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$$r_{it} = a_i + b_i \times r_{mt} + e_{it} ,$$

where  $r_{it}$  is the return on the stock of company  $i$  on day  $t$ ;  $r_{mt}$  is the daily market return; and  $e_{it}$  is the residual. Daily stock returns  $r_{it}$  are obtained from CRSP (for U.S. companies) and the daily stock file of Compustat Global (for non-U.S. companies). Daily market returns  $r_{mt}$  are country-specific. For the U.S., I use the S&P 500. For all other countries I use the country's leading stock market index (e.g., the FTSE 100 Index for the U.K.).<sup>14</sup>

The estimated return on the stock of company  $i$  on day  $t$  is then given by:

$$\hat{r}_{it} = \hat{a}_i + \hat{b}_i \times r_{mt} .$$

I calculate the abnormal return of company  $i$  on day  $t$  as follows:

$$AR_{it} = r_{it} - \hat{r}_{it} .$$

Finally, I compute the cumulative abnormal returns (CAR) by summing up abnormal returns in event time—that is, CAR from  $t_1$  to  $t_2$  is obtained as:

$$CAR_i(t_1, t_2) = \sum_{\tau=t_1}^{t_2} AR_{i\tau} .$$

### 3.1.2 Results

Figure 6 plots the average cumulative abnormal returns (CARs) ten days before and after the

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<sup>14</sup> The results are similar if instead of using country-specific stock market indices, I compute  $r_{mt}$  using the MSCI All-Country World Equity Index.

announcement of green bond issues. As can be seen, CARs are essentially zero prior to the announcement, there is a sharp increase around the event date, and the CARs remain high thereafter. The average CAR in the two-day event window  $(-1, 0)$  is 0.67%, which is significant at conventional statistical levels ( $t = 2.42$ ). This indicates that green bonds are perceived as value-enhancing by the stock market.

----- Insert Figure 6 about here -----

Note that the results are unlikely to capture a “bond effect” as opposed to a “green bond effect.” Indeed, a common finding in the corporate finance literature is that the stock market does not respond significantly to the announcement of bond issues, while it responds negatively to the announcement of equity issues—see, e.g., Eckbo, Masulis, and Norli (2007) and Masulis and Korwar (1986).

### *3.1.3 Certification*

The previous analysis considered all green bonds of public firms, regardless of whether they are certified or not by independent third parties.

To distinguish between certified and non-certified green bonds, I use the certification information provided in the Climate Bonds Initiative (CBI) database. This database compiles information on the certification of each green bond, along with the identity of the third-party certifier. Common certifiers include Sustainalytics, Vigeo Eiris, Ernst & Young, and CICERO (Center for International Climate Research). Green bonds can be issued under a variety of voluntary standards. Two leading standards that verify the integrity of the green bond label are the Green Bond Principles (GBP) and the Climate Bond Standards (CBS). In a nutshell, the certification process is split into two phases. In the pre-issuance phase, the certifier verifies that a) the projects to be financed by the bond proceeds are eligible under the specific certification

standards, and b) the issuer has established internal processes and controls to keep track of how the bond proceeds are used (which includes the submission of annual reports). In the post-issuance phase, the certifier verifies that the proceeds have been allocated to green projects in accordance with the standards.

Out of the 217 green bonds used in the event study, 147 are certified (68%). In Figure 7, I repeat the event study separately for certified and non-certified green bonds. While the average CAR in the two-day event window (-1, 0) is positive in both groups, it is only significant for certified green bonds. Specifically, the two-day CAR is 0.8% for certified green bonds ( $t = 2.27$ ), while it is 0.4% for non-certified green bonds ( $t = 0.94$ ).<sup>15</sup> Overall, these findings suggest that certification is an important determinant of the effectiveness of green bonds.

----- Insert Figure 7 about here -----

## **3.2 Analysis of long-term financial and environmental performance**

### *3.2.1 Methodology*

The 217 green bonds used in the event study correspond to 106 unique firm-year observations (since companies can issue multiple green bonds in the same year). In the following, I estimate how the issuance of green bonds affects firm-level outcomes using a difference-in-differences specification around these 106 “treatments.”

To obtain a control group, I match each treated firm to a control firm from the pool of public companies. The matching is done in two steps. First, for each treated firm, I restrict the pool of candidates to firms that issue a regular bond in the same calendar year as the green bond issue—this criterion ensures that the results capture a “green bond effect” as opposed to a mere “bond

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<sup>15</sup> Note that the difference is not significant ( $p$ -value = 0.389). Due to the limited sample size, there is little power to detect cross-sectional differences in statistical terms.

effect.” I further restrict the pool of candidates to firms that operate in the same 2-digit SIC industry and the same country as the treated firm. Second, among the remaining candidates, I select the nearest neighbor based on a large set of observables prior to the treatment. Specifically, the matching characteristics are size, Tobin’s Q, ROA, leverage, and the company’s environmental, social, and governance ratings. For each characteristic, I consider the variable in the year preceding the green bond issuance (i.e., at  $t - 1$ ), as well as the pre-trend (i.e., the change from  $t - 2$  to  $t - 1$ ). Accordingly, fourteen matching variables are used. The nearest neighbor is the firm with the lowest Mahalanobis distance to the treated firm across these fourteen matching characteristics.<sup>16</sup>

Using this matched control sample, I estimate the following difference-in-differences specification:

$$y_{it} = \alpha_i + \theta_{ct} + \mu_{st} + \sum_{\tau=-2}^{2+} \beta_{\tau} \times Green\ bond(\tau)_{it} + e_{it}, \quad (1)$$

where  $i$  indexes companies,  $t$  indexes years,  $c$  indexes countries, and  $s$  indexes 2-digit SIC industries;  $y$  is the outcome variable of interest (e.g., ROA, CO<sub>2</sub> emissions);  $\alpha_i$  are firm fixed effects;  $\theta_{ct}$  are country by year fixed effects;  $\mu_{st}$  are industry by year fixed effects;  $Green\ bond(-2)$  is a dummy variable equal to one for green bond issuers two years prior to the green bond issue;  $Green\ bond(-1)$  is defined analogously;  $Green\ bond(0)$  is a dummy variable equal to one for green bond issuers in the year that ends before the green bond issue;  $Green\ bond(1)$  is a dummy variable equal to one for green bond issuers in the year that ends after the green bond issue;  $Green\ bond(2+)$  is a dummy variable equal to one for green bond issuers two or more years after the green bond issue.<sup>17</sup> Standard errors are clustered at the 2-digit SIC industry level. For each dependent variable, I plot the full set of coefficients  $\{\beta_{\tau}\}_{\tau=-2}^{2+}$  along with a 90% confidence interval.

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<sup>16</sup> See Flammer (2018) for details, along with a characterization of the treated and matched control firms.

<sup>17</sup> The regressions are estimated using all firm-year observations of the treated and matched control firms from 2010-2017. Note that a broader characterization of the dynamics (i.e., splitting the  $\tau = 2+$  period into  $\tau = 2, 3, 4$ , etc.) is not



### *3.2.2 Financial performance*

To measure financial performance, I use the return on assets (ROA) and the return on equity (ROE). Both measures are obtained from Standard & Poor's Compustat.<sup>18</sup> ROA is defined as operating income before depreciation scaled by the book value of total assets; ROE is defined similarly but using the book value of equity as scaling variable. Both ratios are winsorized at the 1<sup>st</sup> and 99<sup>th</sup> percentiles of their empirical distribution.

The ROA coefficients are plotted in Panel A of Figure 8. As can be seen, i) there is no pre-trend; ii) the effect is positive but insignificant in the short run (i.e., one year after the green bond issue), and iii) the effect is positive and significant in the long run (i.e., two and more years after the green bond issue). In terms of magnitudes, ROA increases by 0.006 in the long run. Since the mean of ROA is 0.056, this implies that performance increases by about 11%. This indicates that green bonds yield tangible (long-term) financial benefits to companies. Panel B provides similar results with respect to ROE.

----- Insert Figure 8 about here -----

### *3.2.3 Environmental performance*

In Figure 9, I use two measures of environmental performance. The first measure is the environmental rating from Thomson Reuters' ASSET4. The second measure is the ratio of CO<sub>2</sub> emissions (in tons) from ASSET4 divided by the book value of total assets in U.S. dollars. I winsorize this ratio at the 1<sup>st</sup> and 99<sup>th</sup> percentiles of its empirical distribution.

Panel A plots the coefficients pertaining to the ASSET4 environmental rating. The rating

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feasible since most green bonds are issued in the later years of the sample, and hence most issuers have no more than two post-issue years available.

<sup>18</sup> Compustat North America is used for U.S. and Canadian companies, while Compustat Global is used for all other companies.

increases significantly in the long run, while there is no evidence for pre-trends. Similarly, Panel B documents a significant decrease in CO<sub>2</sub> emissions following the issuance of green bonds. In economic terms, the environment rating goes up by 7.3 percentage points in the long run, which corresponds to an increase by 8.8% (given a mean of 83.4). Similarly, emissions are reduced by 21.6 tons of CO<sub>2</sub> per \$1M of assets, a reduction by 27.7% (given a mean of 77.9). Overall, these findings indicate that green bonds are effective—they do yield significant improvements in the issuers’ environmental performance.

----- Insert Figure 9 about here -----

### 3.2.4 Certification

In auxiliary regressions, I repeat the previous analysis interacting *Green Bond*( $\tau$ ) with dummy variables that indicate whether the green bond is certified or not by an independent third party. I find that the long-run effects documented above are large and significant for certified green bonds, while they are small and insignificant for non-certified green bonds. This echoes the event study findings, and further highlights the importance of certification in the green bond market.

## 4. Discussion and conclusion

Climate change likely represents the greatest challenge faced by our and future generations. The impact of climate change is felt everywhere, and poses an existential threat to ecosystems and communities around the world. The signing of the Paris Agreement in 2015 marked an important milestone in the fight against climate change.<sup>19</sup> Yet, as the recent U.S. example illustrates—

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<sup>19</sup> The Paris meeting (often referred to as COP21) was the 21st annual meeting of the Conference of the Parties (COP) pursuant to the United Nations Framework Convention on Climate Change (UNFCCC). The Paris Agreement commits to the following (UNFCCC, 2015): a) holding the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change; b) increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions

President Donald J. Trump announced on June 1, 2017 the U.S.’ intention to withdraw from the Paris Agreement—international treaties face challenges on their own. Importantly, nations cannot act alone. Addressing climate change requires an enormous amount of funding—the OECD estimates that \$93 trillion in infrastructure investment will be needed in the next fifteen years to achieve a low-carbon future (OECD, 2017). In comparison, the world’s GDP was about \$80 trillion in 2017. This tremendous financing need represents an opportunity for the complementary use of private and public financing structures.

This paper examines one emerging instrument: green bonds—i.e., bonds whose proceeds are committed to the financing of low-carbon, climate-friendly projects. Since their inception in 2007, green bonds have become increasingly popular among private investors, and practitioners often refer to this evolution as a “green bond boom.” This paper describes the evolution of the green bond market, highlighting the heterogeneity across countries and industry sectors. Furthermore, it examines the effectiveness of corporate green bonds in terms of both financial and environmental performance. Using a sample of green bonds issued by public companies, I find that the stock market responds positively to the announcement of green bond issues, suggesting that green bonds are value-enhancing. I also find that green bond issuers—compared to a matched sample of (non-green) bond issuers—experience long-term improvements in financial performance (measured by an increase in ROA and ROE) and environmental performance (measured by a decrease in CO<sub>2</sub> emissions and an increase in environmental ratings). Moreover, these findings are only significant for green bonds that are certified by independent third parties, suggesting that certification is a key governance mechanism for green bonds. One caveat of this study is that I do not have an instrument for the issuance of green bonds. That being said, it is

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development, in a manner that does not threaten food production; and c) making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

difficult to think about unobservables that would i) not be filtered out by the tight matching used in the analysis *and* ii) explain the full set of results presented in this paper (including the differential outcomes for certified versus non-certified green bonds).

My results highlight the importance of certification in the green bond market. The fact that my findings are only significant for certified green bonds suggests that certification is effective as a private governance regime. Nevertheless, it need not be *the* most effective governance regime. While the green bond market is still in its early years, several challenges have been raised by practitioners. First, the definition of “green” is ambiguous, which complicates the certification. This is exemplified by the recent case of the Spanish energy company Repsol. In 2017, the Climate Bond Initiative (CBI) refused to certify Repsol’s green bond. Interestingly, CBI (2017) acknowledged that the bond did aim at reducing emissions (“The goal of the bond is to reduce GHG emissions from refineries and, yes, the bond will avoid emissions: an estimated 1.2M tonnes of CO<sub>2</sub> annually by 2020”), yet CBI’s concern was that Repsol’s environmental strategy did not go far enough to qualify as green (“[...] any investment in making refineries more efficient, as this bond is aiming to, will likely extend plant operating lifetimes and therefore indirectly increase emissions over time”).

Second, there are a number of international and national taxonomies addressing green bond project definitions, including the Green Bond Principles (GBP) and the Climate Bonds Standard (CBS). However, the lack of universal rules and standardization is a common concern among green bond investors. As the OECD notes, “[c]onvergence towards commonly accepted definitions will be essential to maximise the effectiveness, efficiency and integrity of the market” (OECD, 2017, p. 13).

Third, the current certification of green bonds is binary in nature (i.e., certified vs. not certified), whereas green bonds are likely to differ in terms of their environmental impact. A scheme based on tiered ratings (e.g., a triple A rating for the strongest environmental impact)—similar to the model used by credit rating agencies—could improve the informativeness of the certification and help expand the depth of the green bond market.

Arguably, these challenges are likely to be exacerbated as the market further expands in the years to come. In this context, voices have been raised advocating for a hybrid governance regime that combines the benefits of both public and private governance (Park, 2018). Admittedly, the (current) lack of public governance is likely suboptimal. While private governance is both flexible and pragmatic, it may lack transparency, legitimacy, and accountability. Those could be guaranteed by public governance, which can provide a unified basis that enhances the effectiveness of private governance. More broadly, this discussion illustrates the need for more research that studies the optimal design of the governance of the green bond market.<sup>20</sup>

Several of the challenges that arise in the context of green bonds extend to other instruments that aim at addressing climate change. In particular, carbon offsets are subject to

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<sup>20</sup> Relatedly, the lack of public governance pertaining to the disclosure of non-financial information bears the risk that it leads to i) a lack of best practices, ii) a lack of standardization of disclosure, and iii) difficulties for financial analysts and investors to interpret non-financial performance metrics. Also—and perhaps more importantly—the lack of public governance may lead to a lack of disclosure of non-financial information altogether. This issue arises, for example, in the context of companies' exposure to climate change risks. In many countries (including the U.S.), the disclosure of such information is not mandated by law. As a result, many companies do not disclose their exposure to climate change risks, despite the potential (long-term) financial benefits of mitigating climate-related costs and risks (Cheng, Ioannou, and Serafeim, 20014; Dhaliwal, Li, Tsang, and Yang, 2011; Sharfman and Fernando, 2008). To compensate for the absence of government regulation, shareholders increasingly step up and pressure their portfolio companies to disclose and address climate change risks. Indeed, companies are expected to face a record high of climate-related shareholder proposals at the upcoming shareholder meetings (Wall Street Journal, 2019). In line with this trend, a recent survey of institutional investors paints a striking picture: the majority of surveyed investors believe that climate risk reporting is as important as financial reporting, and one-third believe that climate risk reporting is even more important (Krueger, Sautner, and Starks, 2018). In a recent study, Fabrizio, Flammer, Toffel, and Viswanathan (2019) highlight that investors are indeed effective in eliciting greater corporate transparency with respect to firms' climate risk exposure, thereby contributing to their portfolio companies' governance. A direct implication of their findings is that, in absence of mandatory disclosure requirements, this greater ability also implies a greater responsibility of investors to be active owners and engage with the management to elicit the disclosure of climate risks.

similar concerns. Carbon offsetting is the process of compensating for CO<sub>2</sub> emissions through schemes that are designed to make offsetting reductions in emissions from other parts of the economy. For example, several airlines (such as British Airways, Delta, and Emirates) offer carbon offset programs. Essentially, passengers have the option to “offset” the emissions generated by their flight by contributing to a wide variety of offsetting actions—e.g., the replanting of trees in at-risk areas, the development of wind farms, etc. Such carbon offsets have faced skepticism on several grounds (e.g., Anderson, 2012; Forbes 2019). One key issue is the lack of transparency regarding the environmental impact of the offsetting action.<sup>21</sup> Third-party certification is a potential remedy, and certification standards for carbon offsets have started to emerge (such as the Climate Action Reserve and Green-e Climate). Importantly, the insights gained from the green bond market might help shape the governance structure of this (and other) instruments in the fight against climate change.

Relatedly, some of the lessons learned from the carbon offsets might help inform the policy discussion pertaining to green bonds. In particular, a key consideration in the context of carbon offsets is the notion of additionality. For carbon offsets to be effective, the activity that is financed by the carbon offset (e.g., the planting of trees) needs to be “additional”—if it were to happen anyway (regardless of the carbon offset), it is not additional.<sup>22</sup> To help ensure the additionality of carbon offsets, the United Nations’ Clean Development Mechanism (CDM) has designed a series of “additionality tests” (see UNFCCC, 2004). For example, one of these tests is the *legal and*

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<sup>21</sup> For example, referring to airlines’ carbon offset programs, Forbes (2019) notes that “[b]alancing the carbon emitted by your airline seat through the planting of several trees in South America does not involve solely the solitary act of placing the tree in the soil. In order to plant the trees, there are several steps. Firstly, they must be bought from a supplier, transported to a warehouse before being driven out to a site that needs to be cleared prior to them being planted—all these actions produce their own share of carbon emissions, which are not always taken into account. If your offset produces more emissions than if you had done nothing, then it is really not an offset.”

<sup>22</sup> For example, if airline passengers buy carbon offsets from entities that would have reduced their emissions anyway (i.e., even absent the carbon offset), such offsets are not additional. In such cases, airline passengers are merely subsidizing an activity that would have happened regardless, as opposed to neutralizing their emissions.

*regulatory additionality test*—if the project is implemented to fulfill formal policies, regulations, or industry standards, it does not qualify as additional. If the project goes beyond compliance (“regulatory surplus”), then it may qualify.<sup>23</sup> Naturally, a similar challenge arises in the context of green bonds. For green bonds to make a difference, the projects that are financed by the bond proceeds need to be additional. If companies were to undertake these projects regardless, little is gained from the “green financing,” especially if companies simply refinance their existing (ordinary) bonds into green bonds, with no effective change in companies’ actions. Criteria such as the CDM additionality tests might be helpful in shaping this dimension of the green bond market.

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<sup>23</sup> Other tests include the *investment test*, *barriers test*, and *common practice test*. See UNFCCC (2004) for details.

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**Table 1**  
**Green bonds over time**

This table reports the amount (in \$B) and number (#) of green bonds issued on an annual basis. The table also reports the corresponding statistics for ordinary bonds (i.e., bonds that are not labelled as “green”). The dataset includes all bonds (excluding muni bonds) in Bloomberg issued between January 1, 2007 and December 31, 2018.

Year	\$B Green bonds	# Green bonds	\$B Ordinary bonds	# Ordinary bonds	Share of green bonds (\$)	Share of green bonds (#)
2018	143.1	519	32,341.7	191,362	0.441%	0.270%
2017	146.6	441	38,893.2	172,645	0.376%	0.255%
2016	95.4	263	37,268.9	146,912	0.255%	0.179%
2015	47.7	328	31,573.7	132,506	0.151%	0.247%
2014	34.5	138	29,300.9	123,106	0.118%	0.112%
2013	13.2	39	27,196.3	114,474	0.049%	0.034%
2012	2.1	21	30,066.0	100,283	0.007%	0.021%
2011	1.2	30	28,125.8	86,096	0.004%	0.035%
2010	4.4	55	28,268.9	83,112	0.015%	0.066%
2009	0.9	13	28,868.6	86,364	0.003%	0.015%
2008	0.4	7	23,686.4	115,269	0.002%	0.006%
2007	0.8	1	20,571.3	118,215	0.004%	0.001%
Total	490.4	1,855	356,161.8	1,470,344	0.138%	0.126%

**Table 2**  
**Green bonds across countries**

This table reports the amount (in \$B) and number (#) of green bonds issued by country. The table also reports the corresponding statistics for ordinary bonds (i.e., bonds that are not labelled as “green”). The dataset includes all bonds (excluding muni bonds) in Bloomberg issued between January 1, 2007 and December 31, 2018.

Country	\$B Green bonds	# Green bonds	\$B Ordinary bonds	# Ordinary bonds	Share of green bonds (\$)	Share of green bonds (#)
China	83.9	199	44,358.9	144,346	0.189%	0.138%
France	58.1	176	12,844.8	20,743	0.450%	0.841%
United States	56.9	464	76,308.6	240,434	0.074%	0.193%
Netherlands	40.5	60	5,540.0	37,723	0.726%	0.159%
Luxembourg	39.8	62	3,446.4	16,775	1.141%	0.368%
Germany	39.6	84	17,564.0	299,037	0.225%	0.028%
Sweden	19.4	194	2,622.6	13,711	0.734%	1.395%
Britain	14.1	87	14,562.2	94,228	0.097%	0.092%
Mexico	13.3	13	2,662.4	3,030	0.499%	0.427%
Canada	10.9	25	9,723.9	34,484	0.112%	0.072%
Spain	9.0	19	5,302.8	4,401	0.170%	0.430%
Norway	8.4	43	1,666.1	18,767	0.504%	0.229%
Japan	7.8	46	78,226.9	26,393	0.010%	0.174%
Belgium	7.6	4	1,842.8	2,014	0.411%	0.198%
Finland	7.5	27	864.2	4,663	0.856%	0.576%
Hong Kong	7.4	31	4,458.5	24,319	0.166%	0.127%
Australia	6.8	17	3,420.2	15,942	0.198%	0.107%
Philippines	6.3	27	567.7	2,341	1.093%	1.140%
Brazil	5.4	8	3,542.7	3,892	0.153%	0.205%
South Korea	5.3	15	6,664.1	64,948	0.079%	0.023%
India	5.2	19	5,158.5	33,595	0.101%	0.057%
Italy	4.6	11	10,060.7	54,532	0.045%	0.020%
Denmark	3.5	6	768.9	4,785	0.455%	0.125%

Ireland	3.5	1	1,732.3	5,368	0.199%	0.019%
Ivory Coast	2.6	22	91.7	558	2.783%	3.793%
Indonesia	2.5	4	1,695.2	3,884	0.149%	0.103%
Switzerland	2.1	9	1,532.9	51,789	0.134%	0.017%
Poland	2.0	2	630.1	2,617	0.317%	0.076%
British Virgin	1.8	5	311.7	1,567	0.572%	0.318%
Austria	1.7	4	1,361.9	14,250	0.124%	0.028%
United Arab Emirates	1.6	3	373.6	14,516	0.423%	0.021%
Taiwan	1.6	21	605.3	3,259	0.257%	0.640%
Cayman Islands	1.2	2	792.1	8,260	0.154%	0.024%
Singapore	1.2	10	3,336.6	7,059	0.036%	0.141%
Chile	1.0	2	827.7	3,745	0.121%	0.053%
Costa Rica	1.0	2	123.5	830	0.803%	0.240%
Malaysia	1.0	98	1,477.5	16,624	0.066%	0.586%
Mauritius	1.0	2	49.3	1,985	1.889%	0.101%
Argentina	0.9	4	1,713.1	2,960	0.053%	0.135%
Lithuania	0.7	3	40.6	508	1.741%	0.587%
New Zealand	0.4	4	353.3	1,866	0.124%	0.214%
Peru	0.4	2	290.1	1,598	0.140%	0.125%
South Africa	0.3	5	937.0	6,124	0.033%	0.082%
Latvia	0.2	3	26.1	368	0.627%	0.809%
Slovenia	0.1	1	94.9	307	0.090%	0.325%
Venezuela	0.1	2	226.7	879	0.036%	0.227%
Honduras	0.1	1	161.1	604	0.048%	0.165%
Greece	0.1	1	1,382.3	718	0.005%	0.139%
Colombia	0.1	1	359.6	1,060	0.018%	0.094%
Estonia	0.1	1	2.9	51	1.868%	1.923%
Fiji	0.0	2	2.2	482	2.126%	0.413%
Nigeria	0.0	1	579.4	1,348	0.005%	0.074%
Other	0.0	0	22,873.2	150,057	0.000%	0.000%
Total	490.4	1,855	356,161.8	1,470,344	0.138%	0.126%

**Table 3**  
**Green bonds across industries**

This table reports the amount (in \$B) and number (#) of green bonds issued by industry. Industries are defined according to BICS (Bloomberg Industry Classification Systems) codes. The table also reports the corresponding statistics for ordinary bonds (i.e., bonds that are not labelled as “green”). The dataset includes all bonds (excluding muni bonds) in Bloomberg issued between January 1, 2007 and December 31, 2018.

Industry	\$B Green bonds	# Green bonds	\$B Ordinary bonds	# Ordinary bonds	Share of green bonds (\$)	Share of green bonds (#)
Government	182.6	638	258,220.6	351,741	0.071%	0.181%
Financials	150.9	570	63,873.7	978,456	0.236%	0.058%
Utilities	86.8	259	4,104.5	17,618	2.071%	1.449%
Industrials	31.4	93	5,641.2	32,247	0.553%	0.288%
Energy	15.4	230	4,738.4	11,894	0.325%	1.897%
Consumer Discretionary	12.3	31	5,116.9	31,533	0.239%	0.098%
Materials	5.2	19	3,575.0	16,011	0.144%	0.119%
Technology	3.2	5	1,885.6	7,454	0.169%	0.067%
Consumer Staples	1.9	6	2,658.3	9,372	0.071%	0.064%
Health Care	0.7	3	2,506.6	6,350	0.028%	0.047%
Communications	0.1	1	3,839.4	7,528	0.002%	0.013%
Other	0.0	0	1.7	140	0.000%	0.000%
Total	490.4	1,855	356,161.8	1,470,344	0.138%	0.126%

**Table 4**  
**Summary statistics**

This table reports summary statistics for all green bonds and ordinary bonds (i.e., bonds that are not labelled as “green”). *Issuance amount* is the amount issued (in \$M). *Maturity* is the maturity of the bond (in years). *Coupon* is the coupon rate (in %). *Coupon type* refers to the type of coupon payment. *Bloomberg rating* refers to the Bloomberg composite credit rating. All figures are sample means (and percentages, respectively). The dataset includes all bonds (excluding muni bonds) in Bloomberg issued between January 1, 2007 and December 31, 2018.

	Green bonds	Ordinary bonds
# bonds	1,855	1,470,344
Issuance amount (\$M)	264.38	242.23
Maturity (years)	6.92	3.35
Coupon (%)	3.25	3.52
Coupon type		
Fixed	75.96%	80.77%
Floating	13.05%	8.89%
Other	11.00%	10.34%
Bloomberg rating		
AAA	30.26%	8.52%
AA+	3.41%	21.64%
AA	4.41%	3.26%
AA-	7.21%	7.31%
A+	6.81%	8.01%
A	10.22%	9.06%
A-	7.01%	8.85%
BBB+	9.22%	7.99%
BBB	4.41%	7.04%
BBB-	6.81%	5.79%
BB+	1.00%	2.16%
BB	1.80%	1.56%
BB-	2.00%	2.20%
B+	1.60%	1.67%
B	1.60%	1.93%
B-	1.20%	1.37%
C range	1.00%	1.53%
D range	0.00%	0.11%

**Table 5**  
**Green municipal bonds over time**

This table reports the amount (in \$B) and number (#) of green municipal bonds issued on an annual basis. The table also reports the corresponding statistics for ordinary municipal bonds (i.e., municipal bonds that are not labelled as “green”). The dataset includes all municipal bonds (“munis”) in Bloomberg issued between January 1, 2010 and December 31, 2018.

Year	\$B Green muni bonds	# Green muni bonds	\$B Ordinary muni bonds	# Ordinary muni bonds	Share of green muni bonds (\$)	Share of green muni bonds (#)
2018	4.3	925	398.4	107,114	1.063%	0.856%
2017	11.2	1,334	419.2	133,388	2.597%	0.990%
2016	7.4	952	405.6	155,299	1.794%	0.609%
2015	4.1	735	345.1	148,590	1.188%	0.492%
2014	1.9	260	276.6	122,578	0.699%	0.212%
2013	0.3	115	260.2	126,480	0.115%	0.091%
2012	0.2	146	288.3	155,727	0.073%	0.094%
2011	0.1	140	206.8	120,275	0.066%	0.116%
2010	0.6	187	308.3	150,528	0.189%	0.124%
Total	30.2	4,794	2,908.4	1,219,979	1.027%	0.391%



**Table 6**  
**Green municipal bonds by state**

This table reports the amount (in \$B) and number (#) of green municipal bonds issued by U.S. state. The table also reports the corresponding statistics for ordinary municipal bonds (i.e., municipal bonds that are not labelled as “green”). The dataset includes all municipal bonds (“munis”) in Bloomberg issued between January 1, 2010 and December 31, 2018.

State	\$B Green muni bonds	# Green muni bonds	\$B Ordinary muni bonds	# Ordinary muni bonds	Share of green muni bonds (\$)	Share of green muni bonds (#)
New York	8.0	959	334.0	85,833	2.353%	1.105%
California	7.8	923	435.5	105,375	1.753%	0.868%
Massachusetts	3.1	412	78.2	32,657	3.871%	1.246%
Washington	2.1	182	79.2	22,961	2.527%	0.786%
Indiana	1.2	236	33.6	32,466	3.314%	0.722%
Connecticut	0.8	95	43.6	19,059	1.809%	0.496%
Iowa	0.7	68	17.8	29,274	4.029%	0.232%
District of Columbia	0.7	27	20.9	1,857	3.149%	1.433%
Colorado	0.7	110	57.2	16,705	1.171%	0.654%
Ohio	0.6	128	83.0	39,542	0.730%	0.323%
Arizona	0.5	112	44.7	11,938	1.166%	0.929%
Illinois	0.5	115	125.0	45,843	0.404%	0.250%
Texas	0.4	33	313.0	166,776	0.114%	0.020%
Maryland	0.3	32	52.2	12,016	0.609%	0.266%
Virginia	0.3	61	58.2	16,489	0.514%	0.369%
New Jersey	0.3	277	92.6	40,825	0.322%	0.674%
Hawaii	0.3	63	20.8	2,566	1.403%	2.396%
Nevada	0.2	5	22.4	4,605	0.969%	0.108%
Minnesota	0.2	158	47.7	49,649	0.442%	0.317%
Florida	0.2	81	119.9	24,746	0.171%	0.326%
Michigan	0.2	68	59.3	32,022	0.295%	0.212%
Rhode Island	0.2	142	7.9	4,445	2.176%	3.096%

Vermont	0.2	83	3.8	2,257	3.910%	3.547%
Tennessee	0.1	24	33.9	16,095	0.292%	0.149%
North Dakota	0.1	19	5.8	8,074	1.642%	0.235%
South Carolina	0.1	27	35.3	10,933	0.267%	0.246%
North Carolina	0.1	29	42.3	12,974	0.164%	0.223%
Pennsylvania	0.1	86	118.4	60,387	0.046%	0.142%
Wisconsin	0.1	30	53.0	48,473	0.098%	0.062%
Kentucky	0.1	21	30.5	23,547	0.166%	0.089%
Maine	0.0	1	7.6	6,175	0.592%	0.016%
Louisiana	0.0	4	31.8	10,926	0.140%	0.037%
Kansas	0.0	38	22.8	24,602	0.137%	0.154%
Alabama	0.0	9	32.4	19,338	0.076%	0.047%
Utah	0.0	20	21.4	7,870	0.093%	0.253%
Oregon	0.0	40	32.1	12,886	0.053%	0.309%
Nebraska	0.0	11	19.3	35,985	0.051%	0.031%
Arkansas	0.0	23	13.0	21,717	0.065%	0.106%
Montana	0.0	2	3.7	4,212	0.224%	0.047%
Missouri	0.0	35	42.5	28,968	0.018%	0.121%
Georgia	0.0	1	55.4	13,256	0.013%	0.008%
South Dakota	0.0	3	5.7	5,815	0.115%	0.052%
Delaware	0.0	1	6.6	1,370	0.041%	0.073%
Alaska	0.0	0	7.2	2,711	0.000%	0.000%
Idaho	0.0	0	6.6	2,944	0.000%	0.000%
Mississippi	0.0	0	12.9	9,141	0.000%	0.000%
New Hampshire	0.0	0	6.3	3,638	0.000%	0.000%
New Mexico	0.0	0	12.0	7,291	0.000%	0.000%
Oklahoma	0.0	0	19.7	14,771	0.000%	0.000%
West Virginia	0.0	0	7.1	2,945	0.000%	0.000%
Wyoming	0.0	0	1.5	1,132	0.000%	0.000%
Territories	0.0	0	71.0	1,897	0.000%	0.000%
Total	30.2	4,794	2,908.4	1,219,979	1.027%	0.391%

**Table 7**  
**Green municipal bonds**

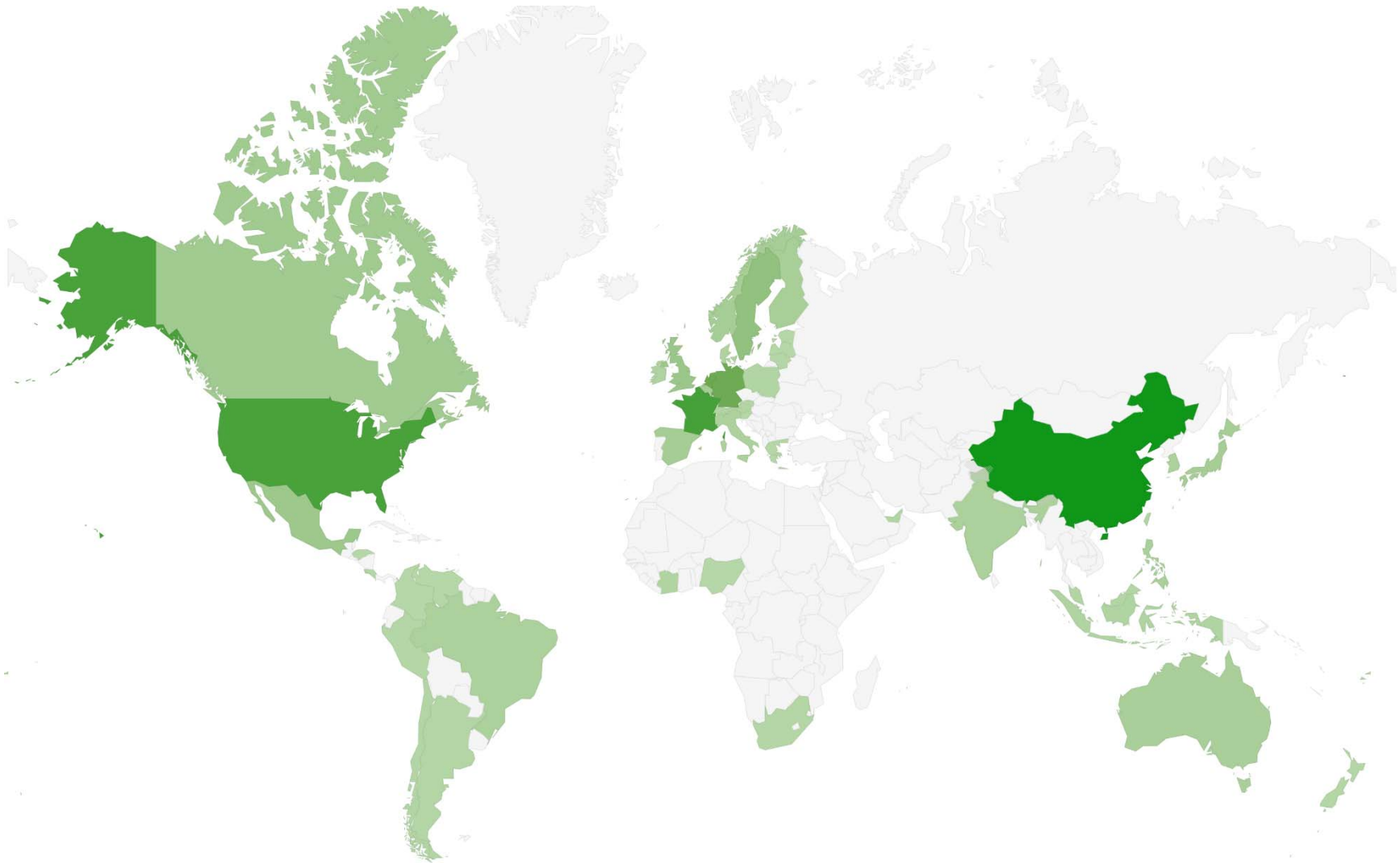
This table reports summary statistics for green municipal bonds and ordinary municipal bonds (i.e., municipal bonds that are not labelled as “green”). *Issuance amount* is the amount issued (in \$M). *Maturity* is the maturity of the bond (in years). *Coupon* is the coupon rate (in %). *Coupon type* refers to the type of coupon payment. *S&P rating* refers to the credit rating of Standard & Poor’s. All figures are sample means (and percentages, respectively). The dataset includes all municipal bonds (“munis”) in Bloomberg issued between January 1, 2010 and December 31, 2018.

	Green muni bonds	Ordinary muni bonds
# bonds	4,794	1,219,979
Issuance amount (\$M)	6.30	2.38
Maturity (years)	11.75	9.54
Coupon (%)	4.05	3.34
Coupon type		
Fixed	97.18%	98.35%
Floating	0.10%	0.14%
Other	2.71%	1.51%
S&P rating		
AAA	40.39%	16.59%
AA+	15.37%	15.89%
AA	19.05%	22.38%
AA-	12.39%	16.47%
A+	4.67%	12.65%
A	3.16%	8.21%
A-	2.58%	3.72%
BBB+	1.89%	1.62%
BBB	0.23%	1.44%
BBB-	0.03%	0.87%
BB+	0.25%	0.08%
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BB-	0.00%	0.01%
B+	0.00%	0.01%
B	0.00%	0.01%

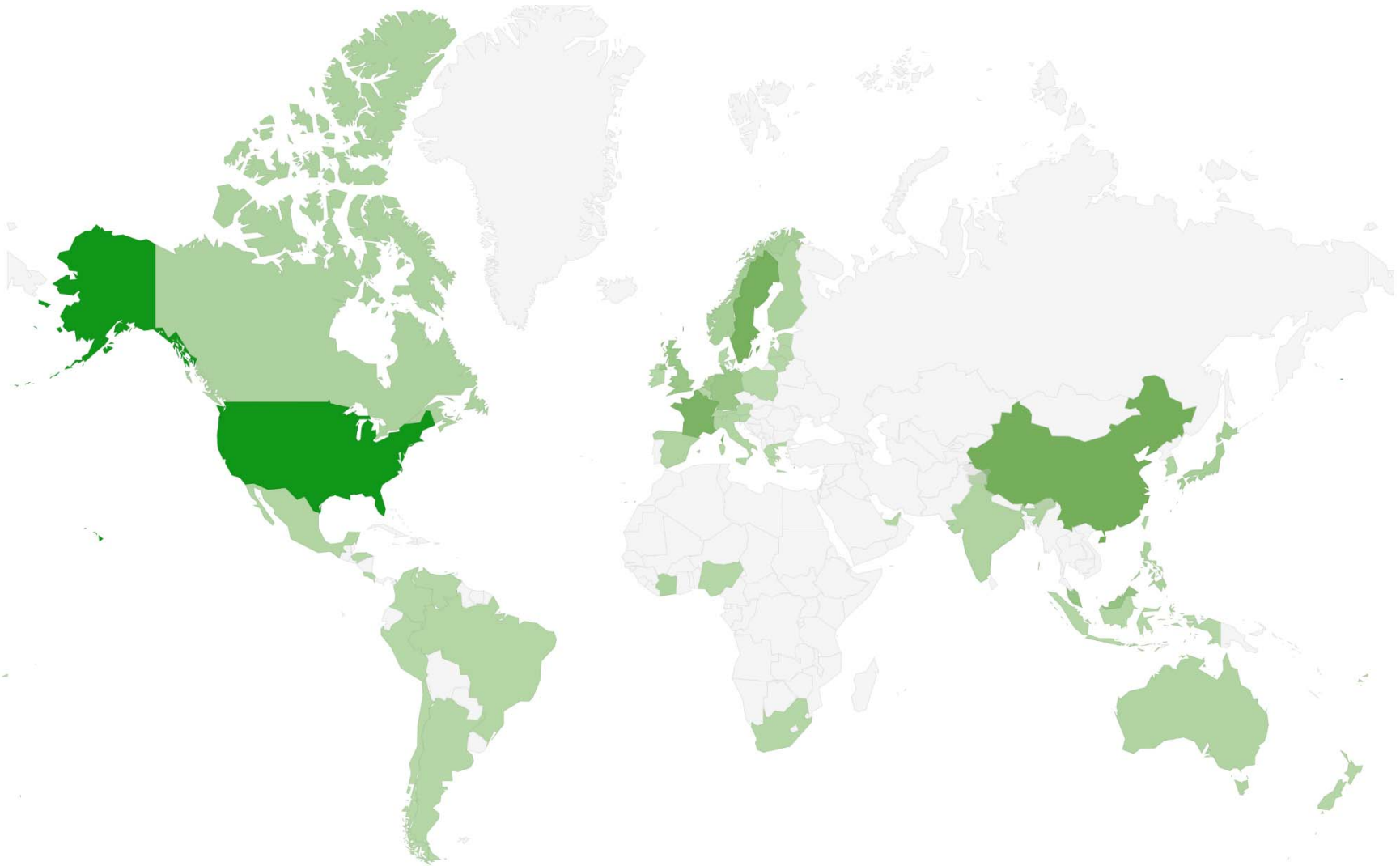
## Figure 1 Green bonds across countries

This figure reports the prevalence of green bonds (excluding green muni bonds) across countries. Darker-shaded areas represent higher issuance amounts (Panel A) and higher number of green bonds (Panel B), respectively. The underlying statistics are provided in Table 2.

Panel A. Green bond issuance (in \$B)

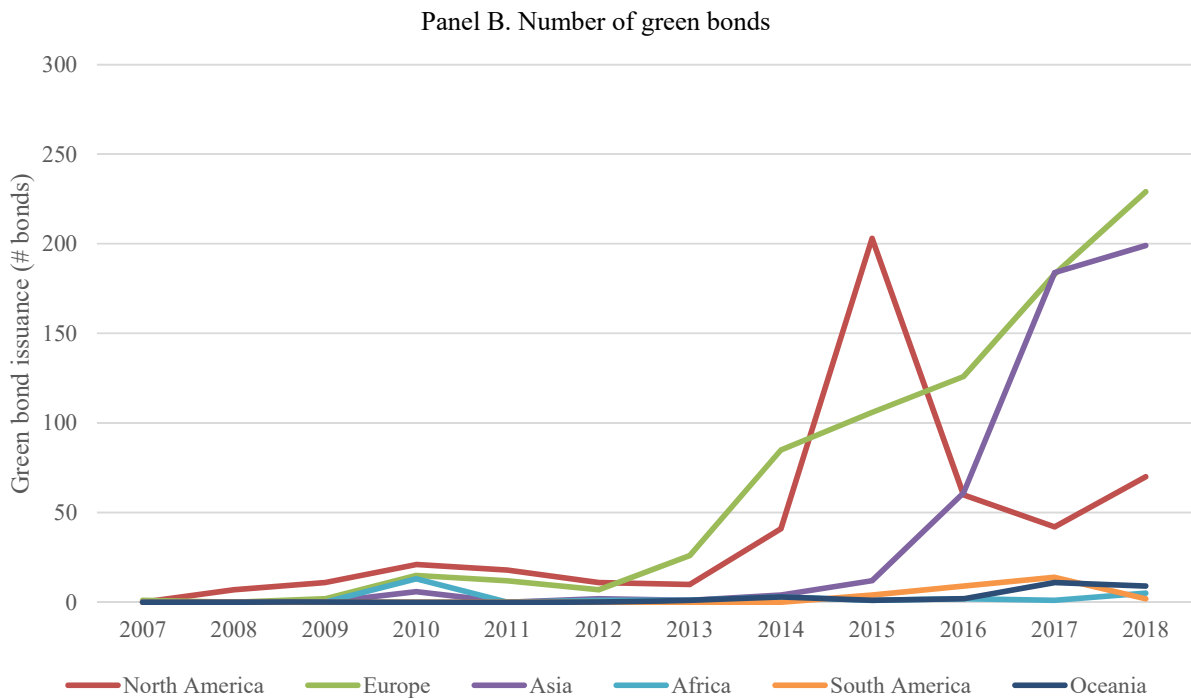
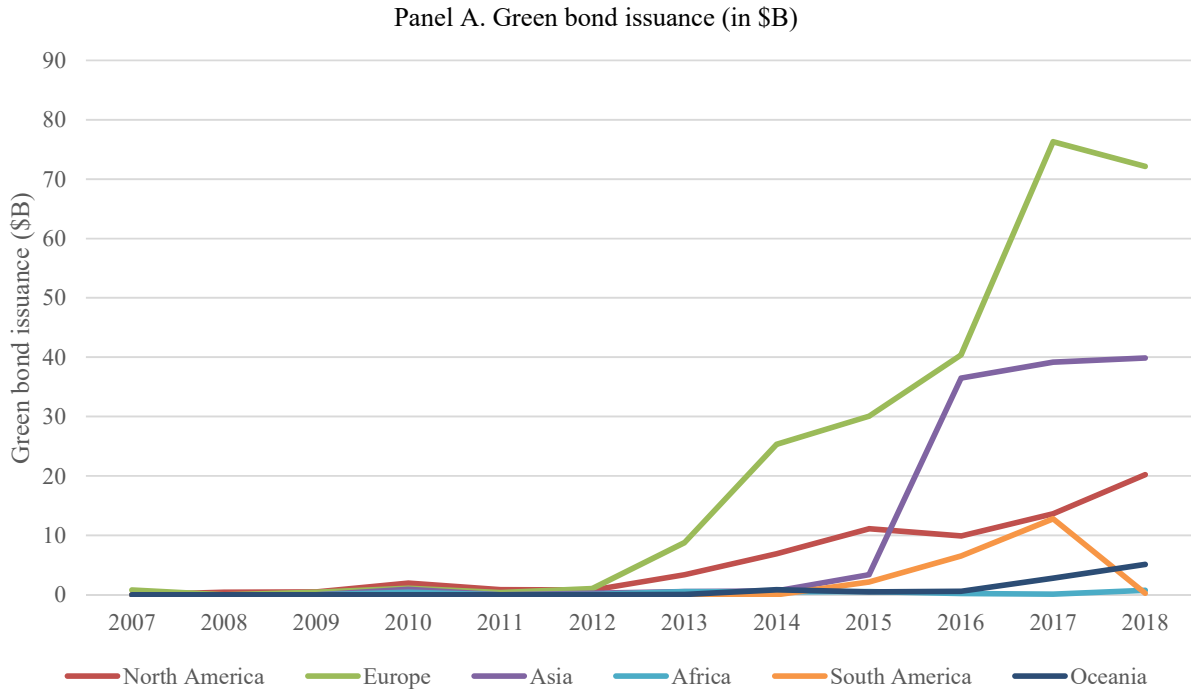


Panel B. Number of green bonds



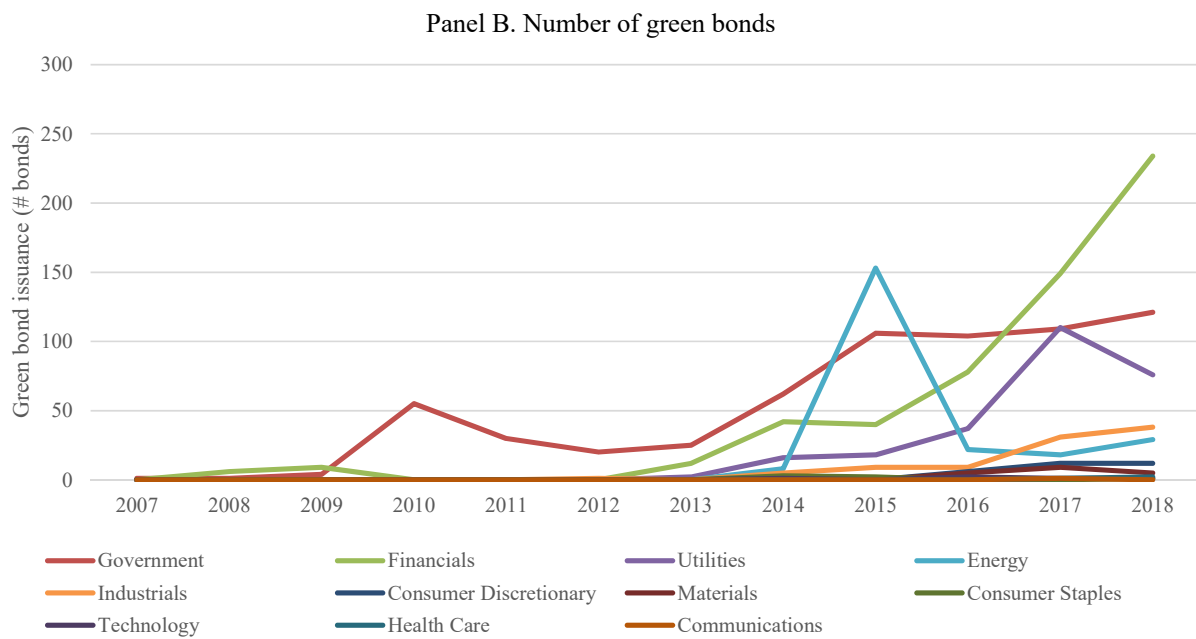
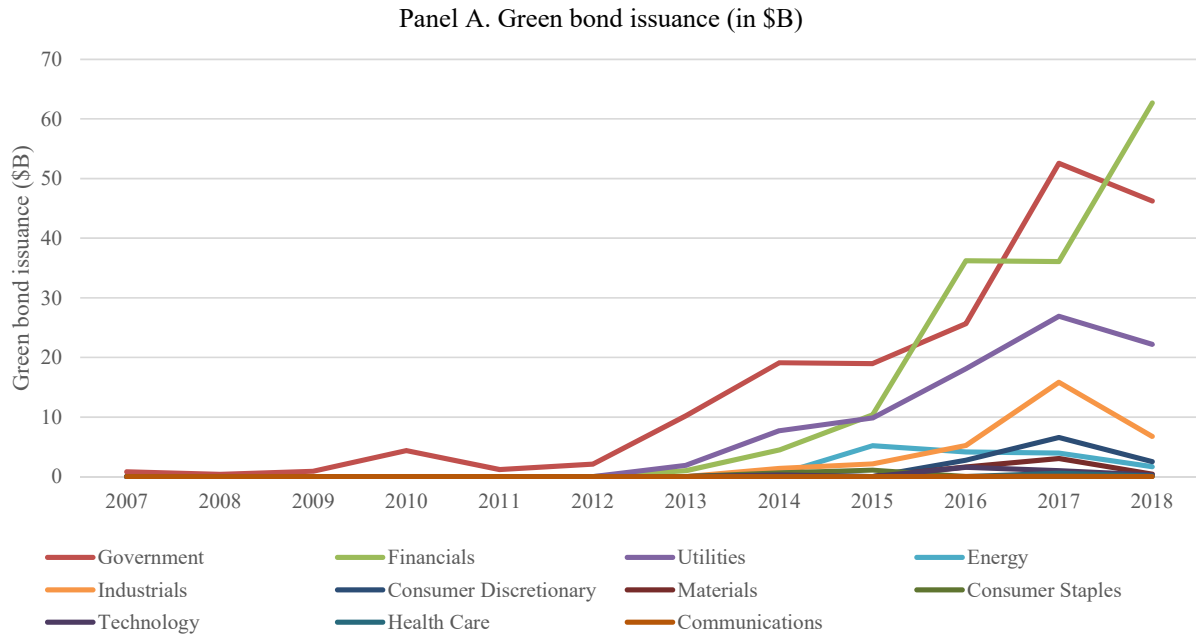
**Figure 2**  
**Evolution of green bonds across regions**

This figure plots the evolution of green bonds across regions. Panel A reports the amount (in \$B) of green bond issuance. Panel B reports the number of green bonds issued. The dataset includes all green bonds (excluding green muni bonds) in Bloomberg issued between January 1, 2007 and December 31, 2018.



**Figure 3**  
**Evolution of green bonds across industries**

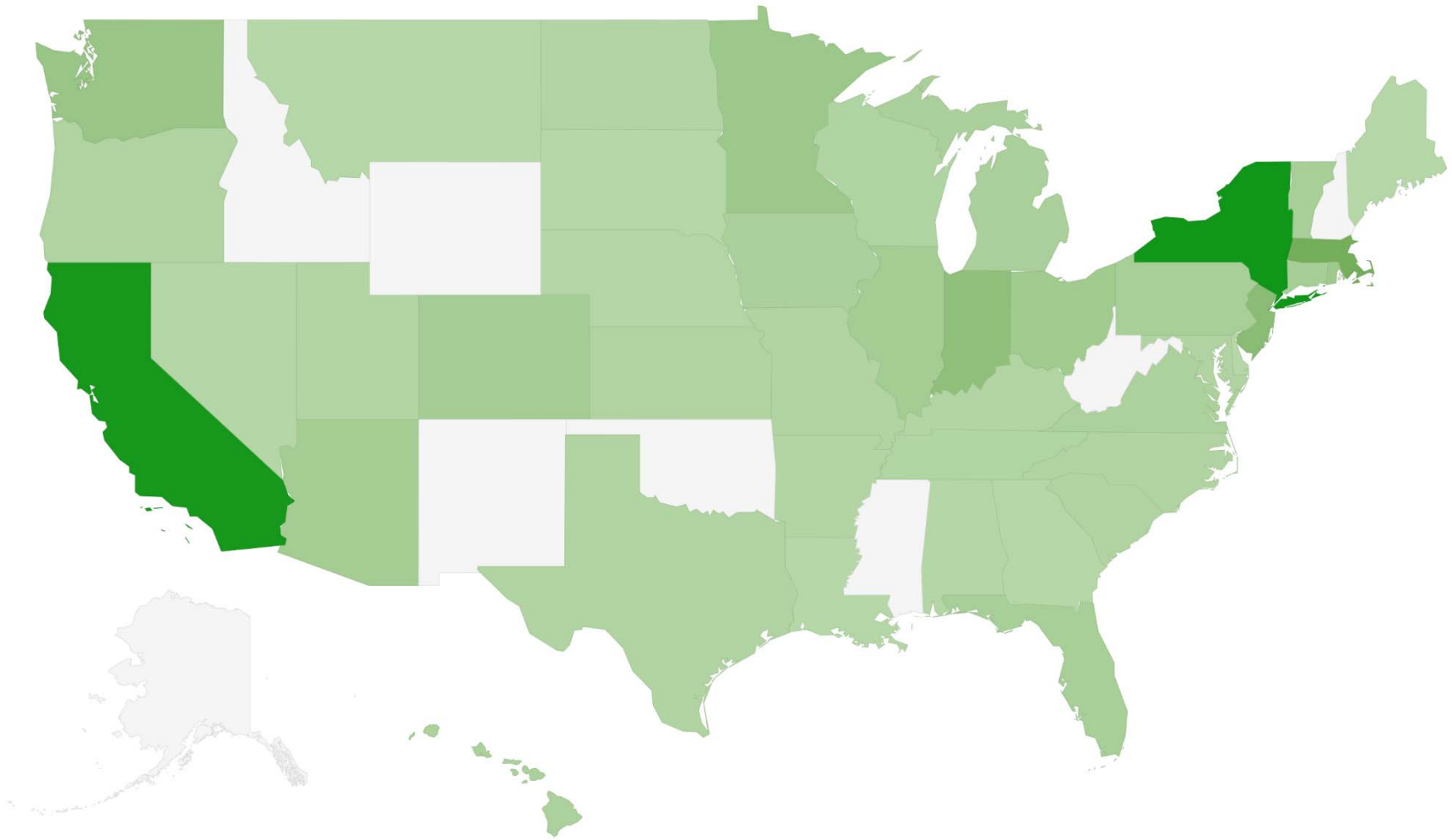
This figure plots the evolution of green bonds across industries. Industries are defined according to BICS (Bloomberg Industry Classification Systems) codes. Panel A reports the amount (in \$B) of green bond issuance. Panel B reports the number of green bonds issued. The dataset includes all green bonds (excluding green muni bonds) in Bloomberg issued between January 1, 2007 and December 31, 2018.





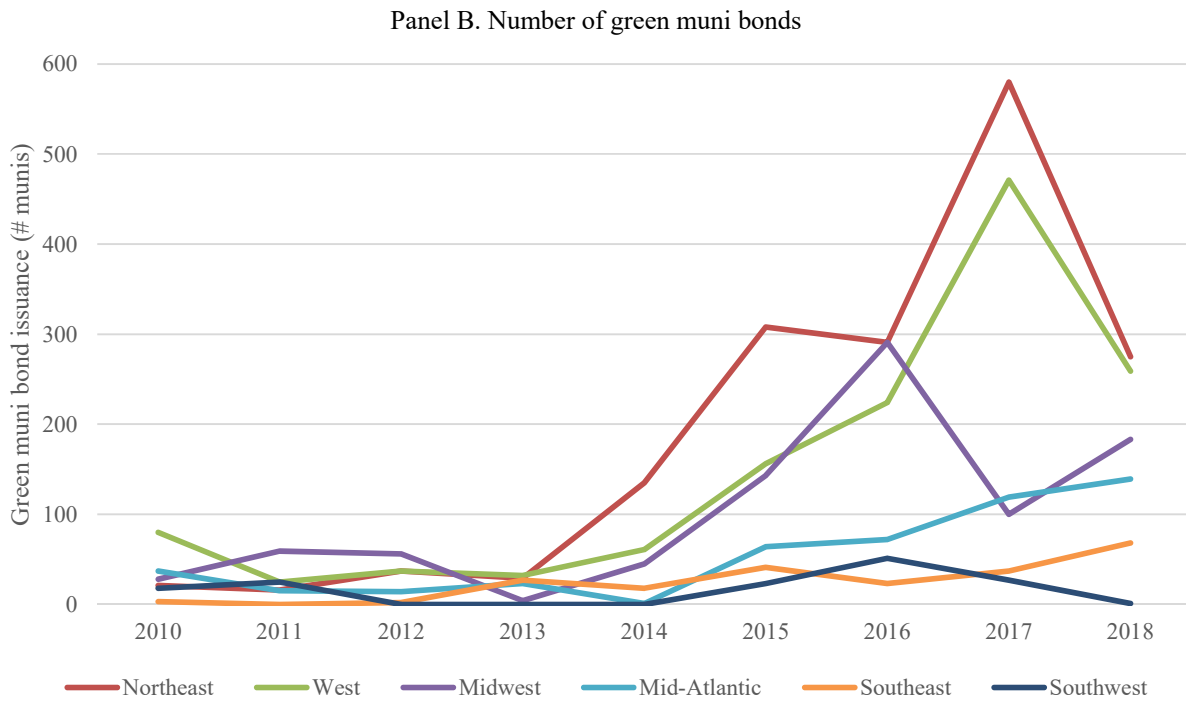
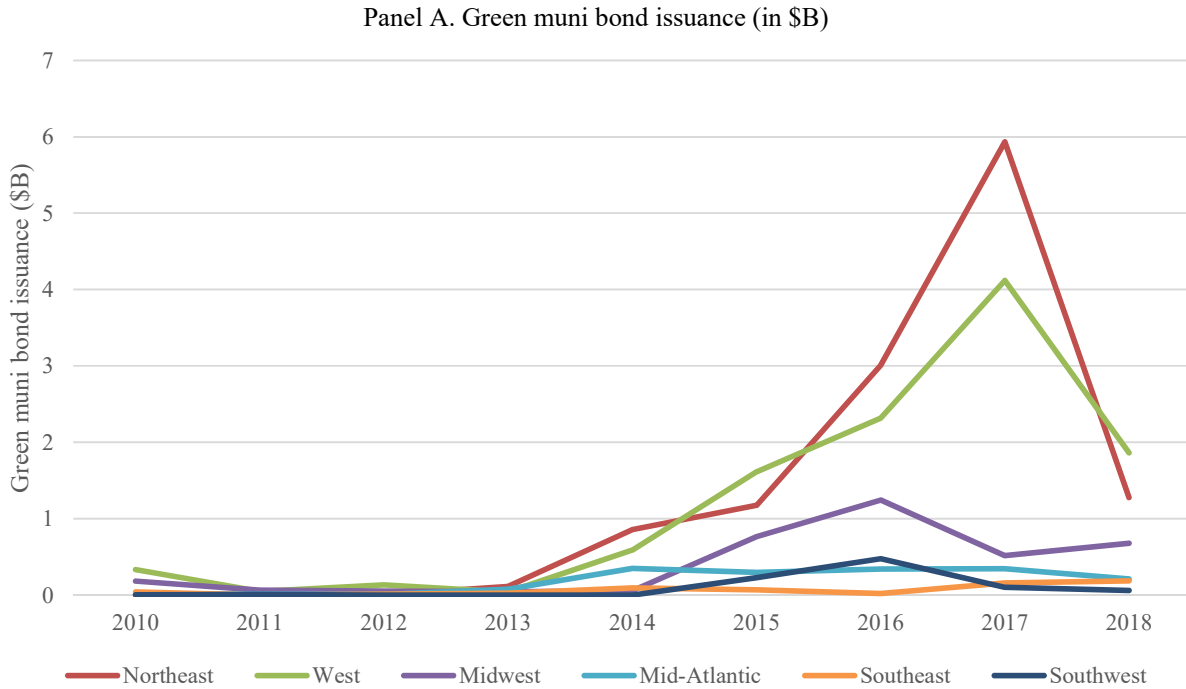


Panel B. Number of green muni bonds



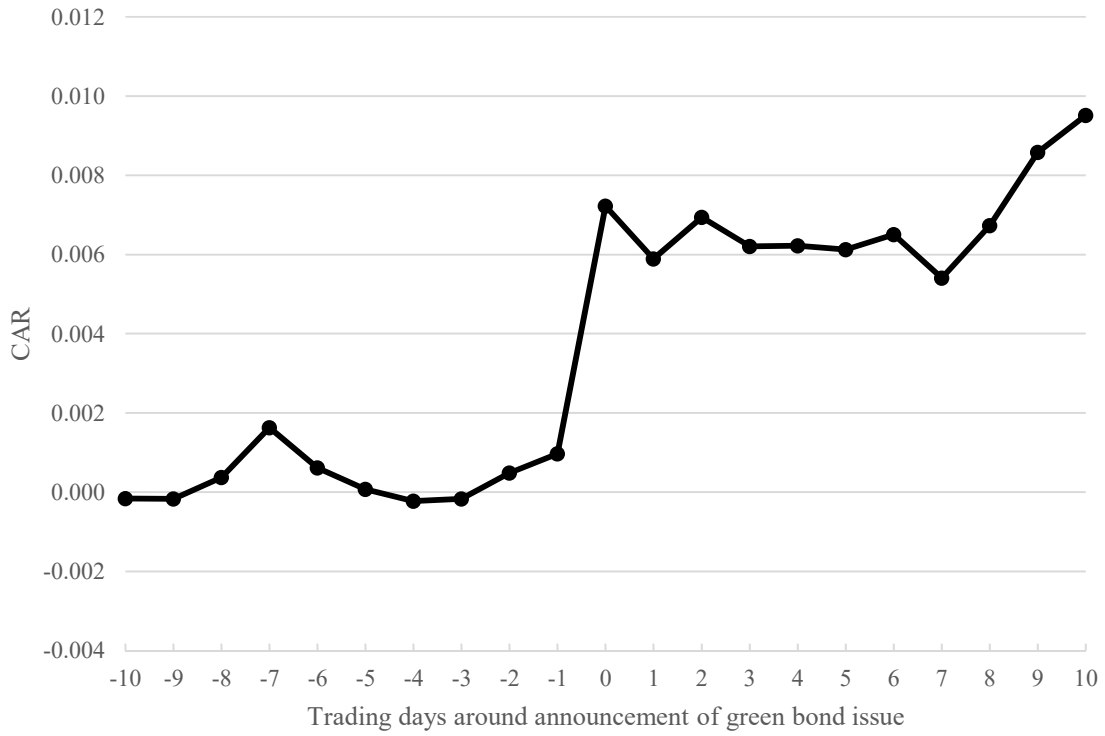
**Figure 5**  
**Evolution of green municipal bonds across regions**

This figure plots the evolution of green municipal bonds across U.S. regions. Panel A reports the issuance amount (in \$B) of green municipal bonds. Panel B reports the number of green municipal bonds issued. The dataset includes all green municipal bonds in Bloomberg issued between January 1, 2010 and December 31, 2018.



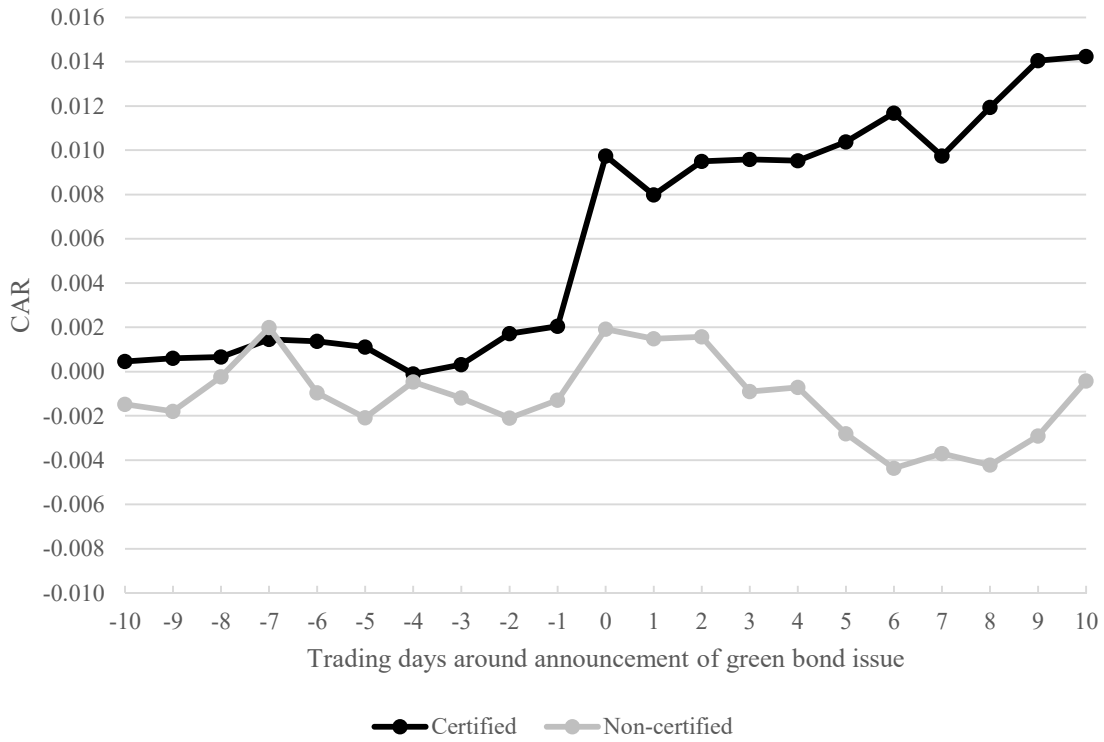
**Figure 6**  
**Stock market reaction to the issuance of green bonds**

This figure plots the cumulative abnormal returns (CAR) around the announcement of green bond issues. The sample consists of  $N = 217$  green bond issues.



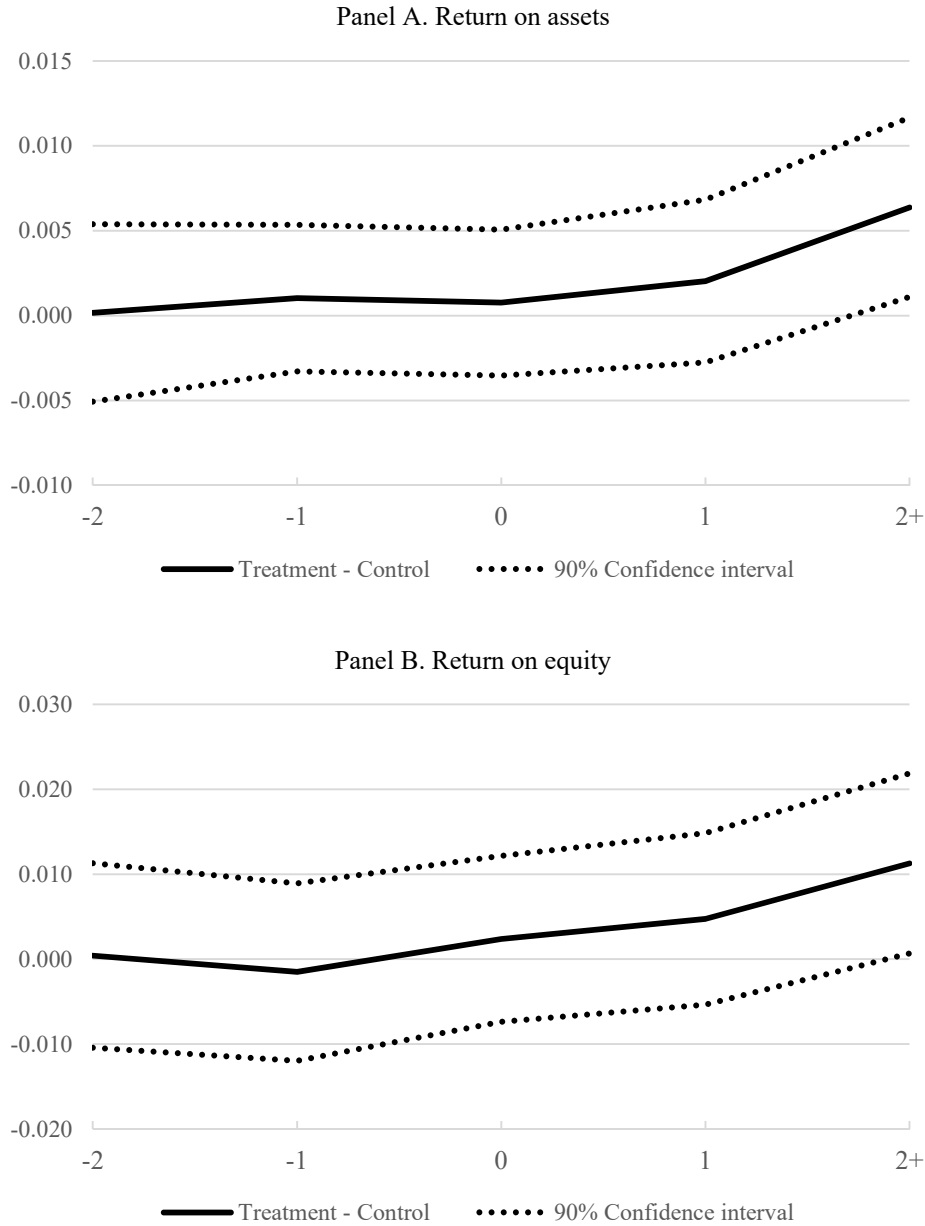
**Figure 7**  
**Certification**

This figure plots the cumulative abnormal returns (CAR) around the announcement of green bond issues, separately for green bonds that are certified by independent third parties and green bonds that are not. The sample consists of  $N = 217$  green bond issues.



## Figure 8 Financial performance

This table reports estimates of the difference-in-differences specification in equation (1) that compares green bond issuers with matched control firms. In Panel A, *return on assets* (ROA) is the ratio of operating income before depreciation to the book value of total assets. In Panel B, *return on equity* (ROE) is the ratio of operating income before depreciation to the book value of equity. The dotted lines represent the 90% confidence interval.



## Figure 9 Environmental performance

This table reports estimates of the difference-in-differences specification in equation (1) that compares green bond issuers with matched control firms. In Panel A, *environmental score* is the environmental rating of Thomson Reuters' ASSET4. In Panel B, *CO<sub>2</sub> emissions* is the ratio of CO<sub>2</sub> emissions (in tons) from ASSET4 divided by the book value of total assets in U.S. dollars. The dotted lines represent the 90% confidence interval.

