Green versus Conventional Corporate Debt: From Issuances to Emissions*

Juan J. Cortina
World Bank

Claudio Raddatz
Central Bank of Chile,
School of Economics and Business,
Universidad de Chile

Sergio L. Schmukler
World Bank

Tomas Williams
George Washington University

October 6, 2025

Abstract

This paper investigates how firms use green versus conventional debt and the associated firm- and aggregate-level environmental consequences. Employing a dataset of 127,711 global bond and syndicated loan issuances by non-financial firms across 85 countries during 2012-23, the paper documents a sharp rise in green debt issuances relative to conventional issuances since 2018. This increase is particularly pronounced among large firms with high carbon dioxide emissions. Local projections difference-in-differences estimates show that, compared to conventional debt, green bond and loan issuances are systematically followed by sustained reductions in carbon intensity (emissions over income) of up to 50 percent. These reductions correspond to as much as 15 percent of global annual emissions. Green bonds contribute to reducing emissions by providing financing to large, high-emitting firms, whose improvements in carbon intensity have significant aggregate consequences. Syndicated loans do so by channeling a larger volume of financing to a wider set of firms.

Keywords: carbon emissions, corporate bonds, firm growth, green debt, green transition, sustainability, syndicated loans

JEL Codes: F33, G00, G01, G15, G21, G23, G31

* We are grateful to Shawn Cole, Caroline Flammer, Galina Hale, Guojun He, Aart Kraay, Paolo Mauro, Dario Tortarolo, and participants at the 2024 Annual Meetings of the Chilean Economic Association, Bank of Korea, HKIMR-ECB-BOFIT conference, IMF MCM Policy Forum, 7th Summer School of Sustainable Finance of the European Commission, and UCSC Center for Analytical Finance workshop for useful comments. Brian Castro, Paolo Sabella, Matias Soria, and Patricio Yunis provided excellent research assistance. The World Bank's Chile Research and Development Center and Knowledge for Change Program (KCP) and Chile's ANID Fondecyt Project 1220115 provided financial support. The findings, interpretations, and conclusions are those of the authors and do not necessarily represent those of the World Bank, its executive directors, or the governments they represent. Email addresses: jcortinalorente@worldbank.org; clraddatz@fen.uchile.cl; sschmukler@worldbank.org; tomaswilliams@gwu.edu.

1 Introduction

Concerns about the economic and environmental consequences of climate change have heightened interest in the role of the financial system in supporting industrial decarbonization (Stern, 2006; IPCC, 2018; IEA, 2021; Draghi, 2024). In response, financial actors have integrated climate considerations into capital allocation decisions at an accelerating pace (GFMA and BCG, 2020). Between 2013 and 2023, assets under management in sustainability-focused funds grew tenfold, reaching over $3.4 trillion, or 7.2 percent of total global portfolios. By 2023, institutions representing more than half of global banking assets had endorsed the UN Principles for Responsible Banking, committing to align their strategies with sustainability goals (United Nations, 2023; Morgan Stanley, 2025). These developments reflect a broader shift toward environmental accountability in corporate finance (OECD, 2021a; CPI, 2023).

Green debt instruments—comprising bonds and syndicated loans—have emerged in this context as leading tools for mobilizing capital toward environmental objectives (ICMA, 2021; OECD, 2021b). These instruments incorporate climate considerations by earmarking proceeds for green uses or by linking repayment terms to environmental performance. While designed to promote decarbonization, the actual relation between green bonds and syndicated loans and changes in firm behavior and carbon emissions—both at the micro and macro levels—remains insufficiently understood.

In this paper, we analyze how firms use green vis-à-vis conventional debt instruments to raise capital, and how these financing choices relate to subsequent changes in firm- and aggregate-level performance. We systematically compare corporate debt issuance along two key dimensions: (i) green versus conventional debt and (ii) bonds versus syndicated loans. We examine how debt market participation relates to issuer characteristics and how firms evolve after issuance in terms of scale (measured by assets and operating income or sales) and carbon intensity (defined as carbon emissions per unit of income). To assess the aggregate significance of green debt, we combine firm-level responses with observed issuer profiles and baseline emissions, offering new evidence on the relation between green debt borrowing and global emissions.

To conduct the analysis, we construct a novel global dataset that links green and conventional corporate bond and syndicated loan issuances to firm-level balance sheet and carbon emissions data. The dataset covers 120,711 conventional debt and 6,412 green debt transactions issued in domestic and international markets by 50,832 non-financial firms across 85 countries between 2012 and 2023.[1] We define green debt broadly to include both green-labeled and sustainability-linked instruments, providing a comprehensive view of the market aimed at directly aligning financing with environmental objectives.

We document a sharp expansion of green debt issuance after 2018, coinciding with a broader slowdown in conventional corporate borrowing. Between 2017–2018 and 2022–2023, annual green issuance increased nearly ninefold, reaching 12 percent of total corporate debt issuance by the end of the period. While the United States and China continue to dominate the conventional debt issuance activity, they play a much smaller role in the green segment. In contrast, Europe has emerged as the global leader, accounting for nearly half of all green issuances between 2012 and 2023. Over time, green syndicated loans have surpassed green bonds in total credit volume and reached a broader range of countries, sectors, and firms.

Green debt is issued primarily by large incumbent debt issuers with high carbon footprints, most of which rely on conventional borrowing before incorporating green instruments into their financing choices. Among these "hybrid" issuers using both conventional and green debt, the share of green debt rose from just 1 percent of their total debt issuance in 2013–2014 to roughly 35 percent by 2022–2023. The median hybrid issuer is about five times larger—both in total assets and carbon emissions—than firms that rely exclusively on conventional debt. The relation between firm size and green debt issuance has strengthened over time, suggesting that high entry costs into a new, untested debt market do not drive this result. Compared to green bonds, green loans are used by smaller companies and first-time debt issuers.

To assess the environmental performance, we estimate firm-level trajectories of scale and carbon intensity, the two components that jointly determine total emissions. We implement a local projections difference-in-differences (LP-DiD) approach (Dube et al., 2025) to trace dynamic firm responses to debt issuance and compare outcomes across green and conventional

[1] We focus on the non-financial corporate sector due to its central role in global emissions (CDP, 2023).

instruments. The results indicate that scale trajectories are broadly similar following green and conventional debt issuances. In contrast, carbon intensity shows a marked divergence: it remains flat or rises after conventional issuance, but declines steadily in the aftermath of green debt issuance, reaching a cumulative reduction of approximately 50 percent by year four. These improvements are also observed within firms that issue both green and conventional debt. While green bonds and loans exhibit comparable reductions in carbon intensity, bond issuance is followed by larger post-issuance expansions in firm scale.

We extend the analysis to the aggregate level by combining our LP-DiD estimates with the observed characteristics of issuers and their baseline emissions. This aggregation suggests that green debt issued between 2018 and 2023 could be associated with projected cumulative carbon dioxide (CO_2) reductions of 4.5 billion to 5.7 billion metric tonnes by 2025. These figures represent roughly 12 to 15 percent of one year's global energy-related CO_2 emissions. A disproportionate share of this aggregate abatement is driven by large firms. For example, the top quartile of firms in our sample accounts for more than 85 percent of the total estimated reductions.

Overall, the aggregate relevance of green debt reflects the profile of its issuers and how their emissions trajectories evolve afterward. Relative to conventional borrowing, green issuance remains concentrated among large firms with substantial carbon footprints. At the same time, issuers of green debt display consistent reductions in carbon intensity. The participation of large global emitters in green debt markets and their post-issuance performance are especially relevant for aggregate outcomes.

Within green debt, bonds and loans shape aggregate carbon emissions outcomes through different channels. Bonds are issued predominantly by large firms with high baseline emissions, so reductions in their carbon intensity translate into sizeable aggregate declines, even when post-issuance expansion tempers these gains. Loans, by contrast, extend to a broader and more heterogeneous group of borrowers. Moreover, their aggregate issuance volume exceeds that of bonds. At the firm level, loan issuances are followed by carbon intensity reductions of a similar order to those of bonds, but with a smaller offsetting expansionary effect. Overall, the larger scale and emissions profile of bond issuers explain why bonds account for most

aggregate reductions, while loans complement this by channeling green finance more widely across the corporate sector.

This paper adds to a growing literature on the drivers and consequences of the rapid expansion of the green debt market. A significant portion of this literature examines whether rising investor demand for green debt instruments translates into financial benefits for issuing firms—either through a lower cost of debt (the so-called "greenium") (Hachenberg and Schiereck, 2018; Zerbib, 2019; Bachelet et al., 2019; Baker et al., 2022; Caramichael and Rapp, 2024), or via a lower cost of equity through signaling effects that attract environmentally minded shareholders (Tang and Zhang, 2020; Flammer, 2021). Another strand investigates whether, given the convenience of issuing green debt, firms use it to improve their environmental outcomes (Fatica and Panzica, 2021; Flammer, 2021; Dursun-de Neef et al., 2023), or instead to finance business-as-usual activities (Ehlers et al., 2020; Tuhkanen and Vulturius, 2022; Ul Haq and Doumbia, 2022; Lam and Wurgler, 2024). A smaller number of studies explore the characteristics of firms issuing green debt in specific markets (Cicchiello et al., 2022; Dutordoir et al., 2024). Most of this research focuses on green bonds, with only a few papers analyzing the fast-growing green syndicated loan market (Aleszczyk et al., 2022; Du et al., 2023; Dursun-de Neef et al., 2023).[2]

We contribute to this literature by systematically analyzing which firms issue green debt and how they use it relative to conventional debt across green debt products. Unlike prior work, our focus is on how the development of the green debt market has altered firms' financing patterns and what consequences this has for their economic activity and environmental footprint. Our joint analysis of issuance decisions, firm expansion, and carbon intensity offers two additional advantages. First, it enables a more detailed characterization of the relation between firms' financing choices and their environmental outcomes. Second, it allows us to project the macroeconomic implications of the green debt issuance by combining firm-level dynamics with baseline emissions and issuance volumes. Importantly, by incorporating the syndicated loan segment—which exceeds the green bond market in size—we capture firms'

[2] A related strand of research examines the role of syndicated lending in the broader green transition without distinguishing between green and conventional loans. For instance, Hale et al. (2024) study how banks' climate commitments and policy developments have influenced the industrial composition of syndicated lending, showing that climate policies can affect credit allocation across firms with different environmental profiles.

use of different green financing instruments and better gauge the significance of the overall green debt market.

Understanding how green debt markets have reshaped firm financing is both important and not obvious. On the one hand, green finance can enhance access to capital and enable the expansion of innovative, environmentally focused firms, which might otherwise not have easy access to conventional markets. On the other hand, green debt issuance entails stricter requirements—including third-party certification and environmental reporting—which can raise issuance costs and restrict eligibility, especially among smaller firms (ICMA, 2020a; Abraham et al., 2021a).

The swift rise of the green syndicated loans relative to green bonds can also influence these dynamics. Banks are traditionally more adept at evaluating and monitoring opaque borrowers, potentially broadening green finance access. Yet, several studies suggest that syndicated loans have become increasingly "market-like," being distributed to non-bank investors and traded on secondary markets (Ivashina and Scharfstein, 2010; Aldasoro et al., 2022; Albuquerque et al., 2025), which could limit their distinction from bonds. To the extent that bond markets incorporate transition risks more effectively than banks, large, carbon-intensive firms would rely more on bank-based financing (Beyene et al., 2024).

The environmental impact of green debt issuance is similarly nuanced. While green instruments are designed to finance environmentally friendly activities, the empirical evidence on post-issuance improvements in firms' carbon footprint remains mixed. More fundamentally, how much carbon firms emit depends not only on changes in carbon intensity but also on the scale of their operations. Here again, the market structure can influence outcomes. Syndicated loans involve more direct monitoring than bonds issued in arm's-length transactions to dispersed investors (Diamond, 1984; Rajan, 1992; Holmstrom and Tirole, 1997; Boot and Thakor, 2000; Acharya et al., 2011). This monitoring could constrain opportunistic uses of proceeds and enhance the credibility of environmental commitments. In contrast, bonds are subject to looser ex-ante scrutiny and less ongoing oversight, which could allow for greater discretion in capital deployment (Bruno and Shin, 2017; Abraham et al., 2021b; Acharya and Plantin, 2025; OECD, 2025). Ultimately, the aggregate environmental relevance of green

debt depends not only on firm-level emission reductions but also on the number and scale of participating firms. Since large emitters account for a disproportionate share of global emissions, their climate actions carry outsized aggregate consequences (CDP, 2023; Acharya et al., 2025).

Our paper contributes to this literature by assembling comprehensive new global data to examine how green debt adoption relates to firm-level performance and aggregate emissions. We show that, unlike conventional debt, both green bonds and loans are systematically associated with reductions in carbon intensity. A key novelty of our approach is to analyze the two instruments jointly rather than in isolation. This perspective reveals that the use of green debt largely mirrors that of conventional debt markets: bonds concentrate among large emitters, and loans reach a broader and more diverse set of firms. Firm-level improvements in carbon intensity are comparable across the two instruments and appear tied to their green design. At the aggregate level, however, differences in market reach generate distinct outcomes for bonds and loans. By analyzing them within a unified framework, our study sheds light on the channels through which green debt markets contribute to emissions abatement.

The remainder of this paper is structured as follows. Section 2 provides an overview of the green debt market and details the main dataset used in the analysis. Section 3 examines the distribution of green and conventional debt over time and across different regions. Section 4 shows the types of firms issuing green and conventional debt. Section 5 investigates the performance patterns at both the firm and aggregate levels associated with conventional and green debt issuances. Section 6 offers concluding remarks.

2 Structure of Corporate Debt Markets and Data Collected

2.1 Conventional and Green Debt Markets

Corporate bonds and syndicated loans are the primary instruments through which firms raise debt at scale. Both markets have expanded significantly over the past two decades, increasing their importance relative to traditional bank lending and playing a central role in the global growth of corporate leverage (Abraham et al., 2021a; Aramonte et al., 2023; Acharya et al., 2024).

Bonds and syndicated loans increasingly operate as part of a common market for corporate debt. Syndicated loans—while originated by banks—have evolved to share some characteristics of public bonds in key respects: they are often syndicated to non-bank institutional investors, structured off banks' balance sheets, tranched by risk, and actively traded in secondary markets (Gatev and Strahan, 2009; Ivashina and Scharfstein, 2010; Aldasoro et al., 2022; Albuquerque et al., 2025). At the same time, syndicated loans retain features that reflect their banking origins. Even when packaged into collateralized loan obligations (CLOs), banks typically remain responsible for origination and loan servicing. In contrast, bonds are fully intermediated through market-based underwriting and servicing.

Since the early 2010s, both instruments have evolved to incorporate environmental objectives, giving rise to the emergence of green bonds and syndicated loans. We define green debt instruments as those that either allocate proceeds for environmentally beneficial projects or connect financial terms to achieving sustainability targets. This includes traditional green-labeled instruments tied to the use of proceeds and newer sustainability-linked bonds and loans tied to environmental performance. While there is no universal regulatory definition of green debt, our approach reflects the two main ways individual debt transactions align with climate goals. Green-labeled instruments publicly commit capital to green projects, whereas sustainability-linked instruments incorporate pricing incentives based on sustainability outcomes. We classify all other debt instruments as conventional.

In bond markets, green-labeled bonds retain the same financial structure as conventional bonds but include a public commitment by the issuer to allocate proceeds to environmentally beneficial projects—such as renewable energy, energy efficiency, or clean transportation. These commitments are typically guided by voluntary market standards rather than enforced through binding contractual clauses. As a result, compliance is driven by reputational concerns, investor oversight, and, in some cases, third-party verification. Issuers can self-label or align green bonds with standards such as the ICMA Green Bond Principles (ICMA, 2021). A subset of these bonds is aligned with the Climate Bonds Initiative (CBI) taxonomy, which builds on ICMA standards by specifying more detailed eligibility criteria for green projects. Some issuers seek formal CBI certification, while others simply declare alignment without

certification. In contrast, sustainability-linked bonds tie financial terms—typically coupon step-ups—to the issuer's progress toward predefined environmental or ESG performance targets (ICMA, 2020b).

A similar green debt structure has emerged within syndicated loan markets. Green-labeled loans follow a use-of-proceeds model in which borrowers commit to allocating funds to eligible environmental investments. As with green bonds, these commitments are generally governed by voluntary guidelines, such as the Green Loan Principles published by the Loan Market Association (APLMA, LMA, and LSTA, 2019). Sustainability-linked loans, by contrast, incorporate environmental incentives directly into the loan contract, with pricing terms (e.g., interest rates) adjusting based on the borrower's performance against specified environmental targets. Introduced in 2017, these instruments have grown rapidly, and thus, represent a substantial share of green lending activity (Du et al., 2023).

2.2 Data

To study the importance of the green debt market, we construct a comprehensive dataset that links transaction-level data on green and conventional corporate debt issuances to firm-level financial and carbon emissions from 2012 to 2023.

The transaction-level data come from the Securities Data Company (SDC) Platinum database from LSEG (the London Stock Exchange Group), formerly from Refinitiv and Thomson Reuters. This database offers detailed coverage of global corporate bond and syndicated loan transactions, including issuance volume, nature of the debt and its terms, and borrower characteristics. LSEG also classifies syndicated loans into conventional, green-labeled, and sustainability-linked categories. Loan transactions include term loans, fixed-amount instruments with scheduled repayments, and revolving credit facilities, allowing borrowers to draw down funds up to a predefined limit as needed. While these structures differ in flexibility and repayment, both are syndicated through similar bank-led arrangements, serve comparable financing functions, and share key contractual features. In our analysis, we group sustainability-linked term loans and revolvers together, as they represent conceptually similar green pricing-based instruments. Moreover, more than half of revolver transactions occur

with term loans attached in the same package, and both aim to incentivize environmental performance through margin adjustments tied to sustainability targets.[3]

For green bonds, we supplement the transaction-level dataset with Govsearch, also from LSEG, which provides systematic green bond identification based on issuer disclosures and external certification frameworks. This source enables the classification of green bonds into five categories: CBI-aligned, CBI-certified, self-labeled green bonds, sustainability bonds, and sustainability-linked bonds.[4]

The firm-year balance sheet and income statement data are obtained from Worldscope Fundamentals, also from LSEG, which provides standardized global coverage of publicly listed firms. Total debt is defined as the stock of all outstanding liabilities, encompassing both green and conventional instruments. Measures of firm size or operational scale are total assets and operating income.[5] As a complementary size proxy, we compute the average transaction size across all debt issuances by each firm during the sample period, using the global transactions dataset. This variable extends coverage to both listed and unlisted issuers and is highly correlated with balance-sheet size measures (Appendix Figure 1). Therefore, it provides a useful benchmark for assessing whether the characterization patterns observed for listed firms are consistent across the broader set of debt issuers. All monetary variables from Worldscope (e.g., assets, income, debt), as well as the transaction-level issuance volumes, are deflated to constant 2011 U.S. dollars and reported in millions.[6]

Firm-year carbon emissions data are primarily sourced from LSEG, with supplementary data from MSCI used only when a firm has missing LSEG emissions data for all years in the sample. The dataset includes Scope 1 (direct emissions) and Scope 2 (indirect emissions from purchased energy), reported in millions of tonnes. Emissions figures include CO_2 and

[3] The main results in this paper hold when sustainability-linked revolver transactions are excluded from the analyses.

[4] Sustainability bonds are a type of green-labeled bond, typically aimed at financing a mix of environmental and social projects. They differ from sustainability-linked bonds, which are pricing-based instruments rather than green-labeled instruments.

[5] For comparison, we also use physical capital (property, plant, and equipment) in the summary statistics.

[6] To deflate all monetary values to constant 2011 U.S. dollars, we use the U.S. Consumer Price Index (CPI). Domestic currency values are first converted to U.S. dollars using contemporaneous exchange rates. This choice is unlikely to bias the empirical results on green versus conventional debt. Both types of debt issuers within a country are similarly exposed to domestic conditions, and all regressions include country-year fixed effects to absorb macroeconomic shocks.

CO_2 equivalent greenhouse gases.[7] For simplicity, we refer to all these as "carbon emissions" throughout the paper. We use this dataset to construct total carbon emissions and carbon intensity, defined as total Scope 1 and 2 emissions (in metric tonnes) divided by firm operating income (in millions of U.S. dollars).

To construct a matched panel, we aggregate transaction-level data to the firm-year level, summing total issuance volumes for each firm separately by instrument type. For firm-years with no recorded issuance, we explicitly assign zeros to ensure a balanced panel coverage. We then merge the debt data with the firm-level financials and carbon emissions using a combination of identifiers, including permanent firm IDs, ISINs, SEDOLs, and CUSIPs.

The final dataset includes 120,711 annual conventional debt transactions and 6,412 green debt transactions across 85 countries during 2012–2023 (Table 1).[8] Green debt transactions tend to be larger than their conventional counterparts. The median issuance size for green debt is $200 million, compared to $149 million for conventional debt. The median maturity is similar across categories, approximately 5.2 years for green debt and 5.0 years for conventional debt. Still, within each category, bonds exhibit longer maturities than syndicated loans (by about 1 year on average). Across all green debt transactions, 58 percent of issuances are sustainability-linked, while 42 percent are green-labeled instruments. However, this composition varies significantly by instrument type. Among green bonds, the majority (88 percent) are green-labeled instruments, whereas 70 percent of green syndicated loans are sustainability-linked.[9]

There is also significant heterogeneity within each category of green bond and loan instruments (Appendix Table 2). Among green bonds, self-labeled green issuances are systematically smaller and shorter in maturity than the other types of green issuances. In particular, their median size is roughly half that of CBI-aligned or CBI-certified bonds, and their maturities are 1 to 2 years shorter. Similar differences hold when comparing self-labeled green bonds with sustainability-linked bonds. In the loan market, green-labeled loans are

[7] CO_2 equivalent includes methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorinated compounds (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3).
[8] Appendix Table 1 provides the full list of countries and the total amounts each country raised through green and conventional debt.
[9] Approximately 91 percent of green debt issuances are classified as investment-grade, compared to 70 percent for conventional debt.

also substantially smaller than sustainability-linked transactions, though they tend to have somewhat longer maturities (about 2 years).

In terms of firms, the dataset includes 50,832 unique non-financial firms across 85 countries (Table 2). Of these, 46,987 firms issued only conventional debt, while 3,845 firms participated in the green debt market. Among green debt issuers, 1,334 firms issued green bonds, 2,773 issued green loans, and only 157 issued both types of instruments (Table 3).[10] This limited overlap suggests that firms tend to specialize in one form of green debt—either bonds or loans—rather than combining them. Approximately 40 percent of green debt issuers report balance-sheet and carbon emissions. This includes the world's largest firms, which are also the most significant emitters. Because reporting requirements are generally required for listed firms or for those subject to enhanced ESG disclosure standards, this dataset provides the most comprehensive available basis for analyzing the relation between corporate debt and carbon emissions.

3 Evolution of Green and Conventional Debt

To examine the evolution of green debt relative to conventional corporate debt over the 2012–2023 period, we begin by showing changes in overall issuance volumes and instrument composition. We then analyze the geographic and sectoral distribution of green versus conventional debt.

Green debt issuance has expanded rapidly since 2018, contrasting with a decline in conventional borrowing. Between 2017–2018 and 2022–2023, annual green issuance rose nearly ninefold, from $64 billion to about $574 billion (Figure 1, Panel A). Over the same period, annual conventional debt issuance declined from $5.6 trillion to $4.1 trillion. As a result, the green share of total corporate debt issuance rose from 2 percent in 2017 to approximately 12 percent by 2023 (Figure 1, Panel B).

Growth in green issuance occurred in both bond and loan markets, although with distinct trajectories. Green bond issuance peaked at approximately $200 billion in 2021 but

[10] For comparison, conventional debt markets exhibit a similar segmentation pattern: of the 46,987 conventional issuers, 42,094 issued only bonds or syndicated loans, while 3,893 firms issued both types of instruments.

declined to $145 billion during 2022-23 (Figure 2, Panel A). This expansion was primarily driven by the issuance of CBI-aligned instruments.[11] Green syndicated loans grew even more rapidly, fueled by the adoption of sustainability-linked contracts. By 2023, green loans had become the dominant vehicle for corporate green finance, with total financing reaching $428 billion—nearly triple the volume of green bonds. Even when excluding revolving credit facilities, green loan volumes totaled $197 billion in 2023, exceeding green bond volumes. Green loans also exhibit a higher market share relative to their conventional counterparts. By 2023, they accounted for nearly 14 percent of total syndicated loan issuance, compared to roughly 10 percent for green bonds within the bond market (Figure 2, Panel B).

The global distribution of green debt between 2012 and 2023 differs markedly from that of conventional debt (Figure 3, Panel A). Europe has emerged as the global leader in green debt markets, accounting for about 51 percent of total green volumes—well above its 19 percent share of conventional debt. This expansion reflects broad-based growth across European countries, most of which improved their global rankings in green debt volumes relative to conventional benchmarks (Appendix Table 1). Other regions have also modestly expanded their presence: East Asia (excluding China) increased its share from 3 to 6 percent, while Latin America (and the Caribbean) rose slightly from 2 percent to 2.4 percent. By contrast, the United States—long the dominant player in corporate bond and syndicated loan markets—lags in green finance. It accounts for 47 percent of global conventional debt but just 20 percent of green issuance. China shows a similar pattern, representing 13 percent of conventional issuance but about 5 percent of green debt. Penetration rates, measured as the share of green in total corporate debt, follow a similar pattern (Figure 3, Panel B). In 2022–2023, over 30 percent of European corporate debt was classified as green, around 18 percent in East Asia and Latin America, and only 6.5 percent and 3 percent in the United

[11] Appendix Figure 2 shows the green debt evolution across different types of green debt instruments.

States and China, respectively.[12]

One possible driver behind the broader adoption of green debt in Europe is regulation (Demski et al., 2025). Europe's leadership in green debt coincides with the rollout of a comprehensive regulatory framework for sustainable finance. The EU Green Taxonomy, finalized in 2020, is the world's only legally binding classification system for environmentally sustainable activities (Merler, 2025). It requires companies to disclose the share of operations aligned with sustainability criteria, offering a consistent reference for green investment. The Sustainable Finance Disclosure Regulation (SFDR), proposed in 2018 and implemented in 2019, mandates ESG disclosures from financial market participants (European Commission, 2024).[13] In contrast, the United States lacks a unified federal regulatory framework for ESG investing. Its system remains fragmented, with variations across states and frequent political shifts that generate uncertainty for both issuers and investors (DataFisher, 2024). This divergence in the institutional context might explain the slower adoption of green instruments in the United States, despite its longstanding dominance in conventional debt markets.[14]

At the sectoral level, the distribution of green debt also differs from that of conventional debt. Utilities account for 43 percent of total green issuance compared to 25 percent of conventional issuance (Figure 3, Panel A). Renewable energy captures 0.5 percent of conventional issuance and 4 percent of green issuance. Manufacturing has a similar share in both markets, at around 30 percent of total issuance. By contrast, services, trade, construction, and fossil fuels have smaller shares in green relative to conventional markets. For instance,

[12] Regional groups are defined as follows. "Europe" includes all European Union member states plus Norway and the United Kingdom. "Other Advanced Economies" comprise Australia, Canada, Iceland, Japan, New Zealand, and Switzerland. The United States and China are reported separately. "East Asia" covers Hong Kong SAR, China, Indonesia, Malaysia, the Philippines, Singapore, Taiwan, China, Thailand, and Viet Nam. "Latin America (and the Caribbean)" includes Argentina, Brazil, Chile, Colombia, Costa Rica, the Dominican Republic, Ecuador, Mexico, Panama, Peru, and Uruguay. "Other Emerging Economies" comprise Albania, the Arab Republic of Egypt, Bahrain, Bangladesh, Bulgaria, Cambodia, the Democratic Republic of Congo, Cyprus, Georgia, Ghana, India, Israel, Kazakhstan, Kenya, Lao PDR, Lesotho, Mauritius, Mongolia, Morocco, Nigeria, Oman, Qatar, Russian Federation, Saudi Arabia, Senegal, Serbia, South Africa, Türkiye, Ukraine, United Arab Emirates, Uzbekistan, and Zambia.

[13] These efforts are further reinforced by the Corporate Sustainability Reporting Directive (CSRD) and the broader European Green Deal, which together strengthen investor confidence and align regulatory incentives for green issuance. The CSRD establishes harmonized sustainability reporting standards across firms and financial institutions. The European Green Deal, launched in 2019, outlines Europe's sustainability and climate strategy.

[14] Consistent with this interpretation, Demirgüç-Kunt et al. (2024) show that stronger climate policy frameworks are associated with a reallocation of global bank lending away from carbon-intensive sectors, highlighting the role of policy in steering financial flows toward greener activities.

fossil fuels account for 10 percent of conventional issuance and 4 percent of green issuance. By 2022–2023, about 50 percent of all debt issuance in the renewable energy sector and 20 percent in utilities was classified as green, the highest sectoral penetration rates observed (Figure 3, Panel B).

These regional and sectoral differences in green debt adoption are consistent across bonds and syndicated loans (Appendix Figure 3). However, green loans reach a wider set of countries and sectors than bonds. Among the 85 countries in our sample, 31 use green loans but not green bonds, while only 5 use green bonds but not green loans (Appendix Table 1). Importantly, the countries that use only green loans are the same ones that use only conventional loans. A similar pattern is present across industries: green loans cover a broader range of two-digit SIC sectors than green bonds, mirroring the differences in conventional loans and bonds. Thus, green loans might play an important role in broadening the reach of sustainable finance across countries and industries.

4 Firms Issuing Green and Conventional Debt

To analyze how green debt is allocated across firms, we compare issuer characteristics with patterns observed in conventional corporate debt markets. We focus on three dimensions: prior use of debt markets, operational scale, and environmental profiles, with distinctions between green bonds and syndicated loans.

Green debt markets are dominated by hybrid issuers—firms that issue both green and conventional instruments. Between 2012 and 2023, these firms accounted for 65 percent of all green debt issuers (Table 2), capturing nearly 85 percent of total green debt volume (Figure 4, Panel A). Among them, 91 percent had issued conventional debt before their first green transaction, indicating that green market participation has expanded mainly through firms with pre-existing access to traditional debt markets.[15] These firms are also the largest in the sample, with a median asset size of $4.9 billion, more than 5 times that of both pure conventional issuers and pure green issuers (Table 2). They carry higher levels of debt, income,

[15] Appendix Table 3 lists the top 20 green debt issuers, showing that the largest borrowers in green markets are well-known corporations, which are also prominent conventional debt issuers. Appendix Table 4 provides the corresponding ranking for lenders, indicating that the same global banks that dominate conventional syndicated loans also lead the bulk of green syndicated lending as arrangers.

and physical capital, and are also substantially more polluting. Their median emissions reach 0.42 million tonnes, compared to 0.11 million tonnes for conventional issuers.[16] This reflects the close link between firm size and emissions, with the top 10 percent of firms in our sample accounting for about 87 percent of reported emissions between 2012 and 2023 (Appendix Figure 1).[17] Over time, hybrid issuers have increased their use of green instruments. By 2022–2023, green debt represented 35 percent of their total issuance (Figure 4, Panel B).

This dominance of large firms is further reflected in the concentration of green debt markets. The top quartile of firms by asset size accounted for 87 percent of total green issuance over the sample period, compared to 77 percent in conventional markets (Figure 5, Panel A). The gap is even wider when measured by the number of transactions. The top quartile of green issuers generated 61 percent of all green debt transactions, compared to 39 percent in the conventional market (Figure 5, Panel B). Green debt issuance is thus more concentrated at the top than in conventional markets, both in terms of issuance volume and activity.

The patterns are broadly consistent when green debt is split into bonds and loans, but important differences arise. Concentration is particularly pronounced in the green bond segment: the top quartile of green bond issuers accounts for 92 percent of total issuance volume and 73 percent of transactions, compared to 84 and 53 percent, respectively, for green loans (Figure 6). Green bond issuers are also more than twice as large as green loan issuers in terms of median assets (Table 3). In contrast, the green loan market features a more balanced issuer composition, with greater participation from smaller firms and pure green issuers. Furthermore, for hybrid loan issuers, green debt constituted over 40 percent of total issuance by 2022–2023, whereas for hybrid bond issuers, it captured just 22 percent (Figure 4, Panel B). Overall, while green bonds remain concentrated in the largest firms, syndicated loans play a distinct role in broadening participation.

To formally assess the link between firm size and participation in green debt markets, we estimate a linear probability model that links firm characteristics to the likelihood of

[16] The size differential between green and conventional issuers holds across regions and sectors (Appendix Figure 4).
[17] Hybrid issuers are also more carbon intensive, with a ratio of 92.7, compared to 50.8 among conventional debt issuers.

issuing green rather than conventional debt, controlling for country- and industry-specific trends. We estimate the following equation:

$$GD_{i,t} = \gamma + \beta X_{i,t} + \theta_{c,t} + \theta_{s,t} + \epsilon_{i,c,s,t}, \tag{1}$$

where $t \in \{2012\text{-}2022\}$ and $GD_{i,t}$ is a binary indicator equal to one if a firm issues green debt in a given year and zero if a firm issues conventional debt. In addition, to directly compare green bonds and loans, we redefine the dependent indicator $GD_{i,t}$ to equal one if a firm issues a green loan in a given year, and zero if it issues a green bond. The vector $X_{i,t}$ includes the logarithm of the average transaction size (2012-23), lagged asset values, lagged income values, lagged carbon emissions, and lagged carbon intensity. The model controls for regional and sectoral heterogeneity using country-time and industry-time fixed effects $\theta_{c,t}$ and $\theta_{s,t}$, respectively. We estimate Equation 1 using the full sample of firm-year observations for debt issuers over the 2012–2023 period.[18]

The results confirm that firm size is a key predictor of green issuance (Table 4). For example, a doubling of total assets is associated with a 2 percentage point higher probability of issuing green rather than conventional debt, equivalent to a 34 percent increase relative to the baseline probability of 5.8 percent. Similar patterns hold across other firm-level characteristics: firms with higher income, larger fixed assets, and greater carbon emissions are significantly more likely to issue green debt. For example, a doubling of carbon emissions is linked to a 27 percent increase in the probability of green issuance. These relations are robust across model specifications and remain statistically significant after controlling for time-varying country and industry effects. The analysis also indicates that more carbon-intensive firms are more likely to issue green debt than conventional debt. However, once industry-year and country-year fixed effects are included, the magnitude and significance of this difference decrease.

Size differences between green and conventional issuers persist across bond and loan markets (Table 5). Within each segment, firm size is positively associated with the probability

[18] We use a linear probability model (LPM) for ease of interpretation, as the coefficients can be directly read as changes in probability. Results are robust to estimating the same specification using logit and probit models, with nearly identical significance and directional patterns. Since our primary interest lies in comparing relative associations across firm characteristics and not in modeling probabilities at the extremes, the LPM provides a transparent and tractable baseline.

of issuing green relative to conventional debt. However, across green instruments, larger firms and higher emissions are more associated with bond issuance than with loan issuance, consistent with the greater preponderance of bonds among large firms observed in the descriptive evidence.

One plausible explanation for the prevalence of large firms among green debt issuers, relative to those relying on conventional instruments, is the presence of substantial fixed costs associated with green issuance. Regulatory compliance, sustainability reporting, third-party verification, and instrument structuring are generally more demanding for green debt than for conventional borrowing. For example, bonds aligned with or certified by the CBI must adhere to a detailed taxonomy of eligible activities and undergo formal pre- and post-issuance verification in the case of certification. These requirements impose added administrative and audit burdens. Similarly, sustainability-linked instruments require firms to define and track environmental performance targets, supported by ongoing data collection, external assurance, and public reporting. These tasks involve substantial up-front investments, which are more easily absorbed by large firms with an established ESG infrastructure and internal compliance capacity (ERM, 2022; OECD, 2021b).

Consistent with this interpretation, firm size varies systematically across green debt instruments (Figure 7). Issuers of green bonds (including CBI-certified, CBI-aligned, sustainability-linked, or self-labeled green bonds) are the largest participants in corporate debt markets. They are typically larger than conventional bond issuers, all types of green loan issuers, and conventional loan issuers. By contrast, green loan issuers, especially those relying on self-labeled instruments, are significantly smaller, though still larger than conventional loan issuers. Within the loan segment, sustainability-linked loan issuers are larger than those issuing green-labeled loans, consistent with the added compliance burden associated with setting and tracking performance targets. A similar hierarchy is evident in the volume of funds raised per transaction. One exception is self-labeled green bonds, which are relatively low-volume transactions issued by otherwise large firms.

The evolution of green debt issuances sheds light on how large incumbent market participants use and can benefit from the rise of a new type of instrument. On the one

hand, conditions in the early stages of the green debt markets, when there was a narrower understanding of the characteristics of these instruments, less standardization, and fewer participants in their origination and certification, could have resulted in higher entry costs that benefited large incumbent firms. On the other hand, the lack of standardization and bureaucratization of the certification process at earlier stages could have resulted in lower entry costs.

The results show that the relation between green debt issuance and firm size gets tighter over time (Table 6).[19] The results show that, before 2018, firm size is only weakly associated with green issuance. However, the relation becomes significantly stronger in the 2018–2023 period, consistent with the growing dominance of larger firms as green markets mature. This supports the view that the standardization of green activities through taxonomies, improvements in the certification process, and increased interest of institutional investors in this type of instrument might have benefited access to green debt markets by larger firms, relative to earlier stages of the market.

5 Performance

Because green instruments are explicitly designed to support environmentally beneficial activities, a first-order question is whether their issuance is associated with observable differences in firm behavior relative to conventional debt. We therefore examine how firms evolve following the issuance of green and conventional instruments. We also distinguish between bonds and loans, given that differences between green and conventional borrowing can partly reflect the market through which financing takes place.

The empirical strategy proceeds in two steps. First, we estimate firm-level changes in total debt, assets, operating income, and carbon intensity following different types of debt issuance. Changes in total debt indicate whether green borrowing is used to expand financing or to alter its composition. These choices, in turn, shape firm scale as reflected in assets and income. Together with carbon intensity, scale determines the trajectory of firms' total emissions, since reductions in emissions per unit of output could be offset—or even

[19] To construct the table, we re-estimate Equation 1 for distinct subperiods.

outweighed—by post-issuance expansion in firm activity. Second, we aggregate firm-level responses using observed green debt issuance patterns to approximate the contribution of green debt to global emissions trends. This aggregation reflects not only firm-level performance but also the scale of participating firms and the patterns of issuance across markets.

5.1 Firm-level Outcomes

To examine how firm performance evolves following debt issuance, we implement the LP-DiD approach. This method estimates dynamic treatment effects while addressing biases that arise in staggered estimation settings, particularly the use of already-treated units as controls. To avoid this problem, we impose a "clean control" condition: we exclude from the estimation any firm-year observation where the firm issues the same type of debt in the four years before the treatment (debt issuance) year. This ensures that control observations have not been recently treated, and thus serve as a valid control group. The treated observations correspond to different types of debt issuance, as described below.

We estimate the following specification for each outcome variable:

$$y_{i,t+h} - y_{i,t-1} = \beta_h^{\text{LP-DiD}} \Delta D_{i,t} + \theta_{c,t}^h + \theta_{s,t}^h + \epsilon_{i,c,s,t}, \tag{2}$$

where $y_{i,t+h}$ denotes the log of the firm i's outcome (total debt, assets, operating income, and carbon intensity) h years after issuance. The treatment indicator $\Delta D_{i,t}$ is equal to one if the firm issues the relevant type of debt in year t, and zero otherwise. Importantly, the estimation is restricted to a sample in which no firm has issued the same type of debt in the four years before year t.[20] This restriction applies to both treated and control units and ensures that control observations are not contaminated by residual effects from prior treatments. Country-year and sector-year fixed effects ($\theta_{c,t}^h$ $\theta_{s,t}^h$) control for time-varying country and industry-specific shocks. The coefficient $\beta_h^{\text{LP-DiD}}$ captures the cumulative post-treatment change relative to the baseline year $t-1$.

This framework enables structured comparisons of firm trajectories following different financing choices. We assess whether green debt issuance is associated with distinct post-

[20] We adopt a four-year cleaning window to align with the event-study horizon, which considers outcomes up to four years before and after issuance. Results are robust to using a five-year window (the median maturity of corporate debt) and a three-year window.

issuance dynamics relative to two benchmarks: (i) firms without new debt issuance in those years, and (ii) firms with conventional debt issued in those years.

The regression results show that, relative to non-issuance periods, green debt issuance is associated with significant firm-level expansion in total balance sheet debt and size (Figure 8, Panel A). Total debt rises by about 15 percentage points (p.p.) in the year of issuance and the two years that follow, accompanied by increases of roughly 10 p.p. in assets and operating income. These dynamics are evident across bond and loan markets, though the magnitude differs. Green bond issuance is followed by stronger expansion of balance sheet variables, with total debt rising by 20 p.p. and operating income by 13 p.p., whereas green loans are associated with more moderate increases of around 10 p.p. in debt and 5 p.p. in income.

Beyond firm growth, green debt is also consistently followed by reductions in carbon intensity (emissions per unit of operating income). Relative to non-issuance periods, carbon intensity falls by 25 p.p. by year three and 45 p.p. by year four (Figure 8, Panel A). These improvements are robust across both bonds and loans: firms issuing either instrument experience statistically significant and sustained declines in carbon intensity (Panels B and C).

By contrast, conventional debt issuance is associated with firm growth but not with improvements in carbon intensity (Figure 9). Following the issuance of conventional bonds or loans, firms increase total debt by approximately 25 p.p., and assets and operating income by up to 13 p.p. However, carbon intensity remains broadly unchanged—or increases slightly—over the same period, indicating that conventional borrowing is not systematically linked to post-issuance decarbonization.

Direct comparisons between green debt (the treated group) and conventional debt (the control group) underscore these differences (Figure 10). Because both types of borrowing are associated with statistically similar increases in debt and income, the LP-DiD estimations show no clear pattern after the green debt issuance.[21] However, environmental outcomes diverge significantly. Green debt is systematically associated with reductions in carbon

[21] Green loans are linked to somewhat smaller firm expansion than their conventional counterparts.

intensity, with the gap relative to conventional debt reaching about 30 p.p. by year three and 50 p.p. by year four. These differences are even more pronounced than those observed when comparing green debt to non-issuance periods, highlighting the distinct environmental alignment of green borrowing relative to conventional financing.[22]

Lastly, we explicitly compare responses to green bond and green loan issuances to assess whether the two instruments generate systematically different outcomes (Figure 11). Bond issuance is associated with significantly larger increases in outstanding debt and firm size than loan issuance, indicating a stronger association between bonds and post-issuance expansion. By contrast, the reductions in carbon intensity following green borrowing do not differ significantly between the two instruments. Overall, these results suggest the distinction between bonds and loans is most relevant for firm growth trajectories, while environmental outcomes are statistically similar across the two types of green debt.

These results are robust to several sensitivity checks (Appendix Figure 7). First, restricting the sample to green debt issuers enables comparisons within those firms and yields estimates similar to the main results. Second, we construct a propensity score-matched (PSM) sample of green and conventional debt issuers based on average firm-level income and carbon intensity across the sample period.[23] The post-issuance trajectories observed in the green issuer and PSM samples closely mirror those in the full data, and in some cases yield slightly larger estimates, with carbon intensity falling by 40–60 p.p. by year four relative to the two counterfactual comparisons (no debt and conventional debt). Third, results are also consistent across different types of debt contracts: both use-of-proceeds instruments and sustainability-linked loans are followed by sustained declines in carbon intensity. Together, these patterns indicate that green debt is systematically associated with environmental improvements across samples and instruments.

[22] Appendix Figures 5 and 6 decompose carbon intensity trends into Scope 1 and Scope 2 emissions. The results show that the post-issuance decline in overall intensity is primarily driven by significant reductions in Scope 1 emissions, while Scope 2 exhibits a noisier pattern with weaker evidence of sustained declines. Taken together, this suggests that firms are adjusting their production processes to reduce direct emissions more efficiently, while indirect emissions linked to purchased energy witness less systematic changes.

[23] Each green debt issuer is matched to the nearest-neighbor conventional issuer using average operating income and carbon intensity over the entire sample window. The matched sample includes 1,149 green issuers, down from the full sample of 3,845.

5.2 Aggregate Outcomes

To assess the macro-level implications of green debt, we aggregate firm-level responses using observed issuance patterns alongside the dynamic effects estimated in the previous section. This exercise combines three elements of the analysis: the volume and timing of green debt issuances, the distribution of green debt issuances across firms, and the post-issuance performance. Together, these components allow us to estimate the total change in corporate carbon emissions associated with green debt.

We project each firm's emissions path by applying our LP-DiD estimates of post-issuance changes in carbon intensity and operating income to the firm's initial scale and emissions profile. We then aggregate these projections to calculate the associated changes in total emissions at the global level.

Formally, firm-level emissions can be expressed as the product of carbon intensity and firm size:

$$\textit{Carbon Emissions}_{i,t} = \left(\frac{\textit{Carbon Emissions}}{\textit{Firm Size}} \right)_{i,t} \textit{Firm Size}_{i,t}. \tag{3}$$

Letting $c_{i,t}$ denote carbon intensity and $s_{i,t}$ denote firm size (measured by operating income), total emissions across firms at time t are:

$$C_t = \sum_i c_{i,t} s_{i,t}. \tag{4}$$

The change in aggregate emissions over the post-issuance horizon h can then be decomposed as:

$$\Delta C_{t+h} = \sum_i \left[(\Delta c_{i,t+h} s_{i,t}) + (\Delta s_{i,t+h} c_{i,t}) + (\Delta c_{i,t+h} \Delta s_{i,t+h}) \right], \tag{5}$$

where $\Delta c_{i,t+h}$ and $\Delta s_{i,t+h}$ represent changes in carbon intensity and firm size, respectively. The decomposition separates aggregate emissions changes into three parts: (i) reductions due to lower carbon intensity (efficiency gains), (ii) increases due to firm growth (scale effects), and (iii) their interaction. This structure provides a transparent and additive mapping from firm-level debt dynamics to economy-wide climate outcomes.

Aggregation Procedure. Building on the decomposition in Equation (5), we quantify the macro-level emissions impact of green debt by applying the LP-DiD estimated changes in carbon intensity ($\beta_{c,h}$) and firm size ($\beta_{s,h}$) to the baseline characteristics of green debt issuers in each year t, allowing us to simulate aggregate emissions outcomes.[24]

In implementing Equation (5), we apply the pooled LP-DiD estimate for carbon intensity, as firm-level trajectories do not differ significantly between green bonds and green loans. For firm size adjustments, we use instrument-specific coefficients, which reflect systematic differences in post-issuance changes in scale between bond and loan markets.

We consider the same two counterfactuals used to estimate firm-level performance: (i) green debt issuance relative to no issuance, and (ii) green debt versus conventional debt issuance. The projected change in aggregate emissions h years after green debt issuance is given by:

$$\Delta C_h^t = \sum_i \left[(\beta_{c,h} c_{i,t-1})\, s_{i,t} + (\beta_{s,h} s_{i,t-1})\, c_{i,t} + (\beta_{c,h} c_{i,t-1})\, (\beta_{s,h} s_{i,t-1}) \right] I_{i,t}, \tag{6}$$

where $s_{i,t}$ and $c_{i,t}$ denote firm-level carbon intensity and size, and $I_{i,t}$ is an indicator equal to one if firm i issued green debt in year t. The first two terms capture the marginal effects of changes in intensity and scale; the final term captures their interaction. This formulation reflects the cumulative emissions change attributable to green debt issued in year t, evaluated h periods later.

To compute the total impact over time, we sum across issuance cohorts. Let t_0 be the baseline year and T the final year, assuming treatment effects persist for H years. Then:

$$C_T - C_{t_0} = \sum_{t=t_0}^{T-H} \Delta C_H^t + \sum_{h=1}^{H-1} \Delta C_h^{T-h},$$

where the first term sums fully realized H-year effects, and the second term captures partial effects for more recent issuances.

[24] To ensure complete firm-level information for the aggregation exercise, we impute missing baseline characteristics using the median value of each variable by industry and instrument type (bond or loan). This approach preserves heterogeneity across firm types while maintaining the representativeness of the issuer sample.

Substituting Equation (6) into this expression yields:

$$C_T - C_{t_0} = \sum_{t=t_0}^{T-H} \sum_i \Big[(\beta_{c,H} c_{i,t-1})\, s_{i,t} + (\beta_{s,H} s_{i,t-1})\, c_{i,t} + (\beta_{c,H} c_{i,t-1})\,(\beta_{s,H} s_{i,t-1}) \Big] I_{i,t} + \sum_{h=1}^{H-1} \sum_i \Big[(\beta_{c,h} c_{i,T-h-1})\, s_{i,T-h} + (\beta_{s,h} s_{i,T-h-1})\, c_{i,T-h} + (\beta_{c,h} c_{i,T-h-1})\,(\beta_{s,h} s_{i,T-h-1}) \Big] I_{i,T-h}. \quad (7)$$

More generally, for any given calendar year t, the cumulative emissions change since baseline year t_0 is:

$$C_t - C_{t_0} = \sum_{h=1}^{t-t_0} \sum_i \Big[(\beta_{c,h} c_{i,t-h-1})\, s_{i,t-h} + (\beta_{s,h} s_{i,t-h-1})\, c_{i,t-h} + (\beta_{c,h} c_{i,t-h-1})\,(\beta_{s,h} s_{i,t-h-1}) \Big] I_{i,t-h}. \quad (8)$$

This structure enables forward-looking simulations of aggregate emissions under different green debt issuance scenarios and translates firm-level behavioral effects into cumulative macroeconomic outcomes.

Aggregate Results. Our analysis indicates that green debt issuance during 2012-23 is associated with substantial reductions in aggregate carbon emissions relative to the no-issuance and conventional-issuance scenarios.

The results suggest that cumulative emissions reductions associated with green debt issuance amount to approximately 4.5 billion metric tonnes in the no-issuance scenario, and 5.7 billion metric tonnes in the conventional-issuance scenario by 2025 (Figure 12). For comparison, global energy-related CO_2 emissions reached a record 37.4 billion metric tonnes in 2023, according to the International Energy Agency (IEA, 2024). Thus, our estimates correspond to roughly 12 to 15 percent of one year's global emissions. The largest issuers account for a disproportionate share of the aggregate effect. In our sample, the top quartile of firms represents about 85 percent of total estimated abatement, reflecting their high baseline emissions and dominant role in issuance volumes.

Both green bonds and green loans are linked to substantial reductions in aggregate emissions. Green bonds are associated with cumulative reductions of 2.8 billion metric tonnes under the no-issuance scenario and 3.6 billion metric tonnes under the conventional-issuance scenario, while green loans contribute 1.6 billion and 2.1 billion metric tonnes, respectively. These differences reflect both firm-level dynamics and issuer composition. Larger expansions in firm size follow green bond issuances, partially offsetting the gains from reduced carbon intensity relative to a no-debt benchmark (Figure 13, Panel A). In contrast, green loans generate emissions reductions more directly through sustained improvements in carbon intensity, coupled with more modest firm expansion (Figure 13, Panel B). Because a common carbon intensity trajectory is applied across instruments, the larger aggregate contribution of green bonds primarily reflects the composition of issuing firms.[25] Green bonds are more frequently issued by large firms with high baseline emissions, whose post-issuance adjustments exert outsized influence on aggregate outcomes. As a result, the distribution of issuer size across instruments plays a central role in shaping the macro relevance of green debt.

Overall, these aggregate results illustrate the potential macroeconomic relevance of firm-level financing patterns for global emissions. However, they should be interpreted as indicative of the scale and relative importance of each market, rather than literal global totals. Although they are approximate estimations, these results provide a transparent and useful benchmark for assessing the global climate impact of green debt markets.

6 Conclusion

This paper analyzed the expansion of green corporate bond and syndicated loan markets around the world, focusing on how firms use green financing relative to conventional debt. We examined which types of firms issue different debt instruments and how they perform after they raise green funding, focusing on firm size and carbon intensity. To complement the firm-level analysis, we developed an aggregation framework to approximate the potential macro-level implications of green debt issuance. Our analysis distinguished between green

[25] Results are broadly consistent when applying instrument-specific carbon intensity trajectories rather than the pooled estimate. Although bond-specific coefficients are moderately larger, issuer composition remains the dominant driver of the greater aggregate abatement linked to green bonds. Using a common trajectory thus yields a conservative estimate of bond-financed impact.

debt and conventional debt overall, as well as between bond versus syndicated loan markets.

We documented a sharp expansion of green debt since 2018, contrasting with a broader deceleration in conventional corporate borrowing. The growth of green debt has been particularly strong in syndicated loan markets and Europe. Syndicated loans account for the largest share of green debt financing and reach a more diverse set of borrowers. Still, green debt issuance as a whole remains dominated by large incumbent firms with elevated baseline emissions, which are central to the climate transition due to their scale and disproportionate contribution to global emissions.

Unlike conventional debt markets, which are not systematically related to environmental improvements, green debt markets are associated with sustained post-issuance reductions in firms' carbon intensity. These patterns are robust across multiple empirical specifications, including within-firm comparisons and matched control samples. Scaling firm-level dynamics to the aggregate level suggests that the cumulative impact of green debt issuance could be meaningful in global terms (roughly equivalent to 12 to 15 percent of one year's energy-related CO_2 emissions), with large firms driving most of the estimated abatement. While approximate, these figures highlight that financing decisions among a relatively small set of large emitters can materially influence aggregate outcomes.

Both green bonds and loans are associated with comparable reductions in carbon intensity but contribute to emissions abatement through complementary channels. Bonds are primarily issued by large, high-emitting firms, implying that similar proportional reductions in carbon intensity translate into greater absolute declines in CO_2. However, post-issuance firm expansion partly offsets these gains. Loans, by contrast, extend more financing to a broader set of firms, sectors, and countries, including smaller borrowers and those in less developed capital markets. Firms that issue green loans also expand after issuance, but to a lesser extent than bond issuers, resulting in a smaller offsetting effect. Taken together, these findings suggest that the environmental effectiveness of green debt is linked to the incentives it generates for firms to align financing with emission-reduction objectives. Moreover, the characteristics of bond and loan markets shape which firms worldwide use them, which is essential for estimating the contribution of green debt to global emissions abatement.

A natural caveat concerns endogeneity. Issuance could reflect pre-existing plans to undertake greener projects that would occur despite the green debt financing. Our analysis does not identify causal effects. Instead, it documents a consistent and economically significant association between debt issuance and subsequent reductions in carbon intensity when firms raise funds through green debt rather than conventional debt. Our decomposition between bonds and loans and the aggregation of firm-level changes also show how the type of financial instrument and the type of firms that use green debt influence the relation between firms' financing choices and climate outcomes.

Lastly, our results raise several questions for future research and policy design. What role can taxonomies, verification standards, and regulatory frameworks play in enhancing the credibility and scaling of green debt? Why has Europe emerged as the global leader in green debt adoption? To the extent that sustainable finance continues to grow, understanding how contractual structures, firm behavior, and institutional environments interact can be essential to realizing its full potential in reducing carbon emissions.

References

Abraham, F., J. J. Cortina, and S. L. Schmukler. 2021a. Growth of global corporate debt: Main facts and policy challenges. *Oxford Research Encyclopedia of Economics and Finance*.

Abraham, F., J. J. Cortina, and S. L. Schmukler. 2021b. The rise of domestic capital markets for corporate financing: Lessons from East Asia. *Journal of Banking & Finance 122*, 105987.

Acharya, V. V., Y. Amihud, and L. Litov. 2011. Creditor rights and corporate risk-taking. *Journal of Financial Economics 102*(1), 150–166.

Acharya, V. V., I. Engle, Robert F, and O. Wang. 2025. Strategic commitments to decarbonize: The role of large firms, common ownership, and governments. NBER Working Paper 33335.

Acharya, V. V. and G. Plantin. 2025. Monetary easing, leveraged payouts, and lack of investment. *Management Science*, 10.1287/mnsc.2022.01440.

Acharya, V. V., G. Plantin, P. Reggiani, and I. Yao. 2024. Monetary easing, lack of investment and financial instability. *Journal of Financial Intermediation 59*, 101100.

Albuquerque, B., E. Cerutti, N. Chen, and M. Firat. 2025. From banks to nonbanks: Macroprudential and monetary policy effects on corporate lending. IMF Working Paper 25/96.

Aldasoro, I., S. Doerr, and H. Zhou. 2022. Non-bank lenders in the syndicated loan market. *BIS Quarterly Review*, March, 15–29.

Aleszczyk, A. A., M. Loumioti, and G. Serafeim. 2022. The issuance and design of sustainability-linked loans. Working paper, SSRN 4287295.

APLMA, LMA, and LSTA. 2019. Sustainability linked loan principles.

Aramonte, S., A. Schrimpf, and H. S. Shin. 2023. Chapter 7: Non-bank financial intermediaries and financial stability. *Research Handbook of Financial Markets*, 147–170.

Bachelet, M. J., L. Becchetti, and S. Manfredonia. 2019. The green bonds premium puzzle: The role of issuer characteristics and third-party verification. *Sustainability 11*(4).

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

Beyene, W., M. D. Delis, and S. R. G. Ongena. 2024. Bond versus banks financing in the climate transition: The role of stranded asset risk. Swiss finance institute research paper no. 24-43, Swiss Finance Institute.

Boot, A. W. A. and A. V. Thakor. 2000. Can relationship banking survive competition? *Journal of Finance 55*(2), 679–713.

Bruno, V. and H. S. Shin. 2017. Global dollar credit and carry trades: A firm-level analysis. *Review of Financial Studies 30*(3), 703–749.

Caramichael, J. and A. Rapp. 2024. The green corporate bond issuance premium. *Journal of Banking and Finance 162*, 107126.

CDP. 2023. The carbon majors database: 2023 update.

Cicchiello, A., M. Corugno, S. Monferrà, and S. Perdichizzi. 2022. Which are the factors influencing green bonds issuance? Evidence from the european bonds market. *Finance Research Letters 50*, 103190.

CPI. 2023. Global landscape of climate finance 2023. 2025-02-07.

DataFisher. 2024. ESG regulations: Comparing the EU and US approaches.

Demirgüç-Kunt, A., A. Pedraza, F. Pulga, and C. Ruiz-Ortega. 2024. Global bank lending under climate policy. *IMF Economic Review 72*, 858–901.

Demski, J., Y. Dong, P. McGuire, and B. Mojon. 2025. Growth of the green bond market and greenhouse gas emissions. *BIS Quarterly Review*, March, 53–71.

Diamond, D. W.. 1984, 07. Financial intermediation and delegated monitoring. *Review of Economic Studies 51*(3), 393–414.

Draghi, M.. 2024. The future of European competitiveness. Report, European Commission.

Du, K., J. Harford, and D. D. Shin. 2023. Who benefits from sustainability-linked loans? *European Corporate Governance Institute—Finance Working Paper*, No 917/2023.

Dube, A., D. Girardi, Ò. Jordà, and A. M. Taylor. 2025. A local projections approach to difference-in-differences event studies. NBER Working Paper 31184.

Dursun-de Neef, , S. Ongena, and G. Tsonkova. 2023. Green versus sustainable loans: The impact on firms' ESG performance. *Swiss Finance Institute Research Paper*, No. 22–42.

Dutordoir, M., J. Quariguasi, and S. Li. 2024. When green is no longer a win - new evidence on the shareholder wealth effects of green bond offerings. Working paper, SSRN 4287295.

Ehlers, T., B. Mojon, and F. Packer. 2020. Green bonds and carbon emissions: Exploring the case for a rating system at the firm level. *BIS Quarterly Review*. September, 31–47.

ERM. 2022. Costs and benefits of climate-related disclosure activities by corporate issuers and institutional investors. Sustainability Institute.

European Commission. 2024. Sustainability-related disclosure in the financial services sector.

Fatica, S. and R. Panzica. 2021. Green bonds as a tool against climate change? *Business Strategy and the Environment 30*(5), 2688–2701.

Flammer, C.. 2021. Green bonds as a tool against climate change? *Journal of Financial Economics 142*(2), 499–516.

Gatev, E. and P. E. Strahan. 2009. Liquidity risk and syndicate structure. *Journal of Financial Economics 93*(3), 490–504.

GFMA and BCG. 2020. Climate finance markets and the real economy. Technical report, Global Financial Markets Association and Boston Consulting Group.

Hachenberg, B. and D. Schiereck. 2018. Are green bonds priced differently from conventional bonds? *Journal of Asset Management 19*(6), 371–383.

Hale, G., A. Mian, N. Novta, and J. C. Xu. 2024. Industrial composition of syndicated loans and banks' climate commitments. CEPR Discussion Paper 18973.

Holmstrom, B. and J. Tirole. 1997, 08. Financial intermediation, loanable funds, and the real sector. *Quarterly Journal of Economics 112*(3), 663–691.

ICMA. 2020a. Bond market size and statistics: Global developments in primary and secondary markets. International Capital Market Association.

ICMA. 2020b. Sustainability-linked bond principles: Voluntary process guidelines for issuing sustainability-linked bonds. International Capital Market Association.

ICMA. 2021. Green bond principles: Voluntary process guidelines for issuing green bonds. International Capital Market Association.

IEA. 2021. Net zero by 2050: A roadmap for the global energy sector.

IEA. 2024. CO_2 emissions in 2023 – Analysis.

IPCC. 2018. Summary for policymakers. In *Global Warming of 1.5°C: An IPCC Special Report*. Cambridge University Press, 3–24.

Ivashina, V. and D. Scharfstein. 2010. Loan syndication and credit cycles. *American Economic Review 100*(2), 57–61.

Lam, P. and J. Wurgler. 2024. Green bonds: New label, same projects. NBER Working Papers 32960.

Merler, S.. 2025. How to improve the European Union's sustainable finance framework. Policy brief, Bruegel.

Morgan Stanley. 2025. Sustainable fund returns lag peers' in second half of 2024. Morgan Stanley Institute for Sustainable Investing.

OECD. 2021a. Public financial institutions and the low-carbon transition: Five case studies on low-carbon infrastructure and project investment. *OECD Environment Working Papers*, No. 72.

OECD. 2021b. Scaling up green, social, sustainability and sustainability-linked bond issuances in developing countries. *OECD Development Perspectives*, No. 11.

OECD. 2025. Global debt report 2025: Financing growth in a challenging debt market environment.

Rajan, R. G.. 1992. Insiders and outsiders: The choice between informed and arm's-length debt. *Journal of Finance 47*(4), 1367–1400.

Stern, N.. 2006. *The Economics of Climate Change: The Stern Review*. Cambridge University Press.

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

Tuhkanen, H. and G. Vulturius. 2022. Are green bonds funding the transition? Investigating the link between companies' climate targets and green debt financing. *Journal of Sustainable Finance & Investment 12*(4), 1194–1216.

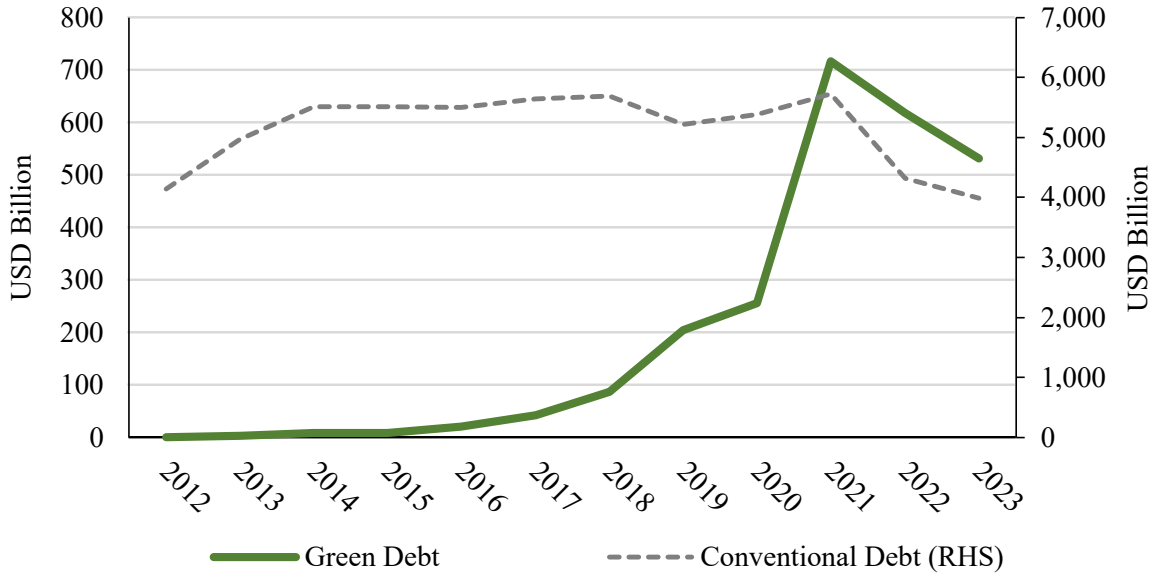
Ul Haq, I. and D. Doumbia. 2022. Structural loopholes in sustainability-linked bonds. World Bank Policy Research Working Paper 10200.

United Nations. 2023. Principles for responsible banking: Key statistics.

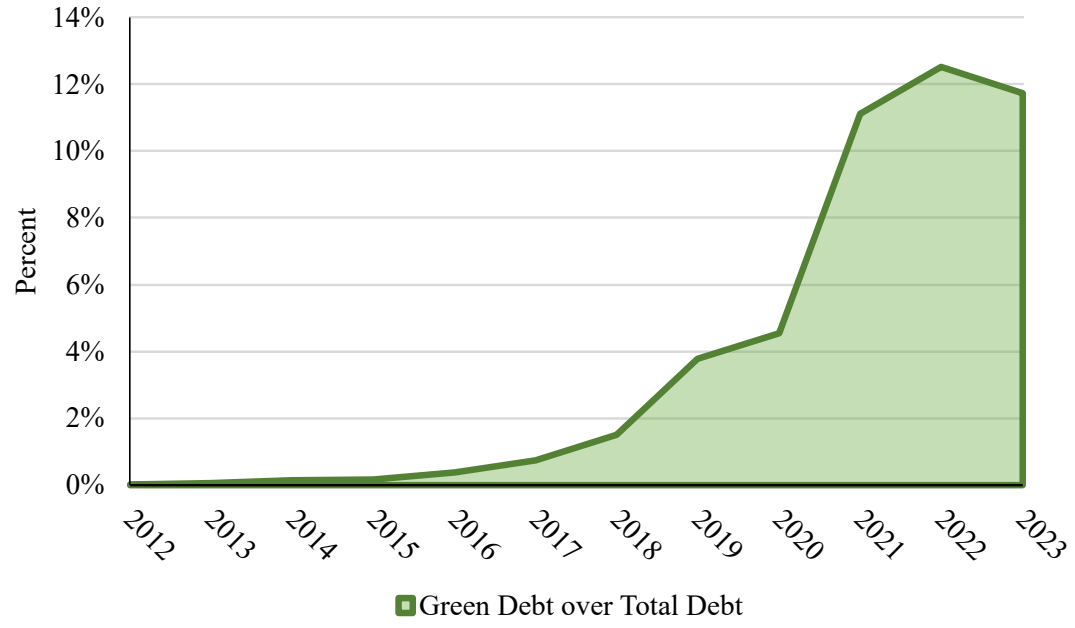
Zerbib, O. D.. 2019. The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking and Finance 98*, 39–60.

Figure 1. Global Corporate Debt Issuance over Time

A. Debt Amounts Issued in Green and Conventional Markets



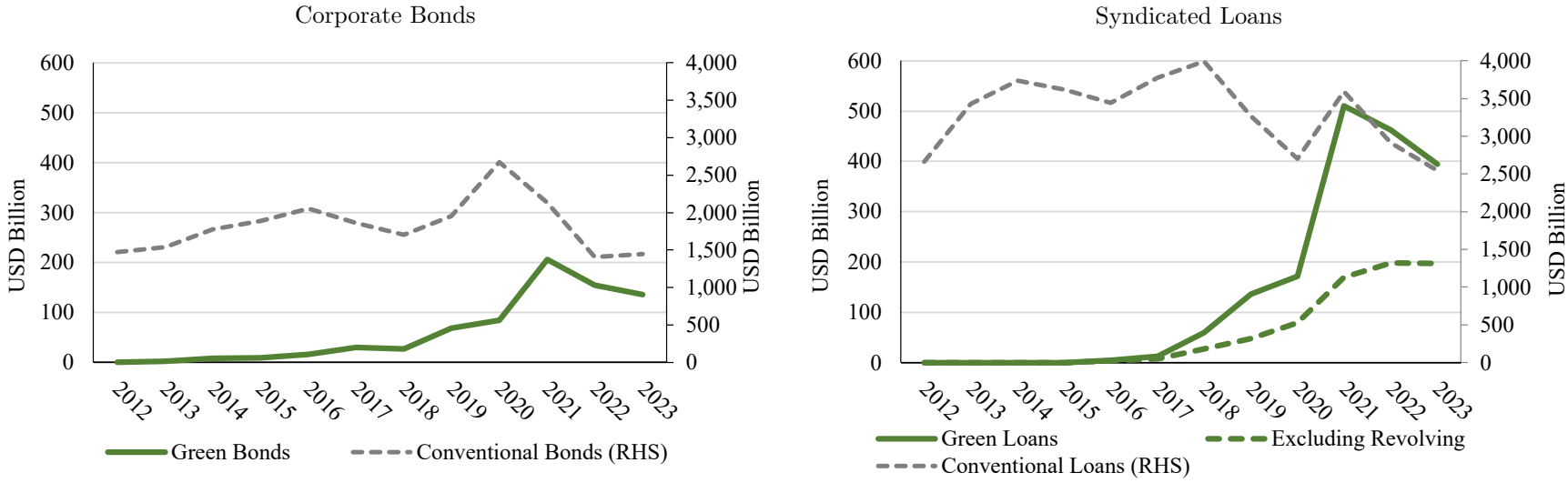
B. Green Debt over Total Debt



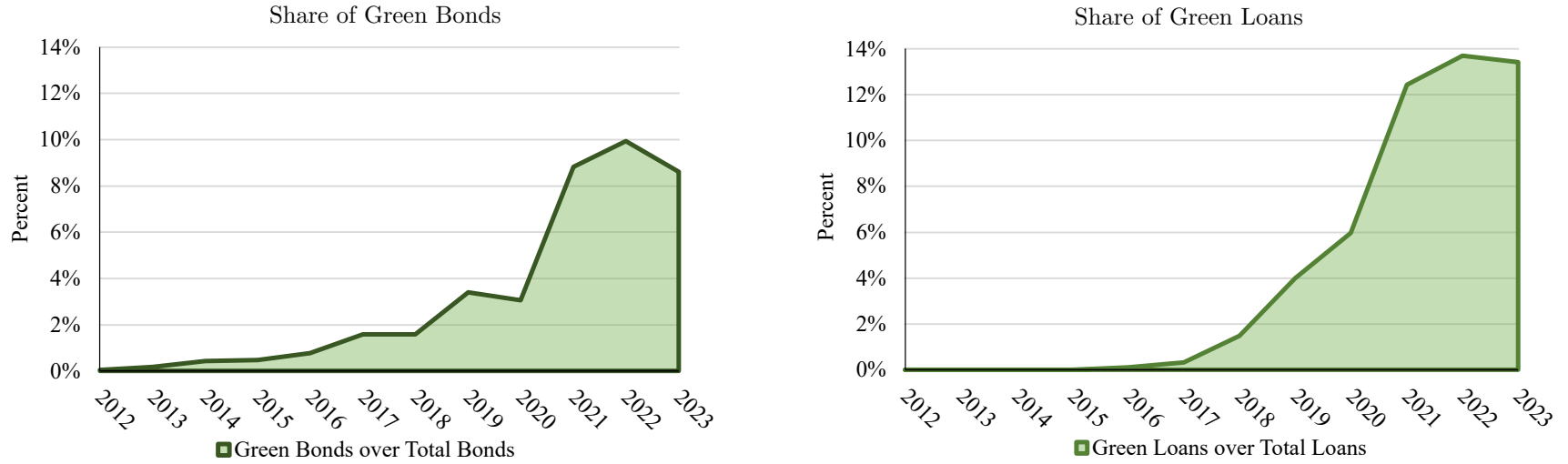
This figure shows trends in green and conventional debt issuances from 2012 to 2023. Panel A reports total issuance volumes in billions of 2011 U.S. dollars (USD). Panel B shows the share of green debt issued per year as a percentage of total debt issuance (green plus conventional). "RHS" denotes the right-hand side axis.

Figure 2. Global Corporate Bond and Syndicated Loan Issuance over Time

A. Debt Amounts Issued in Green and Conventional Markets



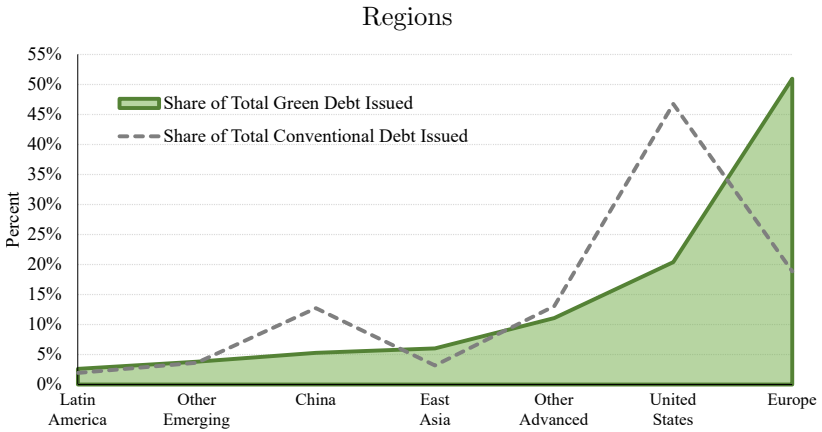
B. Green Debt over Total Debt

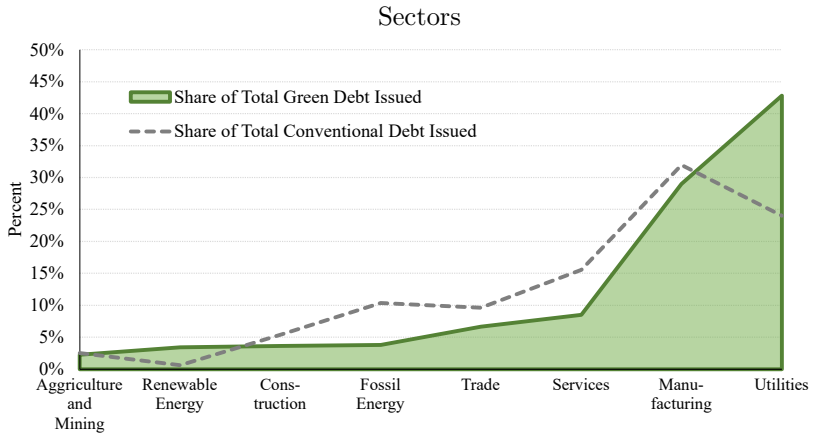


This figure shows trends in green and conventional debt issuances from 2012 to 2023, separately for bonds (left-hand side) and syndicated loans (right-hand side). Panel A reports total issuance volumes in billions of 2011 U.S. dollars (USD). Panel B shows the share of green bonds and syndicated loans issued per year as a percentage of total bond and loan issuances (green plus conventional). "RHS" denotes the right-hand side axis.

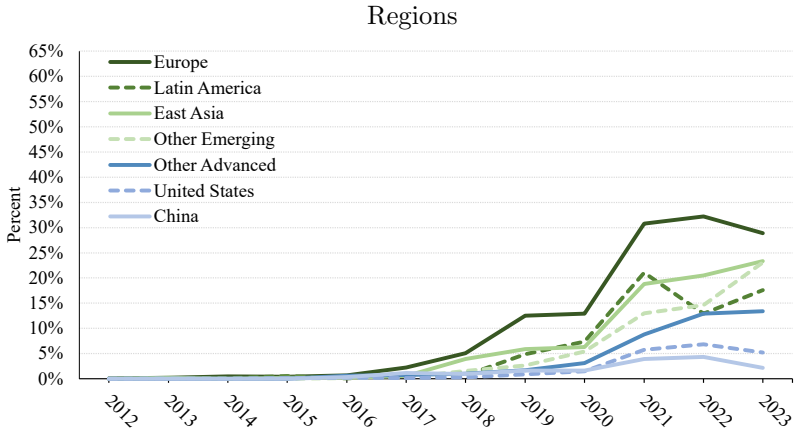
Figure 3. Regional and Sectoral Patterns of Green Debt Issued

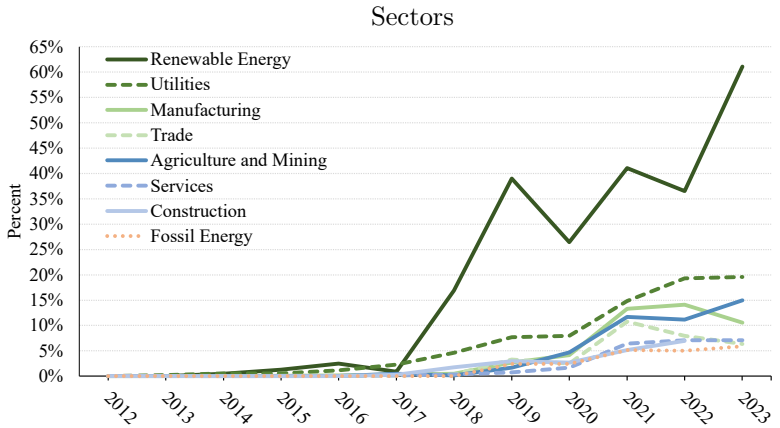
A. Distribution of Green and Conventional Debt across Regions and Sectors





B. Green Debt over Total Debt

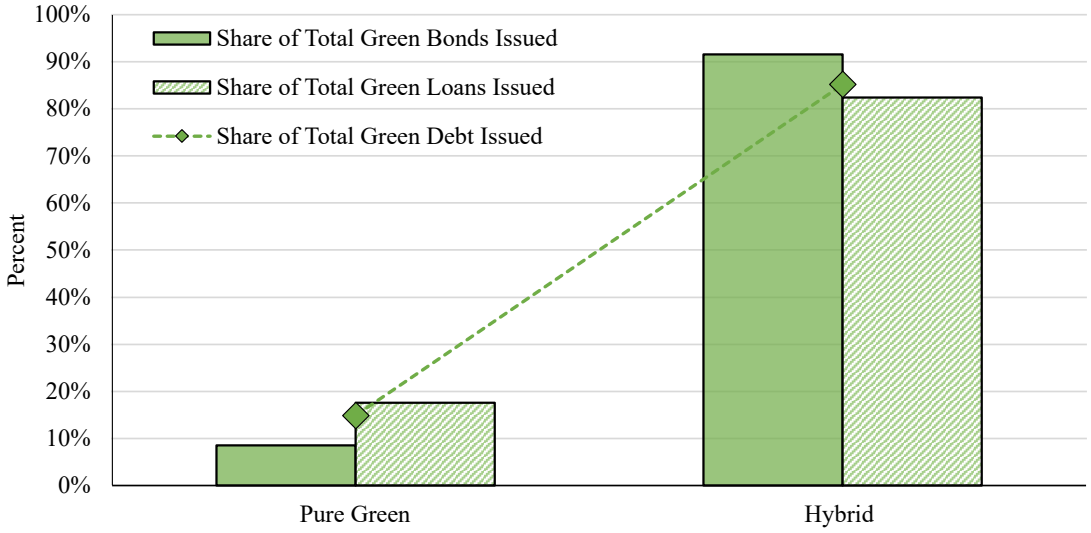




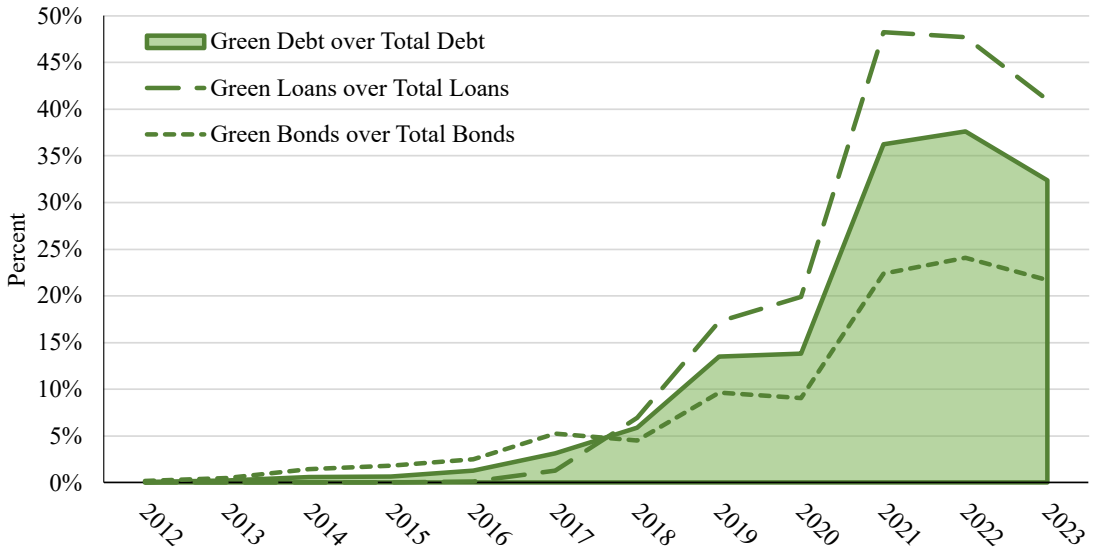
This figure shows the allocation of green and conventional debt issuances across regions (left-hand side) and industries (right-hand side). Panel A reports the share of each region and industry in global green and conventional debt issuance volumes raised from 2012 to 2023. Panel B shows, for each region and industry, the share of green debt issued per year as a percentage of total debt issuance (green plus conventional).

Figure 4. Hybrid and Pure Green Debt Issuers

A. Distribution of Green Debt across Types of Issuers

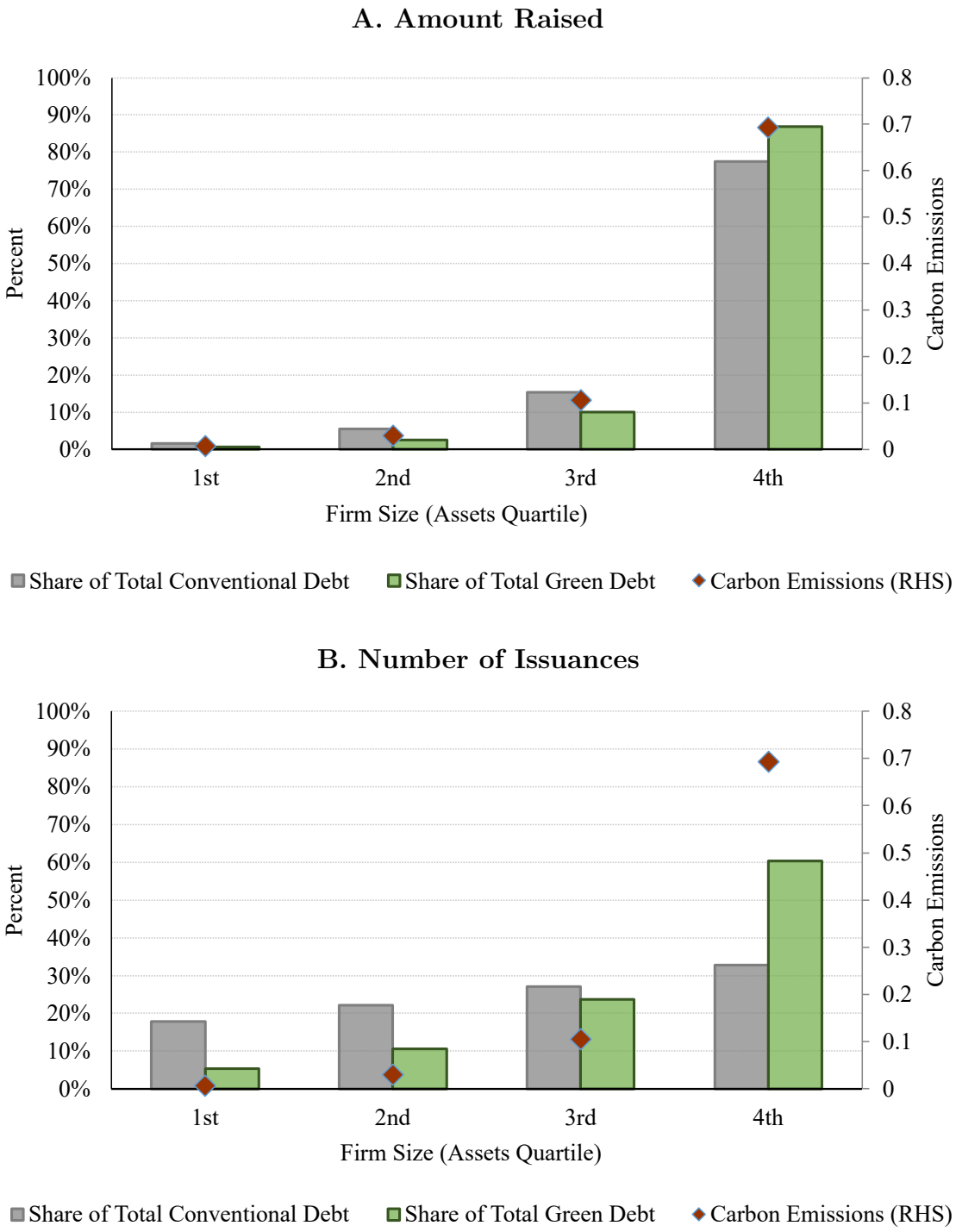


B. Green Debt over Total Debt for Hybrid Issuers



This figure shows green debt issuance patterns for hybrid and pure green issuers. Hybrid issuers are defined as firms that issue both green and conventional debt, while pure green issuers exclusively issue green debt. Panel A reports the share of each type of issuer in global green debt issuance volumes raised from 2012 to 2023. Panel B reports, for hybrid issuers, the share of green debt per year as a percentage of total debt issuance (green plus conventional).

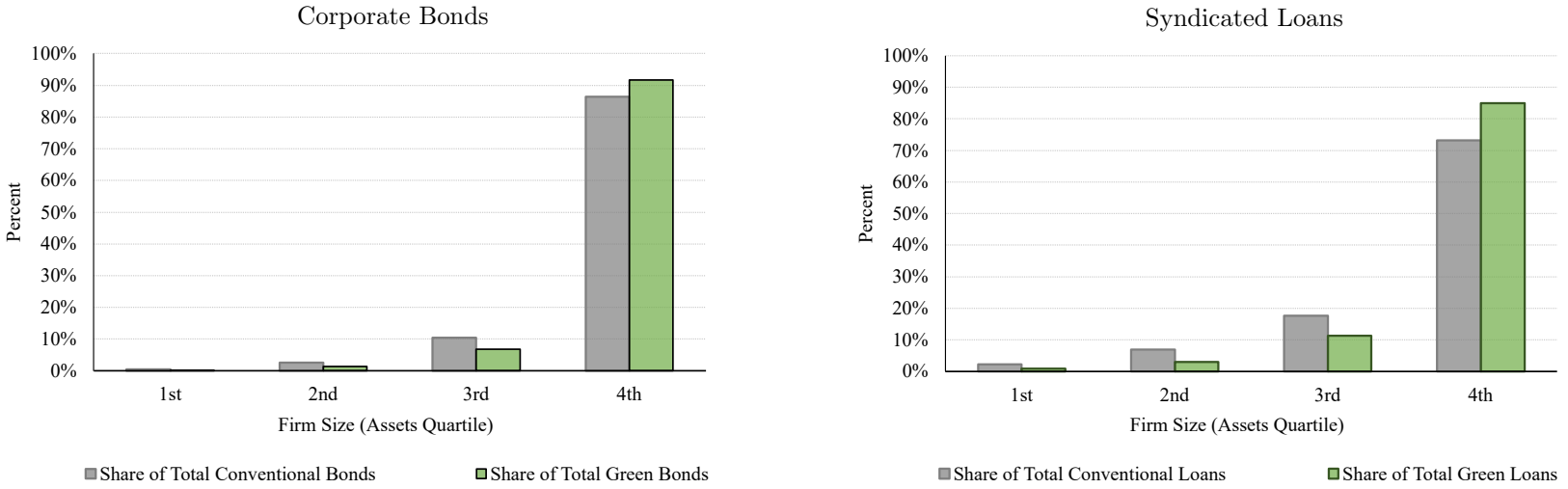
Figure 5. Debt across the Issuer Size Distribution



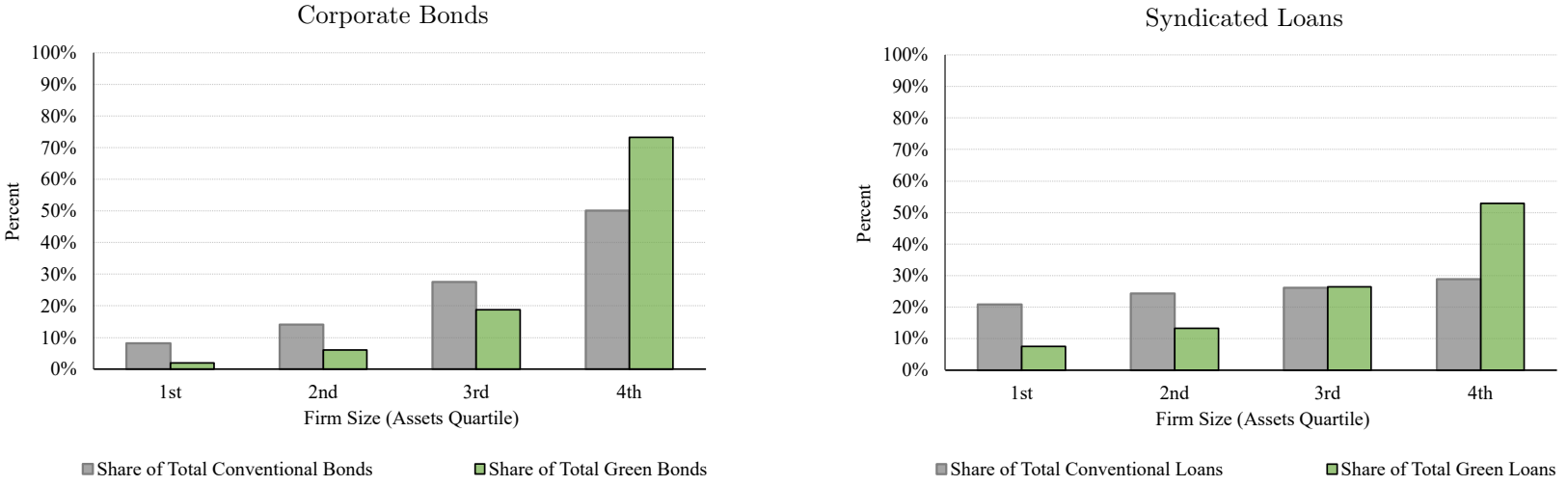
This figure shows the distribution of green and conventional debt issued from 2012 to 2023 across the firm size distribution of issuers. Firms are grouped into quartiles based on their average total assets over the period. Panel A presents the distribution in terms of total debt volume raised, while Panel B shows the distribution based on the number of debt transactions. Each panel also reports the median carbon emissions for firms in each quartile on the right-hand side (RHS). Carbon emissions are expressed in millions of metric tonnes.

Figure 6. Bonds and Syndicated Loans across the Issuer Size Distribution

A. Amount Raised

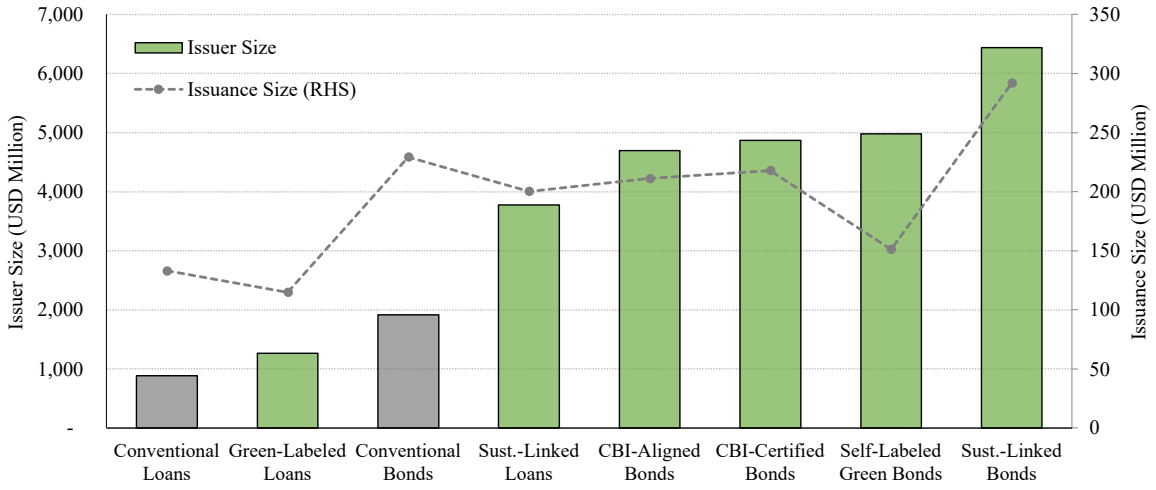


B. Number of Issuances



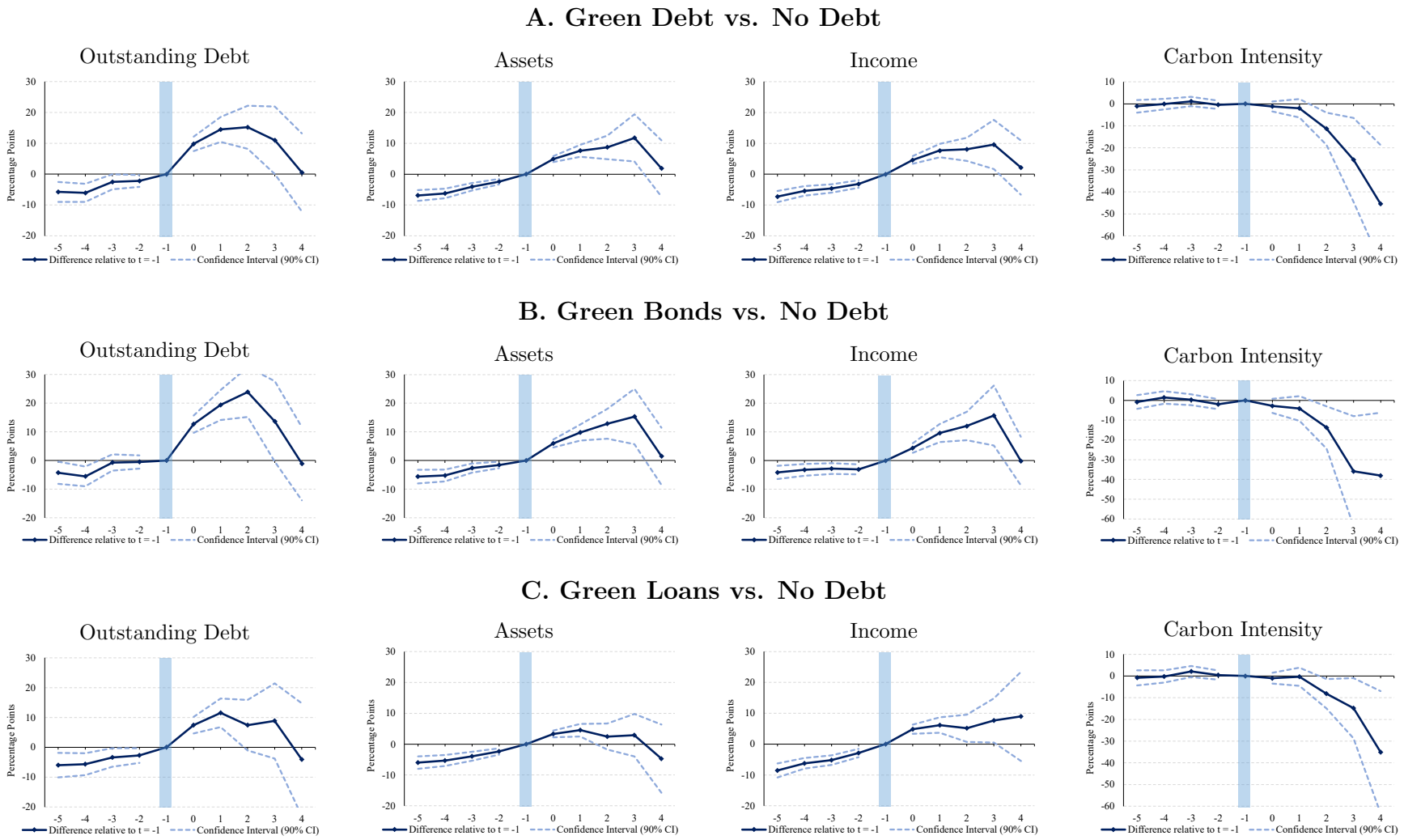
This figure shows the distribution of green and conventional debt issued from 2012 to 2023 across the firm size distribution of bond and loan issuers. Firms are grouped into quartiles based on their average total assets over the period. Panel A presents the distribution in terms of total debt volume raised, while Panel B shows the distribution based on the number of debt transactions. Each panel distinguishes between bonds (left-hand side) and syndicated loans (right-hand side).

Figure 7. Median Issuer Size across Debt Instruments



This figure illustrates the median size of issuers—measured by total assets—and the median size of issuances across different types of green debt instruments. Issuance sizes are shown on the right-hand side (RHS).

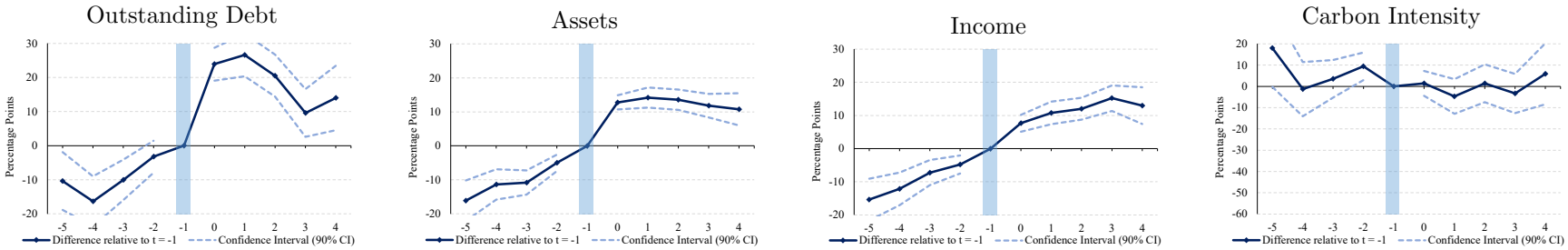
Figure 8. LP-DiD Outcomes: Green Debt versus No Debt



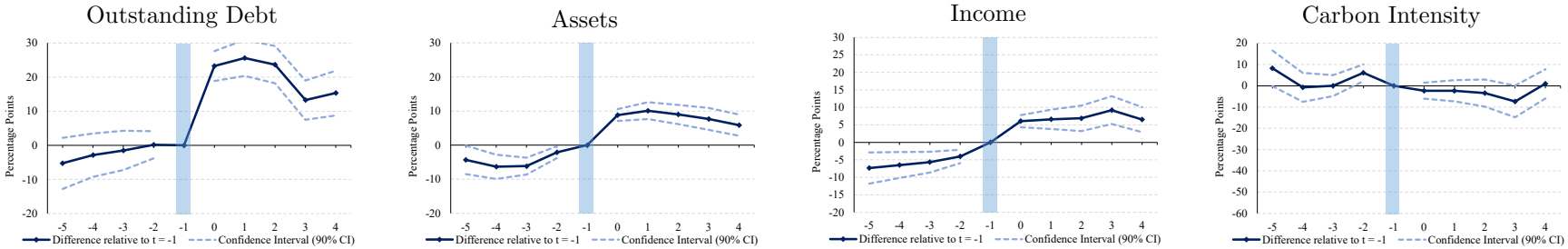
This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around green debt issuances to periods without any debt issuance. Panel B compares outcomes around green bond issuances to periods without any debt issuance. Panel C compares outcomes around green loan issuances to periods without any debt issuance. The dependent variables are the log of balance sheet debt, assets, operating income, and carbon intensity, measured as differences from the year before issuance ($t = -1$).

Figure 9. LP-DiD Outcomes: Conventional Debt versus No Debt

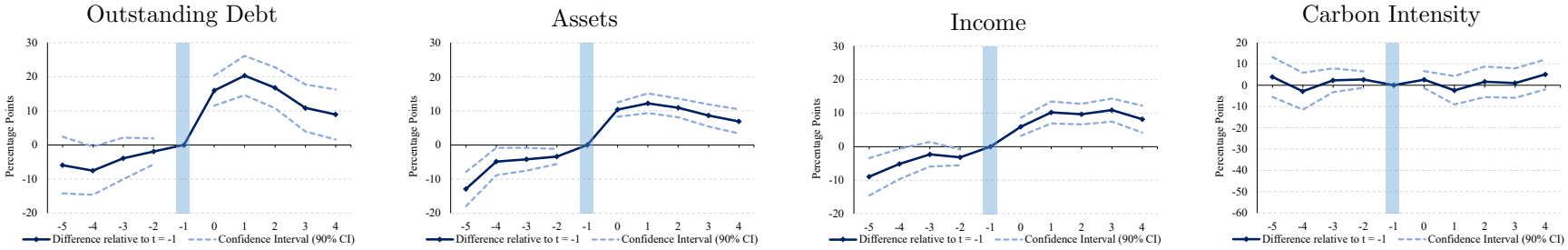
A. Conventional Debt vs. No Debt



B. Conventional Bonds vs. No Debt



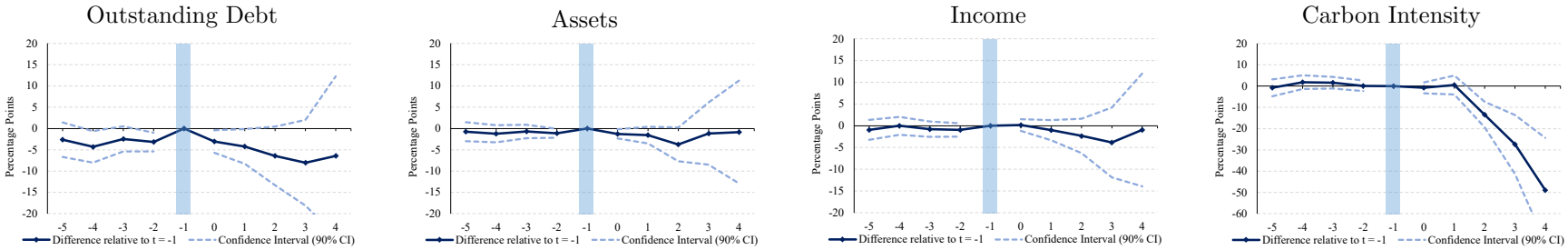
C. Conventional Loans vs. No Debt



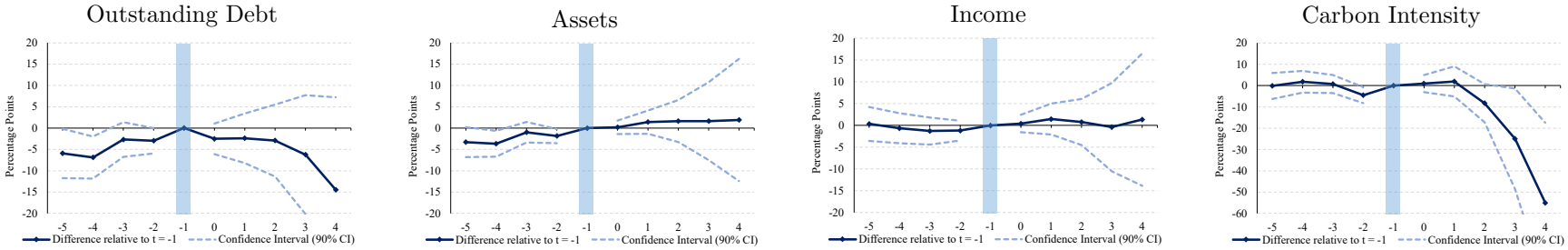
This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around conventional debt issuances to periods without any debt issuance. Panel B compares outcomes around conventional bond issuances to periods without any debt issuance. Panel C compares outcomes around conventional loan issuances to periods without any debt issuance. The dependent variables are the log of balance sheet debt, assets, operating income, and carbon intensity, measured as differences from the year before issuance ($t = -1$).

Figure 10. LP-DiD Outcomes: Green Debt versus Conventional Debt

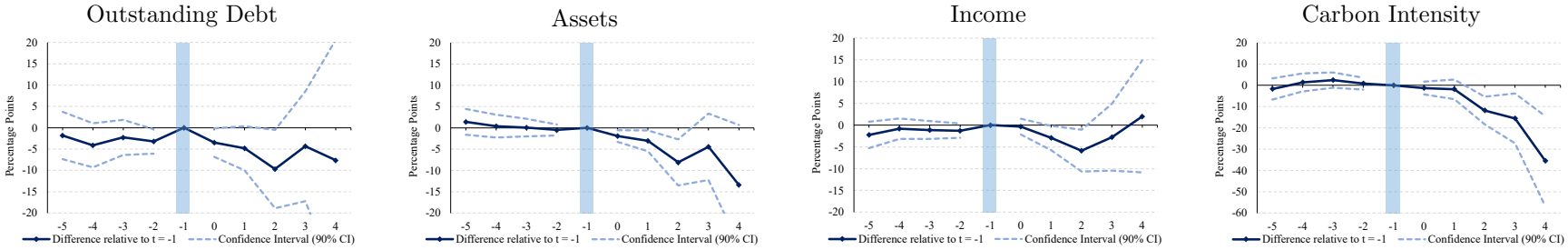
A. Green Debt vs. Conventional Debt



B. Green Bonds vs. Conventional Bonds



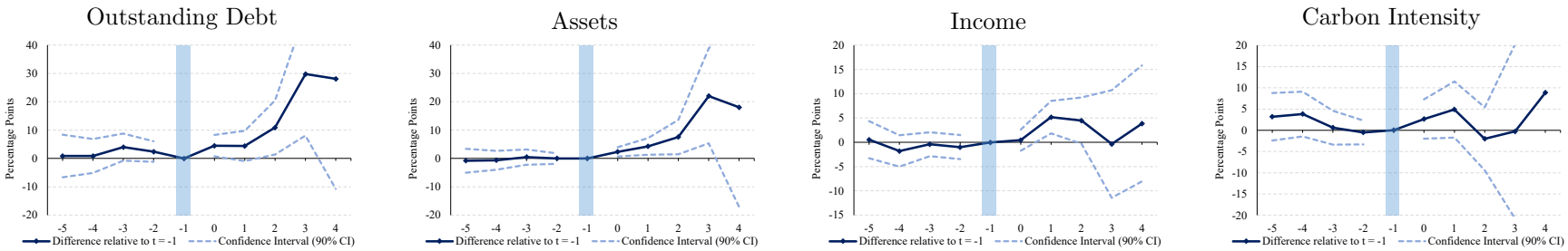
C. Green Loans vs. Conventional Loans



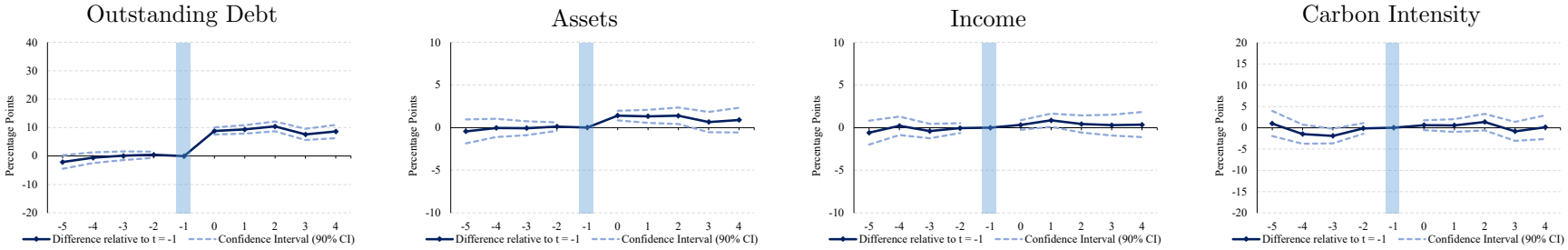
This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around green debt issuances to periods around conventional debt issuances. Panel B compares outcomes around green bond issuances to periods around conventional bond issuances. Panel C compares outcomes around green loan issuances to periods around conventional loan issuances. The dependent variables are the log of balance sheet debt, assets, operating income, and carbon intensity, measured as differences from the year before issuance ($t = -1$).

Figure 11. LP-DiD Outcomes: Bonds versus Loans

A. Green Bonds vs. Green Loans

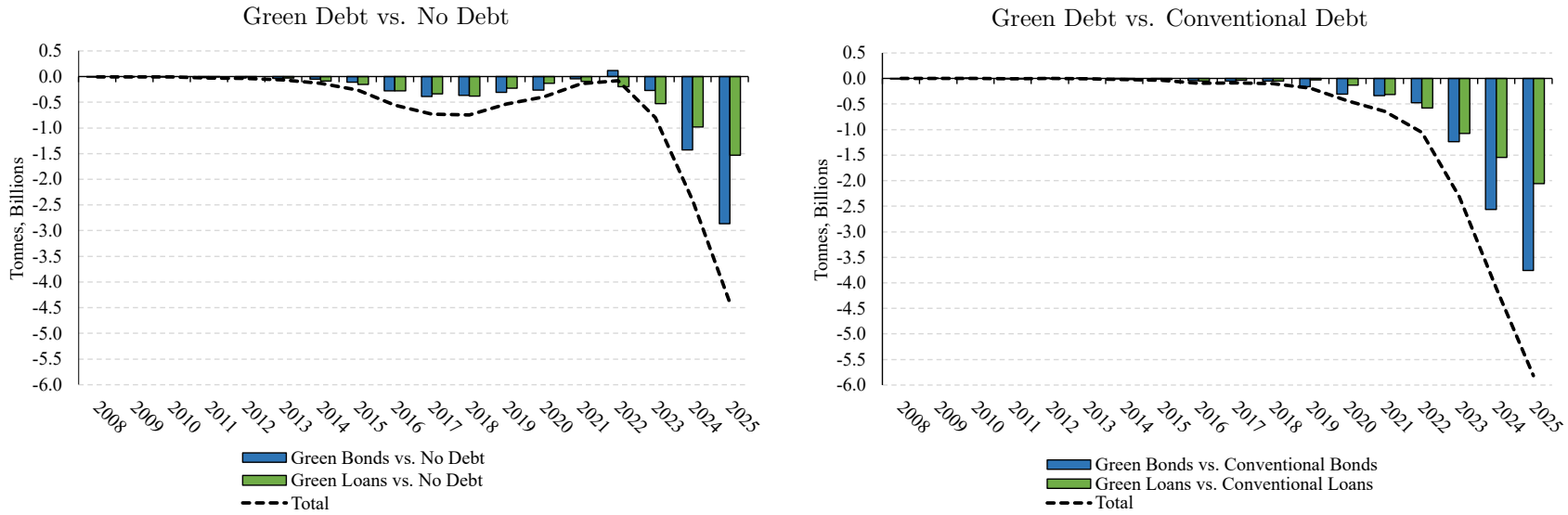


B. Conventional Bonds vs. Conventional Loans



This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around green bond issuances to periods around green loan issuances. Panel B compares outcomes around conventional bond issuances to periods around conventional loan issuances. The dependent variables are the log of balance sheet debt, assets, operating income, and carbon intensity, measured as differences from the year before issuance ($t = -1$).

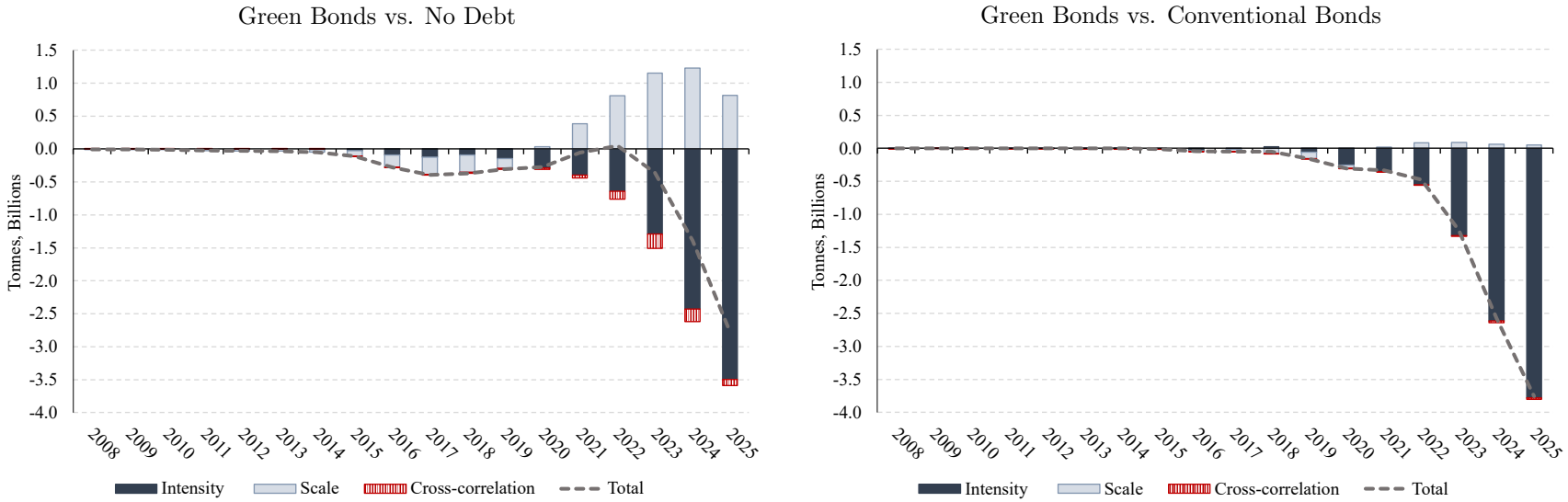
Figure 12. Green Debt and Global Carbon Emissions



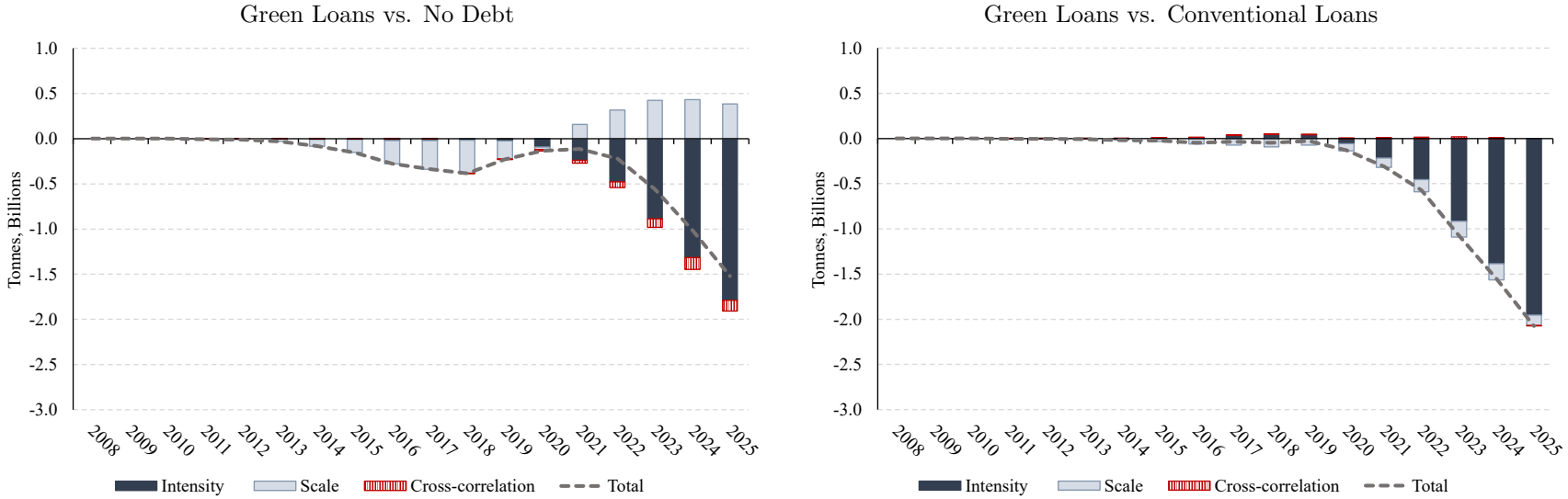
This figure presents the aggregate estimates of changes in total carbon emissions associated with green debt issuance. It compares two counterfactual scenarios: green debt versus no debt issuance (left-hand side), and green debt versus conventional debt issuance (right-hand side).

Figure 13. Aggregate Carbon Emissions' Decomposition

A. Green Bonds



B. Green Loans



This figure presents aggregate estimates of changes in total carbon emissions associated with green debt issuances, decomposed into intensity, scale, and cross-correlation effects. It compares two counterfactual scenarios: green debt versus no debt issuances (left-hand side), and green debt versus conventional debt issuances (right-hand side). Panel A shows the aggregate decomposition for corporate bonds. Panel B shows the aggregate decomposition for syndicated loans.

Table 1. Summary Statistics of Green and Conventional Debt Issuances

Type of Debt Instrument	Total No. of Transactions	Debt Raised (USD, Bn)	Median Size (USD, Mn)	Median Maturity (Years)	Share of Green-Labeled Instruments	Share of Sustainability-Linked Instruments
Conventional Debt	**120,711**	**61,600**	**149**	**5.0**	**.**	**.**
Bonds	36,799	21,900	229	6.0	.	.
Loans	83,912	39,700	133	5.0	.	.
Green Debt	**6,412**	**2,496**	**200**	**5.2**	**42%**	**58%**
Bonds	2,255	745	192	6.0	88%	12%
Loans	4,157	1,751	205	5.0	30%	70%

This table shows summary statistics for conventional and green debt transactions from 2012 to 2023. Dollar amounts are expressed in 2011 U.S. dollars (USD). The units used are: Mn = million and Bn = billion.

Table 2. Summary Statistics of Green and Conventional Debt Issuers

Type of Debt Issuer	Debt Issuance Activity					Firm-Level Characteristics					
	Number of Issuers		Debt Issued (USD, Tn)			Balance Sheet (USD, Bn)				Carbon Emissions (Tonnes, Mn)	Carbon Intensity
	Total	Share Listed	Total	Conventional	Green	Debt	Assets	Fixed Assets	Income		
Pure Conventional	46,987	21%	48.1	48.1	.	0.25	0.93	0.25	0.70	0.11	50.8
Green	3,845	37%	16.0	13.5	2.5	1.31	4.19	1.32	2.81	0.38	89.6
Hybrid Green	2,503	52%	15.6	13.5	2.1	1.53	4.91	1.52	3.24	0.42	92.7
Pure Green	1,342	8%	0.4	0.0	0.4	0.15	0.55	0.21	0.35	0.08	65.6

This table shows summary statistics for conventional and green debt issuers for 2012–2023. It displays the total number of issuers, the share of publicly listed firms, and the total amount of conventional and green debt issued by type of firm. For firm-level balance sheet and carbon emission characteristics, the table presents the median values. Hybrid issuers are defined as firms that issue both green and conventional debt, whereas pure green issuers exclusively issue green debt. Debt issuance and balance sheet values are expressed in 2011 U.S. dollars (USD). Carbon emissions are expressed in metric tonnes. The units used are: Mn = million, Bn = billion, Tn = trillion.

Table 3. Summary Statistics of Green and Conventional Debt Issuers in Different Markets

A. Bonds

Type of Bond Issuer	Bond Issuance Activity					Firm-Level Characteristics					
	Number of Issuers		Bond Issued (USD, Tn)			Balance Sheet (USD, Bn)				Carbon Emissions (Tonnes, Mn)	Carbon Intensity
	Total	Share Listed	Total	Conventional	Green	Debt	Assets	Fixed Assets	Income		
Pure Conventional	12,878	38%	16.4	16.4	.	0.68	2.12	0.62	1.40	0.25	67.4
Green	1,334	49%	6.3	5.5	0.7	2.42	7.36	2.88	4.85	0.79	130.2
Hybrid Green	1,107	56%	6.2	5.5	0.7	2.72	8.27	3.14	5.36	0.86	133.8
Pure Green	227	14%	0.1	0.0	0.1	0.17	0.54	0.13	0.32	0.09	76.1

B. Loans

Type of Loan Issuer	Loan Issuance Activity					Firm-Level Characteristics					
	Number of Issuers		Loan Issued (USD, Tn)			Balance Sheet (USD, Bn)				Carbon Emissions (Tonnes, Mn)	Carbon Intensity
	Total	Share Listed	Total	Conventional	Green	Debt	Assets	Fixed Assets	Income		
Pure Conventional	38,808	20%	34.9	0.0	.	0.25	0.96	0.26	0.78	0.10	47.7
Green	2,773	35%	6.54	1.8	1.8	1.01	3.50	1.06	2.55	0.29	65.7
Hybrid Green	1,652	54%	6.24	4.8	1.4	1.18	3.87	1.16	2.94	0.31	66.9
Pure Green	1,121	7%	0.31	0.0	0.3	0.13	0.56	0.22	0.43	0.03	45.3

This table shows summary statistics for conventional and green debt issuers for 2012–2023. It displays the total number of issuers, the share of publicly listed firms, and the total volume of conventional and green debt issued, disaggregated by type of firm. For firm-level balance sheet and carbon emission characteristics, the table presents the median values. Hybrid issuers are defined as firms that issue both green and conventional debt, whereas pure green issuers exclusively issue green debt. Debt issuance and balance sheet values are expressed in 2011 U.S. dollars (USD). Carbon emissions are expressed in metric tonnes. The units used are: Mn = million, Bn = billion, Tn = trillion.

Table 4. Firm Characteristics around Green versus Conventional Debt Issuances

Dependent Variable:	Dummy = 1 if a firm issues green debt in a given year and 0 if it issues conventional debt									
Base Value:	0.037									
Independent Variable:	Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Fixed Effects:	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
No	0.012***	95,064	0.020***	28,492	0.017***	28,531	0.012***	16,304	0.010***	16,788
Industry-Time	0.017***	94,962	0.020***	28,383	0.017***	28,425	0.016***	16,222	0.014***	16,712
Industry- and Country-Time	0.017***	94,958	0.018***	28,367	0.017***	28,408	0.012***	16,180	0.005*	16,671

This table reports linear probability regression estimates of the likelihood of issuing green debt, conditional on debt issuances. The dependent variable is a binary indicator equal to one if a firm issues green debt in a given year and zero if it issues conventional debt. Independent variables are lagged log values of firm-level characteristics. Standard errors are clustered at the country-year level. Asterisks (*, **, ***) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5. Firm Characteristics around Green versus Conventional Bond and Loan Issuances

A. Green Bonds vs. Conventional Bonds										
Dependent Variable:	Dummy = 1 if a firm issues green bonds and 0 if it issues conventional bonds									
Base Value:	0.072									
Independent Variable:	Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Fixed Effects:	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
No	0.011***	29,241	0.019***	11,896	0.012***	12,090	0.011***	7,848	0.012***	8,189
Industry-Time	0.011***	29,124	0.017***	11,826	0.008***	12,020	0.014***	7,769	0.014***	8,107
Industry- and Country-Time	0.012***	29,084	0.014***	11,781	0.009***	11,978	0.007***	7,685	0.001	8,023
B. Green Loans vs. Conventional Loans										
Dependent Variable:	Dummy = 1 if a firm issues green loans and 0 if it issues conventional loans									
Base Value:	0.051									
Independent Variable:	Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Fixed Effects:	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
No	0.010***	69,590	0.016***	19,820	0.015***	19,781	0.008***	11,328	0.008*	11,546
Industry-Time	0.014***	69,484	0.016***	19,710	0.016***	19,671	0.011***	11,222	0.008***	11,450
Industry- and Country-Time	0.015***	69,480	0.015***	19,666	0.016***	19,629	0.011***	11,173	0.005	11,403
C. Green Bonds vs. Green Loans										
Dependent Variable:	Dummy = 1 if a firm issues green bonds and 0 if it issues green loans									
Base Value:	0.371									
Independent Variable:	Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Fixed Effects:	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
No	0.056***	4,439	0.106***	1,670	0.045***	1,691	0.052***	1,678	0.038***	1,675
Industry-Time	0.060***	4,321	0.086***	1,599	0.053***	1,616	0.051***	1,611	0.045***	1,599
Industry- and Country-Time	0.067***	4,239	0.083***	1,510	0.065***	1,527	0.038***	1,535	0.008	1,533

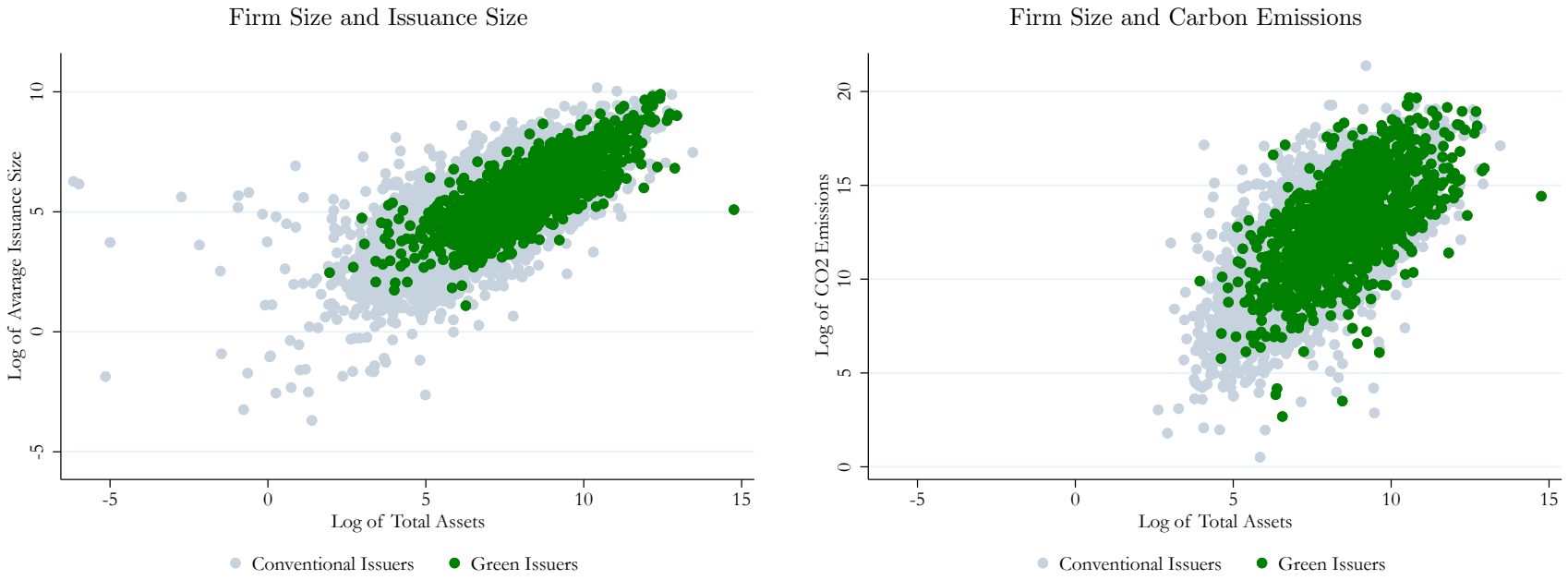
This table reports linear probability regression estimates of the likelihood of issuing green debt, conditional on debt issuances. In Panel A, the dependent variable equals one if a firm issues green bonds and zero if it issues conventional bonds in a given year. In panel B, the dependent variable equals one if a firm issues green loans in a given year and zero if it issues a conventional loan. In Panel C, the dependent variable equals one if a firm issues green bonds in a given year and zero if it issues green loans. Independent variables are lagged log values of firm-level characteristics. Standard errors are clustered at the country-year level. Asterisks (*, **, ***) denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Linear Probability Regressions over Time

A. Green Debt vs. Conventional Debt											
Dependent Variable:		Dummy = 1 if a firm issues green debt in a given year and 0 if it issues conventional debt									
Independent Variable:		Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Period	Base	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
2012-18	0.007	0.003***	27,054	0.003***	6,365	0.002**	6,320	0.00	3,152	-0.001	3,713
2018-20	0.045	0.020***	17,813	0.023***	4,267	0.020***	4,272	0.019***	3,449	0.004	3,453
2021-23	0.141	0.052***	19,462	0.072***	4,117	0.067***	4,094	0.034***	3,713	0.013*	3,707
B. Green Bonds vs. Conventional Bonds											
Dependent Variable:		Dummy = 1 if a firm issues green bonds in a given year and 0 if it issues conventional bonds									
Independent Variable:		Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Period	Base	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
2012-18	0.013	0.004***	7,516	0.004*	2,970	0.002	2,953	0.00	1,593	0.001	2,032
2018-20	0.064	0.015***	4,939	0.018***	1,817	0.007	1,849	0.010**	1,904	-0.005	1,911
2021-23	0.170	0.049***	5,027	0.060***	1,607	0.042***	1,595	0.019***	1,969	0.000	1,953
C. Green Loans vs. Conventional Loans											
Dependent Variable:		Dummy = 1 if a firm issues green loans in a given year and 0 if it issues conventional loans									
Independent Variable:		Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Period	Base	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
2017-18	0.004	.	.	.	.	.	.	.	.	.	.
2019-20	0.035	0.014***	13,740	0.012***	3,108	0.015***	3,124	0.014***	2,416	0.007	2,402
2021-23	0.129	0.043***	15,194	0.058***	3,071	0.058***	3,074	0.027***	2,572	0.016**	2,556
D. Green Bonds vs. Green Loans											
Dependent Variable:		Dummy = 1 if a firm issues green bonds in a given year and 0 if it issues green loans									
Independent Variable:		Issuance Size		Total Assets		Income		Carbon Emissions		Carbon Intensity	
Period	Base	Beta	N	Beta	N	Beta	N	Beta	N	Beta	N
2017-18	.	.	.	.	.	.	.	.	.	.	.
2019-20	0.431	0.085**	588	0.029	150	-0.014	147	0.002	158	-0.054	159
2021-23	0.341	0.064***	2,327	0.112***	692	0.080**	684	0.041***	770	-0.001	755

This table reports linear probability regression estimates of the likelihood of issuing green debt over time, conditional on debt issuance. Regressions are estimated separately by period and include country-industry fixed effects. In Panel A, the dependent variable equals one if a firm issues green bonds in a given year and zero if it issues conventional bonds. In Panel B, the dependent variable equals one if a firm issues green loans and zero if it issues conventional loans. In Panel C, the dependent variable equals one if a firm issues green bonds and zero if it issues green loans. Independent variables are lagged log values of firm-level characteristics. Standard errors are clustered at the country-industry level. Asterisks (*, **, ***) denote statistical significance at the 10%, 5%, and 1%, respectively.

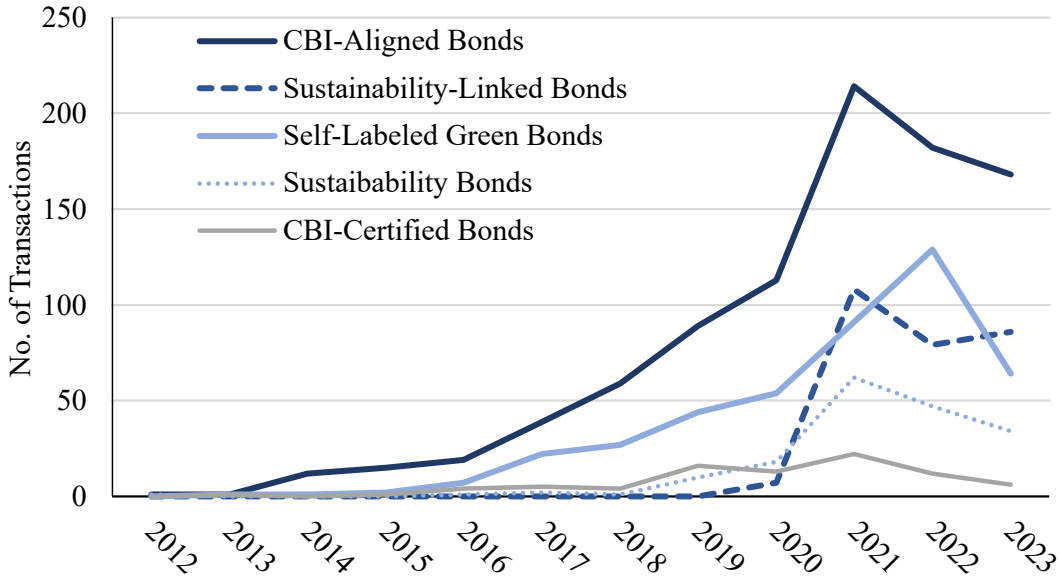
Appendix Figure 1. Firm Size and Carbon Emissions



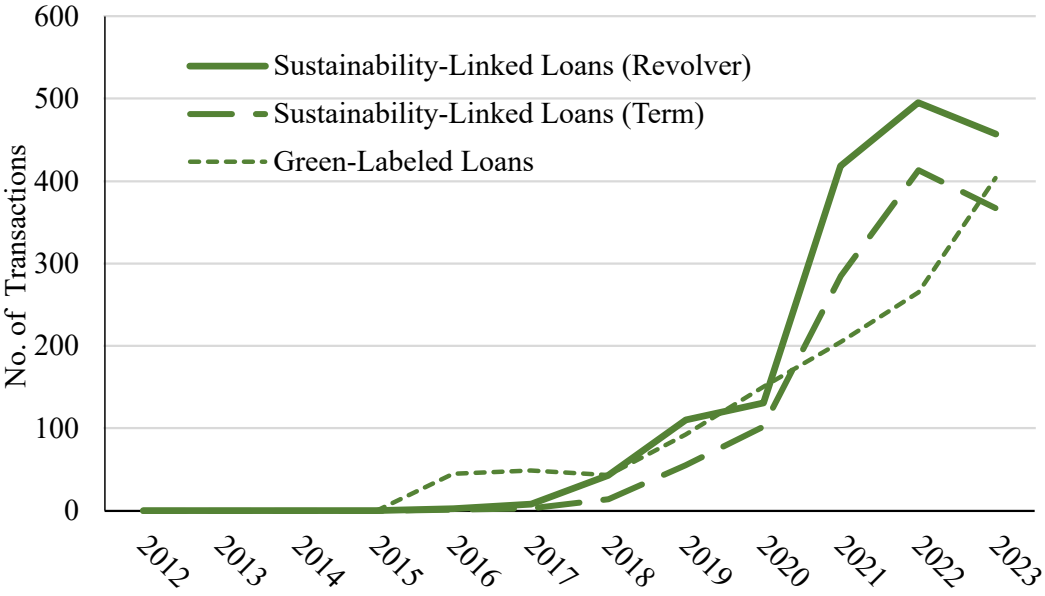
This figure illustrates the relation between firm size and carbon emissions over 2012–2023. The left panel shows the correlation between firm size (log of total assets) and debt issuance size (log of total funds raised per issuance). The right panel plots the relation between firm size and carbon emissions (in logs). Each point represents a firm-level average over 2012–2023.

Appendix Figure 2. Green Debt Instruments over Time

A. Green Bond Instruments



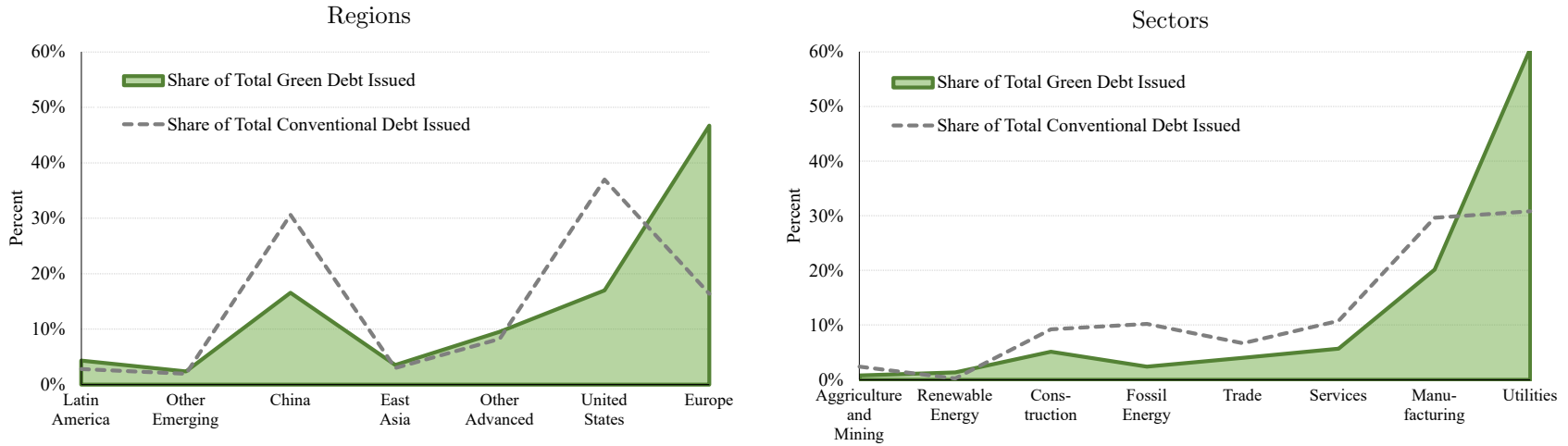
B. Green Loan Instruments



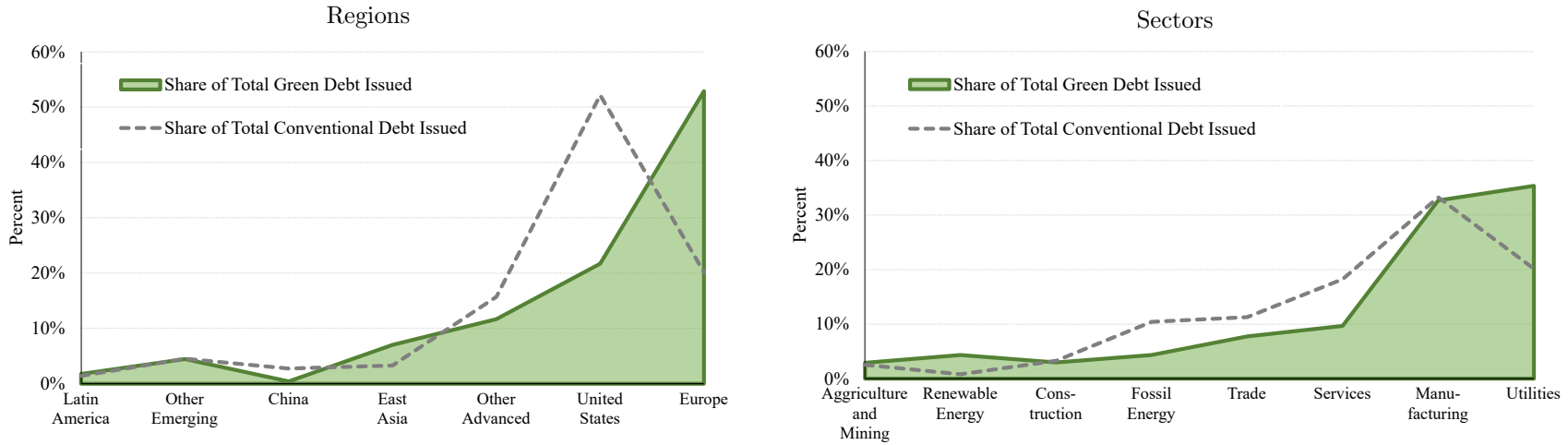
This figure depicts the time trends in green debt instruments. Panel A shows the annual number of different types of green bond transactions, while Panel B displays the corresponding trends for green syndicated loan transactions.

Appendix Figure 3. Bond and Loan Distribution across Regions and Industries

A. Corporate Bonds



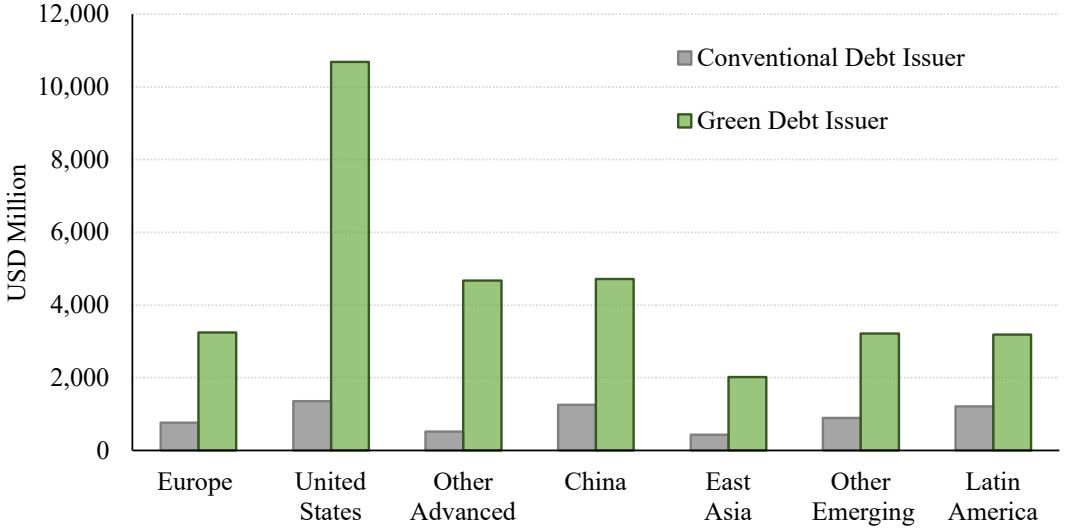
B. Syndicated Loans



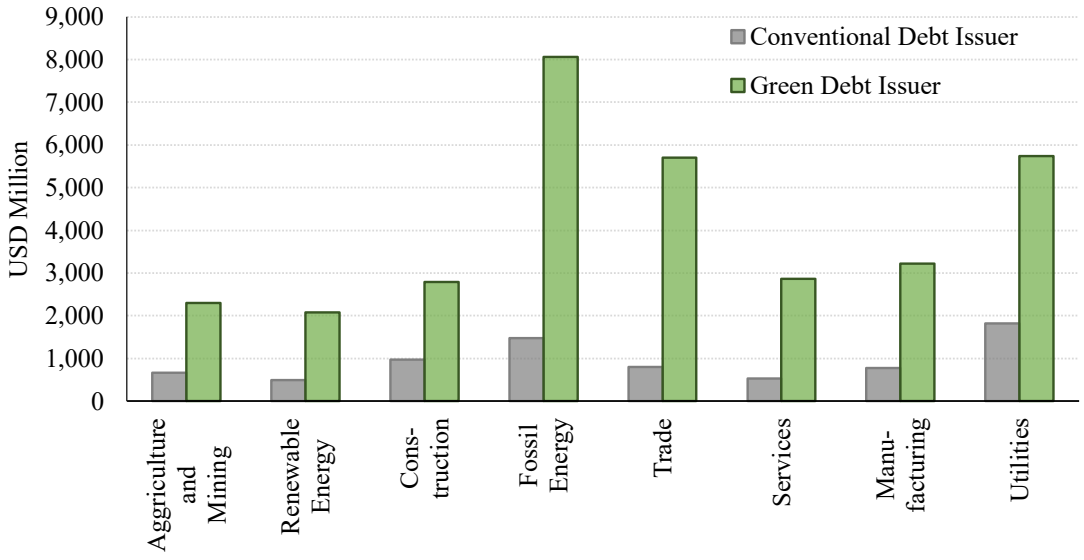
This figure shows the allocation of green and conventional bonds and loans across regions and industries. Panel A reports the share of each region (left-hand side) and industry (right-hand side) in global green and conventional bond issuance volumes raised from 2012 to 2023. Panel B shows the percentage share of each region and industry in global green and conventional syndicated loan issuance volumes raised over the same period.

Appendix Figure 4. Issuer Size across Regions and Industries

A. Debt Issuer Size per Region



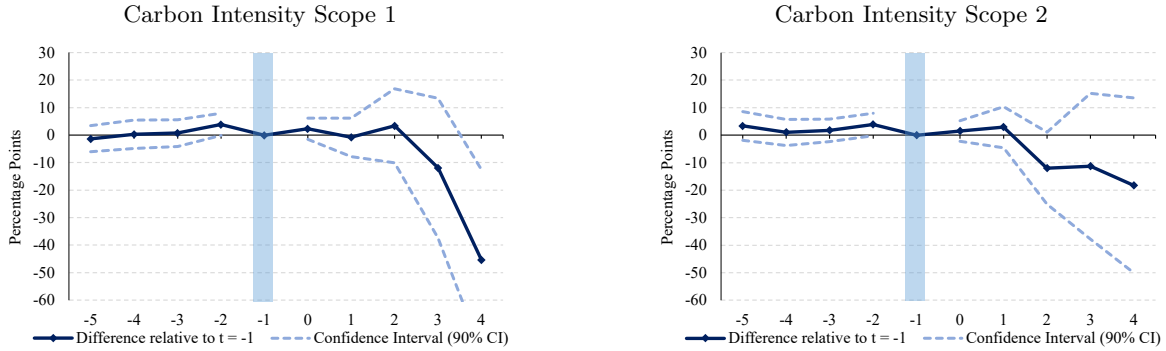
B. Debt Issuer Size per Industry



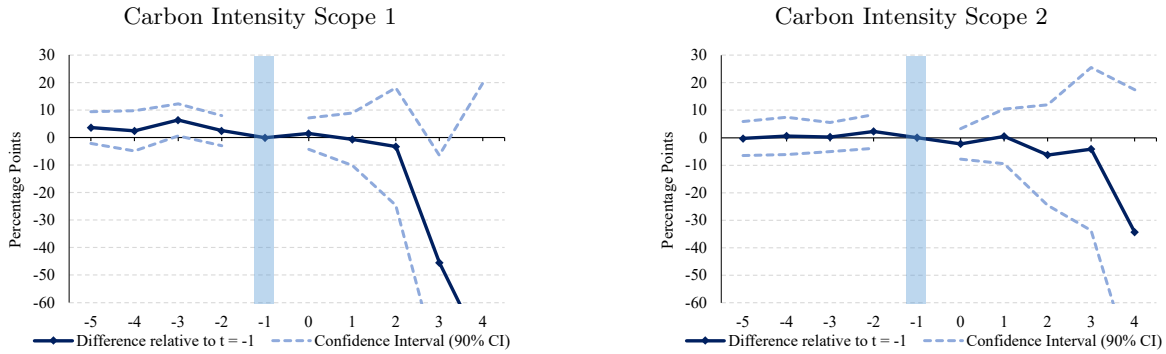
This figure shows the median size of debt issuers in conventional and green markets, disaggregated by region (Panel A) and industry (Panel B). Issuer size is measured in terms of total assets, in millions of 2011 U.S. dollars (USD).

Appendix Figure 5. Carbon Scopes 1 and 2: Green Debt versus No Debt

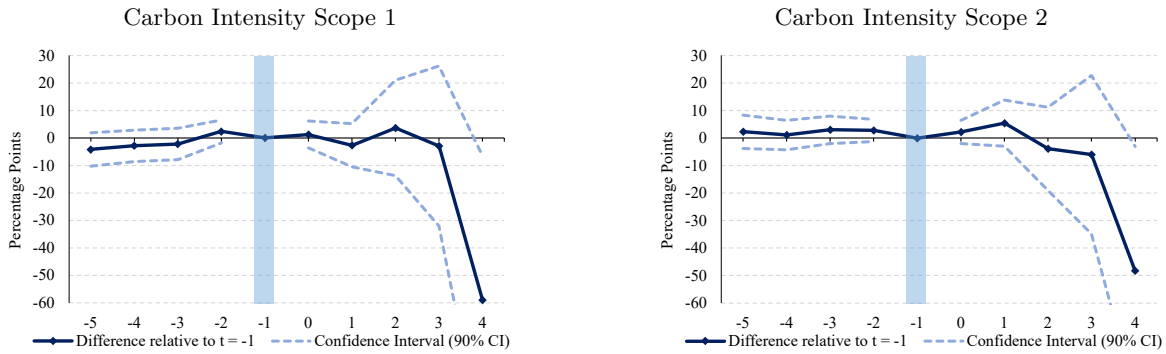
A. Green Debt vs. No Debt



B. Green Bonds vs. No Debt



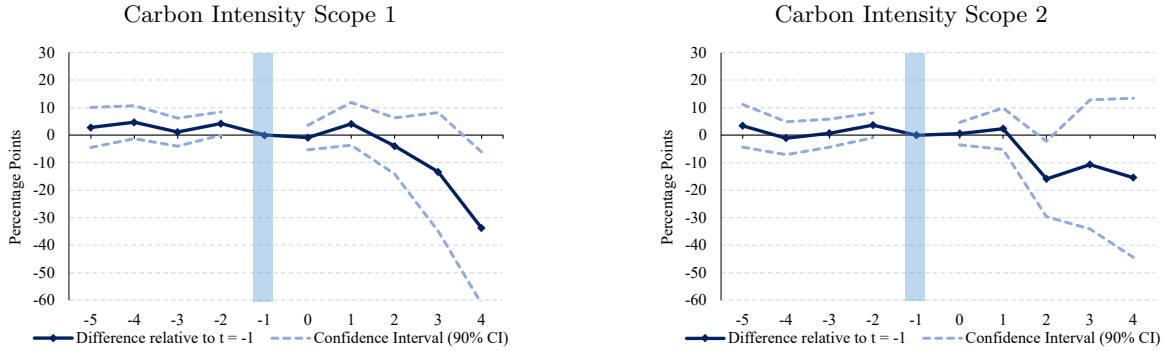
C. Green Loans vs. No Debt



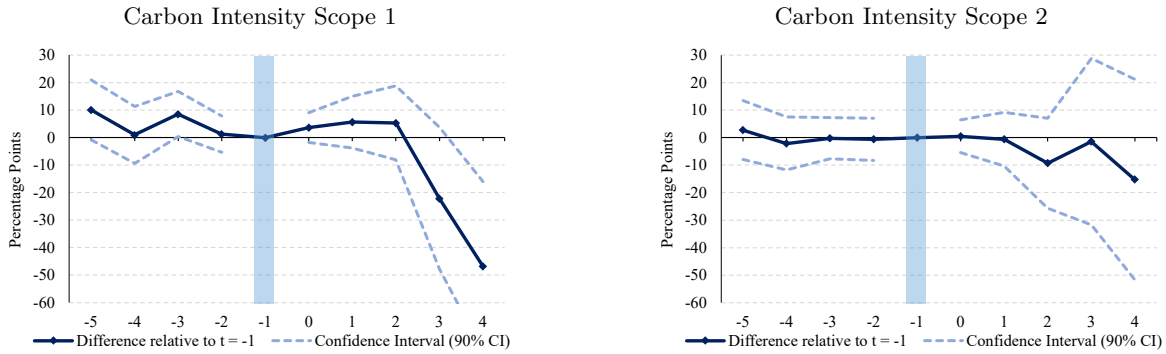
This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around green debt issuances to periods without any debt issuance. Panel B compares outcomes around green bond issuances to periods without any debt issuance. Panel C compares outcomes around green loan issuances to periods without any debt issuance. The dependent variables are carbon intensity Scope 1 and Scope 2, measured as differences from the year before issuance ($t = -1$).

Appendix Figure 6. Carbon Scopes 1 and 2: Green Debt versus Conventional Debt

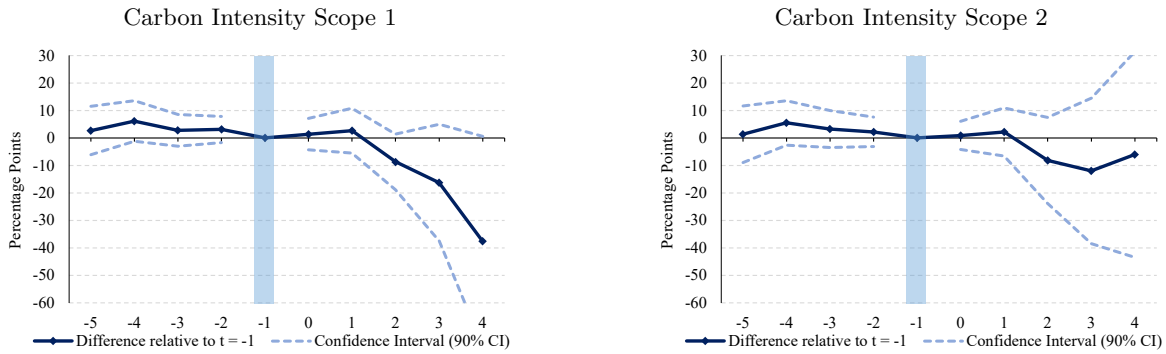
A. Green Debt vs. Conventional Debt



B. Green Bonds vs. Conventional Bonds



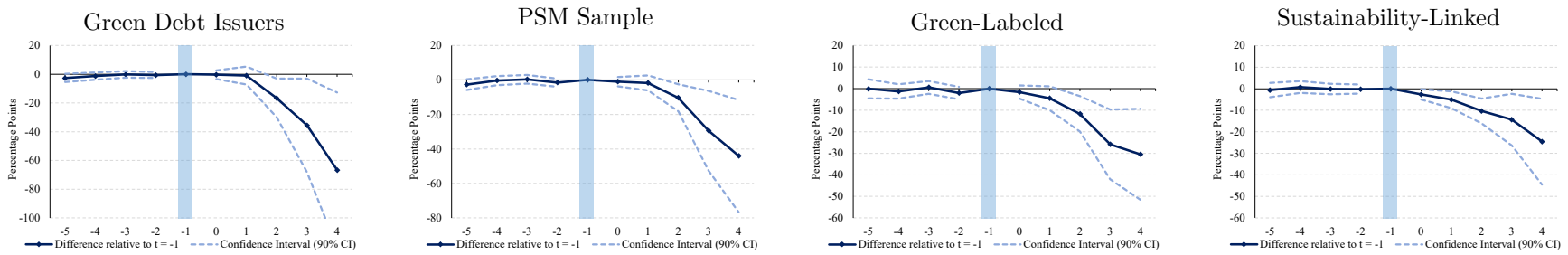
C. Green Loans vs. Conventional Loans



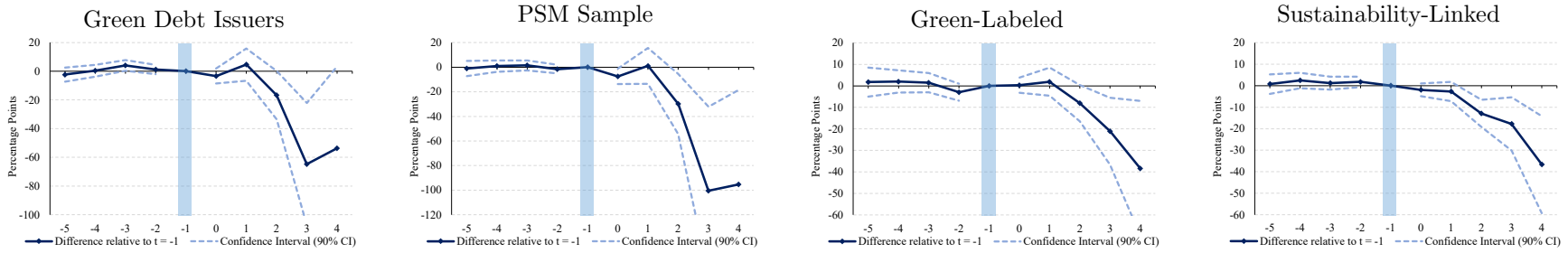
This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around green debt issuances to periods around conventional debt issuances. Panel B compares outcomes around green bond issuances to periods around conventional bond issuances. Panel C compares outcomes around green loan issuances to periods around conventional loan issuances. The dependent variables are carbon intensity Scope 1 and Scope 2, measured as differences from the year before issuance ($t = -1$).

Appendix Figure 7. LP-DiD Green Debt Estimates: Carbon Intensity across Different Samples

A. Green Debt vs. No Debt



B. Green Debt vs. Conventional Debt



This figure presents the estimated beta coefficients and 90 percent confidence intervals from LP-DiD estimations of Equation 2. Panel A compares firm-level outcomes around green debt issuances to periods without any debt issuance, while Panel B compares outcomes around green versus conventional debt issuance. The dependent variable is the log of carbon intensity, measured as the difference from the year before issuance ($t = -1$). The different charts show results across subsamples: all green debt issuers, a propensity-score-matched (PSM) sample, green-labeled instruments, and sustainability-linked instruments. The PSM sample matches green and conventional debt issuers based on average income and carbon intensity levels.

Appendix Table 1. Green and Conventional Debt by Country

Country	Green Debt			Conventional Debt			Share of Green Debt	Country	Green Debt			Conventional Debt			Share of Green Debt
	Total Volume Raised	Share of Bonds	Share of Loans	Total Volume Raised	Share of Bonds	Share of Loans			Total Volume Raised	Share of Bonds	Share of Loans	Total Volume Raised	Share of Bonds	Share of Loans	
United States	508,471	25%	75%	28,809,927	28%	72%	**2%**	Philippines	1,895	61%	39%	97,015	40%	60%	**2%**
France	245,798	31%	69%	2,001,954	38%	62%	**11%**	Czechia	1,870	74%	26%	64,312	25%	75%	**3%**
United Kingdom	179,972	16%	84%	2,561,999	28%	72%	**7%**	Peru	1,813	69%	31%	47,484	36%	64%	**4%**
Germany	172,695	19%	81%	1,830,765	20%	80%	**9%**	Iceland	1,708	0%	100%	5,022	15%	85%	**25%**
Spain	144,242	17%	83%	682,671	18%	82%	**17%**	Ghana	1,465	0%	100%	30,871	0%	100%	**5%**
Netherlands	139,939	48%	52%	1,206,649	52%	48%	**10%**	Viet Nam	1,417	0%	100%	41,748	11%	89%	**3%**
China	130,664	94%	6%	7,810,397	86%	14%	**2%**	Mauritius	1,278	0%	100%	11,413	24%	76%	**10%**
Italy	127,297	30%	70%	717,399	31%	69%	**15%**	Lithuania	1,056	64%	36%	3,937	20%	80%	**21%**
Japan	97,765	43%	57%	3,023,276	27%	73%	**3%**	Egypt, Arab Rep.	1,044	0%	100%	39,270	0%	100%	**3%**
Canada	83,259	19%	81%	2,990,543	21%	79%	**3%**	Colombia	1,038	35%	65%	71,440	40%	60%	**1%**
Taiwan, China	54,705	11%	89%	360,069	27%	73%	**13%**	Lao PDR	847	33%	67%	4,460	37%	63%	**16%**
Sweden	46,966	26%	74%	385,314	29%	71%	**11%**	Kenya	743	0%	100%	4,115	0%	100%	**15%**
Switzerland	43,000	7%	93%	964,296	14%	86%	**4%**	Qatar	689	0%	100%	29,395	35%	65%	**2%**
Singapore	42,879	5%	95%	404,967	17%	83%	**10%**	Ukraine	685	100%	0%	17,759	19%	81%	**4%**
Australia	42,760	18%	82%	927,015	22%	78%	**4%**	Georgia	562	74%	26%	2,658	52%	48%	**17%**
Denmark	39,470	37%	63%	158,115	21%	79%	**20%**	Congo, Dem. Rep.	461	0%	100%	1,043	0%	100%	**31%**
Norway	33,614	32%	68%	317,513	26%	74%	**10%**	Panama	446	51%	49%	17,453	33%	67%	**2%**
Hong Kong SAR, China	30,295	33%	67%	431,916	28%	72%	**7%**	Slovak Republic	409	0%	100%	16,083	20%	80%	**2%**
Finland	29,384	31%	69%	168,274	23%	77%	**15%**	Uruguay	399	67%	33%	6,187	27%	73%	**6%**
India	28,629	30%	70%	575,406	25%	75%	**5%**	Oman	375	0%	100%	46,175	2%	98%	**1%**
Mexico	27,203	43%	57%	416,851	51%	49%	**6%**	Latvia	374	100%	0%	669	29%	71%	**36%**
Belgium	25,330	13%	87%	318,560	27%	73%	**7%**	Nigeria	371	0%	100%	46,874	2%	98%	**1%**
Brazil	18,925	57%	43%	427,082	61%	39%	**4%**	Romania	328	0%	100%	13,187	9%	91%	**2%**
Ireland	18,668	28%	72%	360,134	21%	79%	**5%**	Morocco	309	0%	100%	7,900	52%	48%	**4%**
Saudi Arabia	17,934	11%	89%	268,296	12%	88%	**6%**	Malta	268	0%	100%	11,191	31%	69%	**2%**
Portugal	16,106	37%	63%	47,126	29%	71%	**25%**	Dominican Republic	247	100%	0%	2,294	15%	85%	**10%**
Luxembourg	15,367	44%	56%	425,237	55%	45%	**3%**	Costa Rica	247	100%	0%	3,543	24%	76%	**7%**
United Arab Emirates	15,101	12%	88%	344,526	9%	91%	**4%**	Uzbekistan	203	0%	100%	9,953	8%	92%	**2%**
Poland	14,628	10%	90%	83,190	9%	91%	**15%**	Senegal	190	0%	100%	2,280	7%	93%	**8%**
Chile	11,899	57%	43%	129,479	46%	54%	**8%**	Bulgaria	81	0%	100%	6,003	9%	91%	**1%**
Thailand	9,400	47%	53%	224,962	69%	31%	**4%**	Croatia	76	0%	100%	15,518	14%	86%	**0%**
Austria	8,893	23%	77%	107,997	34%	66%	**8%**	Cyprus	70	0%	100%	7,229	27%	73%	**1%**
New Zealand	7,435	36%	64%	117,991	18%	82%	**6%**	Zambia	67	0%	100%	3,206	0%	100%	**2%**
South Africa	6,807	0%	100%	133,088	7%	93%	**5%**	Kazakhstan	52	0%	100%	36,157	34%	66%	**0.1%**
Russian Federation	6,419	21%	79%	346,911	41%	59%	**2%**	Serbia	51	0%	100%	4,593	13%	87%	**1%**
Indonesia	5,715	23%	77%	245,540	29%	71%	**2%**	Ecuador	40	0%	100%	2,282	0%	100%	**2%**
Greece	5,012	38%	62%	47,516	13%	87%	**10%**	Lesotho	35	0%	100%	168	0%	100%	**17%**
Bahrain	4,514	0%	100%	16,647	11%	89%	**21%**	Albania	34	0%	100%	81	0%	100%	**29%**
Malaysia	3,831	44%	56%	155,764	62%	38%	**2%**	Mongolia	22	0%	100%	12,523	8%	92%	**0.2%**
Türkiye	3,774	44%	56%	123,782	12%	88%	**3%**	Cambodia	15	100%	0%	2,988	15%	85%	**0.5%**
Argentina	2,309	72%	28%	49,503	52%	48%	**4%**	Bangladesh	0.3	0%	100%	12,700	2%	98%	**0.0%**
Estonia	2,002	0%	100%	3,715	35%	65%	**35%**								
Israel	1,974	0%	100%	73,579	11%	89%	**3%**								
Hungary	1,921	29%	71%	36,843	9%	91%	**5%**								

This table reports total volumes of green and conventional debt issued between 2012 and 2023. All amounts are expressed in millions of 2011 U.S. dollars (USD).

Appendix Table 2. Types of Green Debt Instruments

Type of Bond Instrument	Total No. of Yearly Transactions	Total Debt Raised (USD, Bn)	Median Transaction Size (USD, Mn)	Median Maturity (Years)	Green Labeled	Sust. Linked
A. Corporate Bonds						
CBI-Aligned	912	363	212	6.0	✓	
CBI-Certified	84	27	218	7.0	✓	
Sustainability	176	67	220	7.6	✓	
Self-Labeled Green	442	107	131	5.0	✓	
Sustainibility-Linked	280	113	292	6.0		✓
B. Syndicted Loans						
Type of Loan Instrument	Total No. of Yearly Transactions	Total Debt Raised (USD, Bn)	Median Transaction Size (USD, Mn)	Median Maturity (Years)	Green Labeled	Sust. Linked
Green-Labeled	1,253	333	115	7.0	✓	
Sustainibility-Linked (Term)	1,240	397	137	5.0		✓
Sustainibility-Linked (Revolver)	1,664	1,022	244	5.0		✓

This table shows summary statistics for conventional and green debt transactions from 2012 to 2022. Dollar values are expressed in 2011 U.S. dollars (USD). The units used are: Mn = million, Bn = billion.

Appendix Table 3. Top Green Debt Issuers

Top	Company Name	Green Debt Issued (USD, Mn)	Conventional Debt Issued (USD, Mn)	Share of Green Debt	Country	Industry
1	Ford Motor Co.	42,277	116,718	27%	United States	Manufacturing
2	Engie SA	27,455	52,475	34%	France	Utilities
3	Alphabet Inc.	23,774	12,834	65%	United States	Services
4	RWE AG	21,636	24,148	47%	Germany	Utilities
5	Enel SpA	20,127	66,115	23%	Italy	Utilities
6	Airbus SE	18,255	30,434	37%	France	Manufacturing
7	TenneT Holding BV	16,550	5,169	76%	Netherlands	Utilities
8	EDF – Électricité de France SA	16,108	72,461	18%	France	Utilities
9	ENI SpA	15,749	26,028	38%	Italy	Fossil Energy
10	China Three Gorges Corp.	15,670	27,970	36%	China	Utilities
11	Iberdrola SA	14,595	21,339	41%	Spain	Utilities
12	Orsted A/S	13,979	5,687	71%	Denmark	Utilities
13	Pfizer Inc.	13,100	108,806	11%	United States	Manufacturing
14	Intel Corp.	12,665	59,543	18%	United States	Manufacturing
15	Siemens Energy AG	12,276	–	100%	Germany	Renewable Energy
16	Sanofi SA	12,102	58,752	17%	France	Manufacturing
17	EDP – Energias de Portugal SA	11,692	16,442	42%	Portugal	Utilities
18	E.ON SE	11,677	19,704	37%	Germany	Utilities
19	Crown Castle International Corp.	11,485	69,591	14%	United States	Utilities
20	Terna Rete Elettrica Nazionale SpA	10,562	9,514	53%	Italy	Utilities

Rankings based on total volumes of green and conventional debt issued during 2012–2023. Amounts shown in millions of 2011 U.S. dollars (USD).

Appendix Table 4. Top Lead Arrangers in Green and Conventional Syndicated Lending

Top Green Lenders			Top Conventional Lenders		
Top	**Bank Name**	Green Debt Lent (USD, Mn)	**Top**	**Bank Name**	Conventional Debt Lent (USD, Mn)
1	BNP Paribas	500,472	1	JP Morgan	6,384,464
2	JP Morgan	142,922	2	Bank of America	4,445,685
3	Bank of America	78,283	3	BNP Paribas	3,298,894
4	ABN AMRO Bank	77,275	4	Citigroup	2,749,404
5	Australia & New Zealand Banking Group Ltd	47,577	5	Wells Fargo	1,788,545
6	Banco Santander SA	47,201	6	MUFG	1,187,601
7	Mizuho Bank Ltd	45,401	7	Barclays	1,042,085
8	MUFG	43,987	8	Credit Suisse AG	1,022,068
9	Citigroup	43,440	9	Deutsche Bank	794,150
10	Banco Bilbao Vizcaya Argentaria SA	43,107	10	Australia & New Zealand Banking Group Ltd	761,676
11	Credit Agricole	31,697	11	Mizuho Bank Ltd	754,301
12	Wells Fargo	28,850	12	Goldman Sachs & Co	681,954
13	Barclays	27,984	13	ABN AMRO Bank	626,064
14	CaixaBank SA	23,686	14	Sumitomo Mitsui	602,001
15	Canadian Imperial Bank of Commerce	21,465	15	Scotiabank	522,691
16	Sumitomo Mitsui	20,837	16	Morgan Stanley Group Inc	497,354
17	Agricultural Bank of China	19,460	17	Banco Bilbao Vizcaya Argentaria SA	482,547
18	HSBC	16,830	18	Bank of China Ltd	448,004
19	Bank of China Ltd	15,857	19	The Royal Bank of Canada	415,037
20	Deutsche Bank	15,195	20	Credit Agricole	322,596

Rankings are based on total syndicated loan volumes during 2012–2023 in which each bank participated as a lead arranger. Amounts are expressed in millions of 2011 U.S. dollars (USD). Reported figures reflect the full size of the syndicated loans, not the individual lending commitments of each bank.