420
				(0.239)	(0.293)	(0.326)
If Guaranteed				-0.441***	-0.298*	-0.441**
				(0.148)	(0.150)	(0.160)
If Privately Placed				1.034***	0.886*	1.034**
				(0.336)	(0.472)	(0.428)
If ECB Eligible				0.000892	-0.185	0.000892
				(0.124)	(0.139)	(0.178)
Premium at Issue				-0.609***	-0.583*	-0.609*
				(0.126)	(0.308)	(0.323)
Constant	2.942***	2.927***	2.942***	5.438***	5.803***	5.438***
	(0.0690)	(0.0246)	(0.0252)	(0.422)	(0.678)	(0.664)
Industry Fixed Effects	Yes	No	Yes	Yes	No	Yes
Month-Year Fixed	Yes	Yes	Yes	Yes	Yes	Yes
Clustering of Standard Error at Bond Currency X Month-Year level	No	Yes	Yes	No	Yes	Yes
Observations	489	496	489	277	284	277
Adjusted R-squared	0.468	0.393	0.468	0.831	0.809	0.831

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Difference-in-Differences Estimate with Green Bonds issued by Non US firms in all currencies

VARIABLES	(1) Coupon Rate	(2) Coupon Rate	(3) Coupon Rate	(4) Coupon Rate	(5) Coupon Rate
Treated X AfterIRA	-0.592***	-0.746***	-0.910***	-1.031***	-1.031***
	(0)	(0.0588)	(0.290)	(0.303)	(0.145)
Tenor			0.0309***	0.0346***	0.0346**
			(0.00665)	(0.00703)	(0.0108)
Bond Grade			-2.044***	-2.029***	-2.029***
			(0.169)	(0.171)	(0.119)
Amount Issued			-0.000448***	-0.000450***	-0.000450***
			(0.000134)	(0.000135)	(0.000109)
If Covered			-0.770***	-0.850***	-0.850***
			(0.158)	(0.166)	(0.0490)
Coupon Frequency(Semi-Annually)			-0.0858	-0.421	-0.421**
			(0.817)	(0.815)	(0.150)
If callable			0.404*	0.265	0.265
			(0.235)	(0.235)	(0.800)
If Exchange Listed			0.248**	0.211*	0.211
			(0.0976)	(0.117)	(0.119)
Coupon Type- Fixed then Floating			-0.141	-0.220	-0.220***
			(0.166)	(0.166)	(0.0600)
Coupon Type - Plain Vanilla Fixed			-0.386	-0.660	-0.660
			(0.885)	(0.872)	(0.422)
If Guaranteed			-0.571	-0.898	-0.898**
			(0.843)	(0.832)	(0.295)
If Privately Placed			-0.601	-0.568	-0.568*
			(0.858)	(0.834)	(0.256)
If ECB Eligible			-1.023	-1.323	-1.323***
			(0.868)	(0.869)	(0.345)
Premium at Issue			-1.827*	-2.199**	-2.199***
			(1.075)	(1.066)	(0.552)
Constant			-0.125	-0.305**	-0.305*
			(0.101)	(0.121)	(0.154)
If Privately Placed			0.373***	0.369***	0.369**
			(0.141)	(0.140)	(0.137)
Constant	3.384***	3.385***	6.497***	6.921***	6.921***
	(0)	(0.00307)	(0.903)	(0.916)	(0.558)
Bond Currency X Month-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	No	Yes	No	Yes	Yes
Clustering of Standard Error at Bond Currency level	Yes	Yes	No	No	Yes
Observations	1,527	1,513	508	498	498
Adjusted R-squared	0.558	0.592	0.791	0.802	0.801

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Difference-in-Differences Estimate for Placebo Test with fake treatment from May 2022 onward in the Pre Treatment Period

VARIABLES	(1) Euro Control Group Coupon Rate	(2) All Currency Control Group Coupon Rate
Treated X Placebo	-0.418	-0.424
	(0.306)	(0.286)
Control Variables	Yes	Yes
Month-Year Fixed	Yes	No
Bond Currency X Month-Year Fixed Effects	No	Yes
Industry Fixed Effects	Yes	Yes
Clustering of Standard Error at Country of Incorporation Level	No	Yes
Clustering of Standard Error at Bond Currency X Month-Year level		
Observations	277	498
Adjusted R-squared	0.825	0.797

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1