

NBER Conference on Environmental and Energy Policy and the Economy

# Green Bonds: Effectiveness and Implications for Public Policy

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# New Phenomenon in Sustainable Finance

- Issuance of **green bonds**
  - Bonds whose proceeds are committed to finance environmental and climate-friendly projects
    - E.g., renewable energy, green buildings, resource conservation, etc.

# Anecdotal Evidence

- Several public and private entities issued **green bonds** in recent years.
  - For example:



In 2007, the **first green bond** was issued by **European Investment Bank** (EIB) to finance renewable energy and energy efficiency projects. (Morgan Stanley, 2017)



In March 2014, **Unilever** issued a **£250M green bond** to *“cut in half the amount of waste, water usage and greenhouse gas emissions of existing factories”*. (Financial Times, 2014)



In February 2016, **Apple** issued a **\$1.25B green bond** to finance the *“installation of more energy efficient heating and cooling systems, and an increase in the company’s use of biodegradable materials”*. (The Guardian, 2016)

# Green Bond Issuance over Time

- **The “green bond boom”** (issued by corporates and governments)

| 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%                   |

# This Study

- Green Bonds are on the rise
- Yet, very little is known about this new financial innovation
  - Its effectiveness in terms of environmental performance
  - Its implications for firm-level outcomes
- Key questions
  - Do green bonds deliver on their promise and yield **improvements in environmental footprint?** Or are they merely a greenwashing tool?
    - Greenwashing is of particular concern given lack of legal enforceability
  - Do companies benefit from issuing green bonds? What are the **implications for shareholder wealth?**
- If both financial and environmental performance improve, green bonds could serve as a **powerful tool against climate change**

# This Study

- This study:
  - 1) **Characterize** this new phenomenon
  - 2) Examine **effectiveness** and **implications** of corporate green bonds w.r.t.
    - Financial performance
    - Environmental performance
  - 3) Discuss the role of **private governance**
  - 4) Discuss **public policy implications**

# Agenda

## 1. Introduction

## 2. The Green Bond Market

- Issuance by corporations and governments (global)
- Issuance by municipalities (US only)

## 3. Corporate Green Bonds

- Implications for financial performance
- Implications for environmental performance

## 4. Role of Private Governance (Certification)

## 5. Conclusion and Implications for Public Policy

# Data

- Database of green bonds
  - Source: Bloomberg's fixed income database
  - Extract **all bonds labeled as green**  
(i.e. "green bond indicator" = "Yes")
    - For each bond, information on:
      - Amount
      - Currency ➔ to facilitate comparison convert in USD
      - Maturity
      - Coupon
      - Credit rating
      - Date of announcement
      - Date of issuance



# Data

## ➤ Coverage:

- All bonds issued by
  - Public and private firms (asset class: “corporate”)
  - Governments (asset class: “governments”)
- Across the world
- 12 years (January 1, 2007—December 31, 2018)

## ➤ Final sample:

- 1,855 green bonds (out of 1,472,199 bonds)

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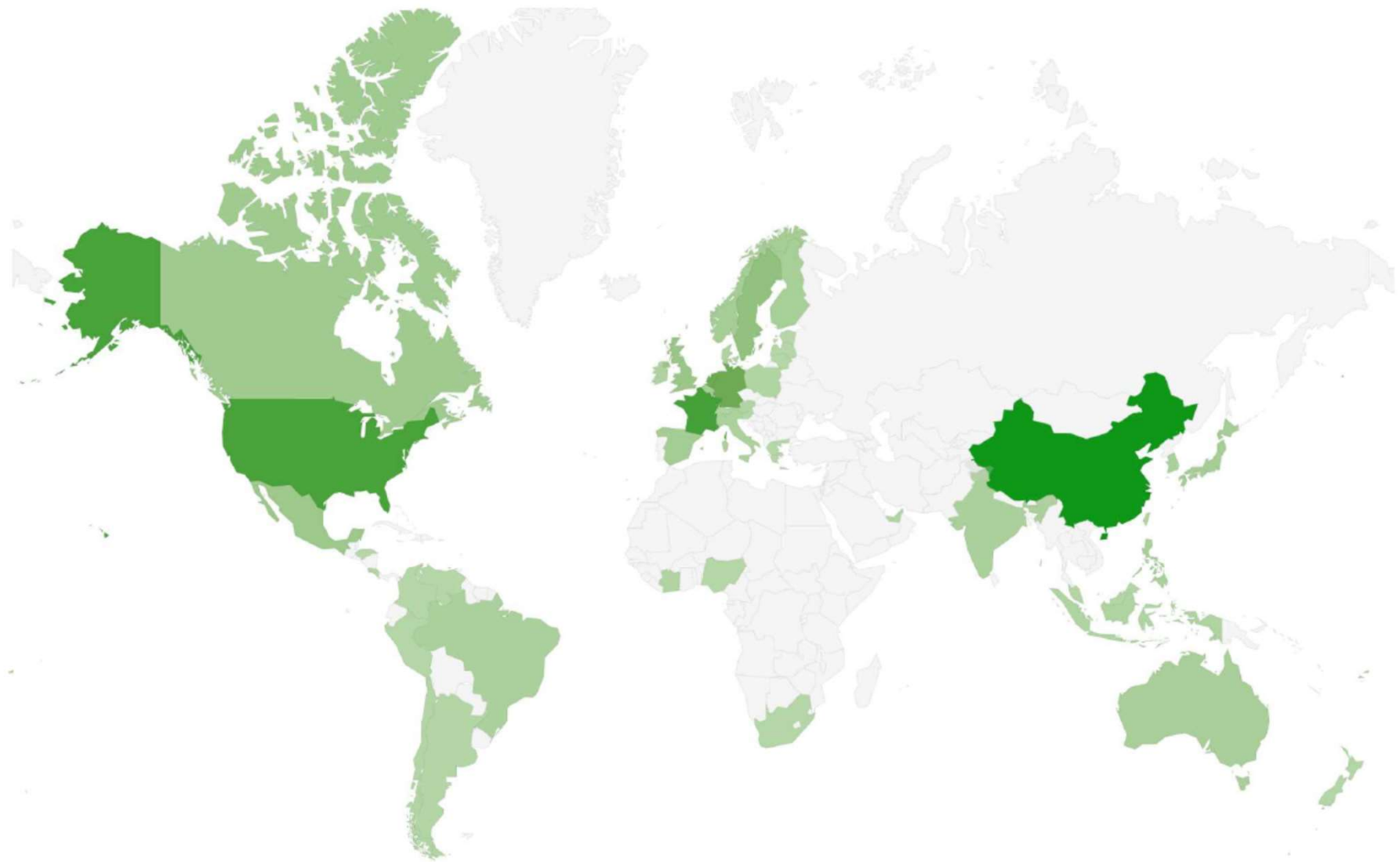
# Green Bond Issuance across Countries

| 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%                   |

# Green Bond Issuance across Countries

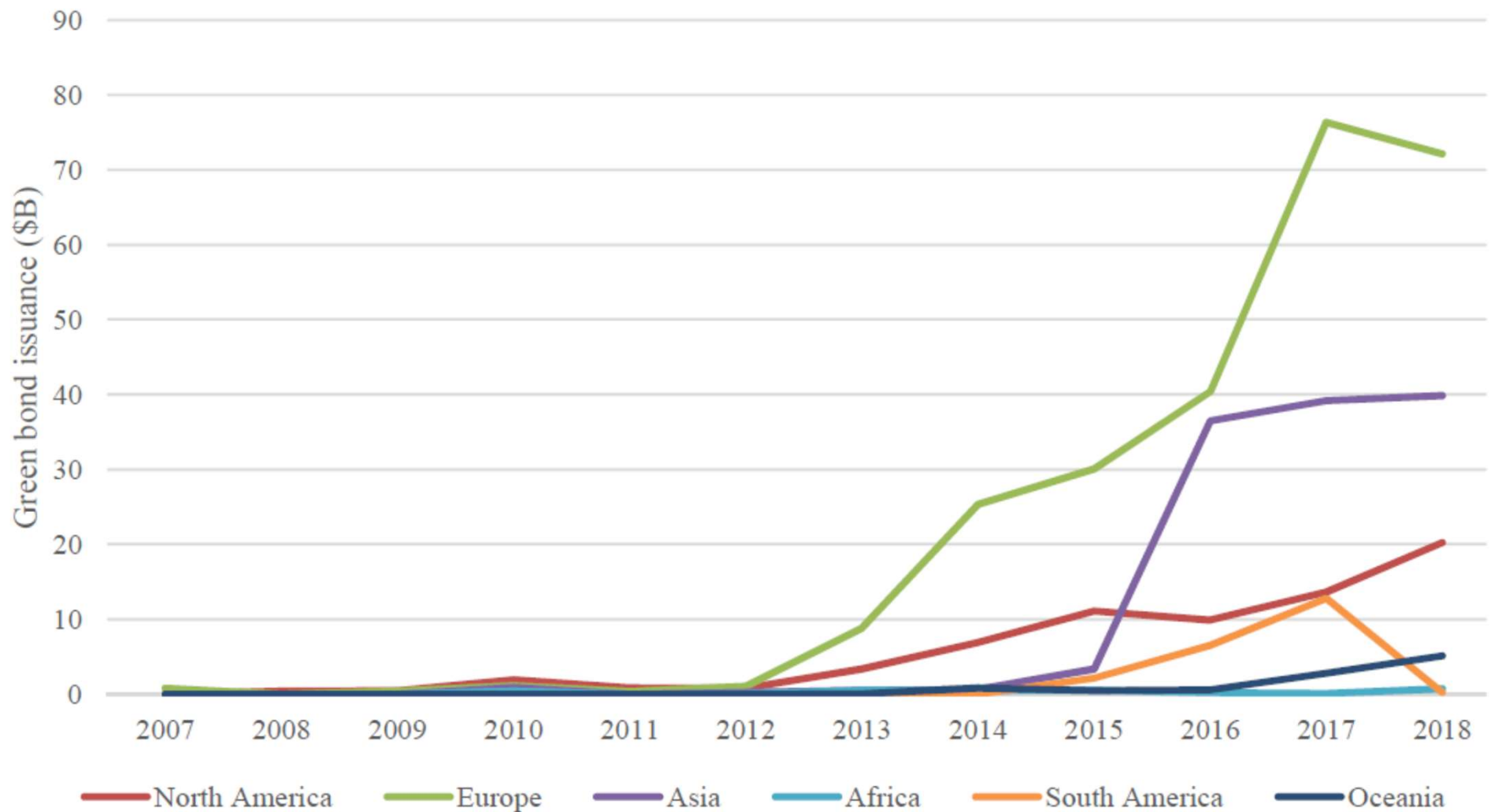
|                      |       |       |           |           |        |        |
|----------------------|-------|-------|-----------|-----------|--------|--------|
| Denmark              | 3.5   | 6     | 768.9     | 4,785     | 0.455% | 0.125% |
| Ireland              | 3.5   | 1     | 1,732.3   | 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% |

# Green Bond Issuance across Countries (in \$B)





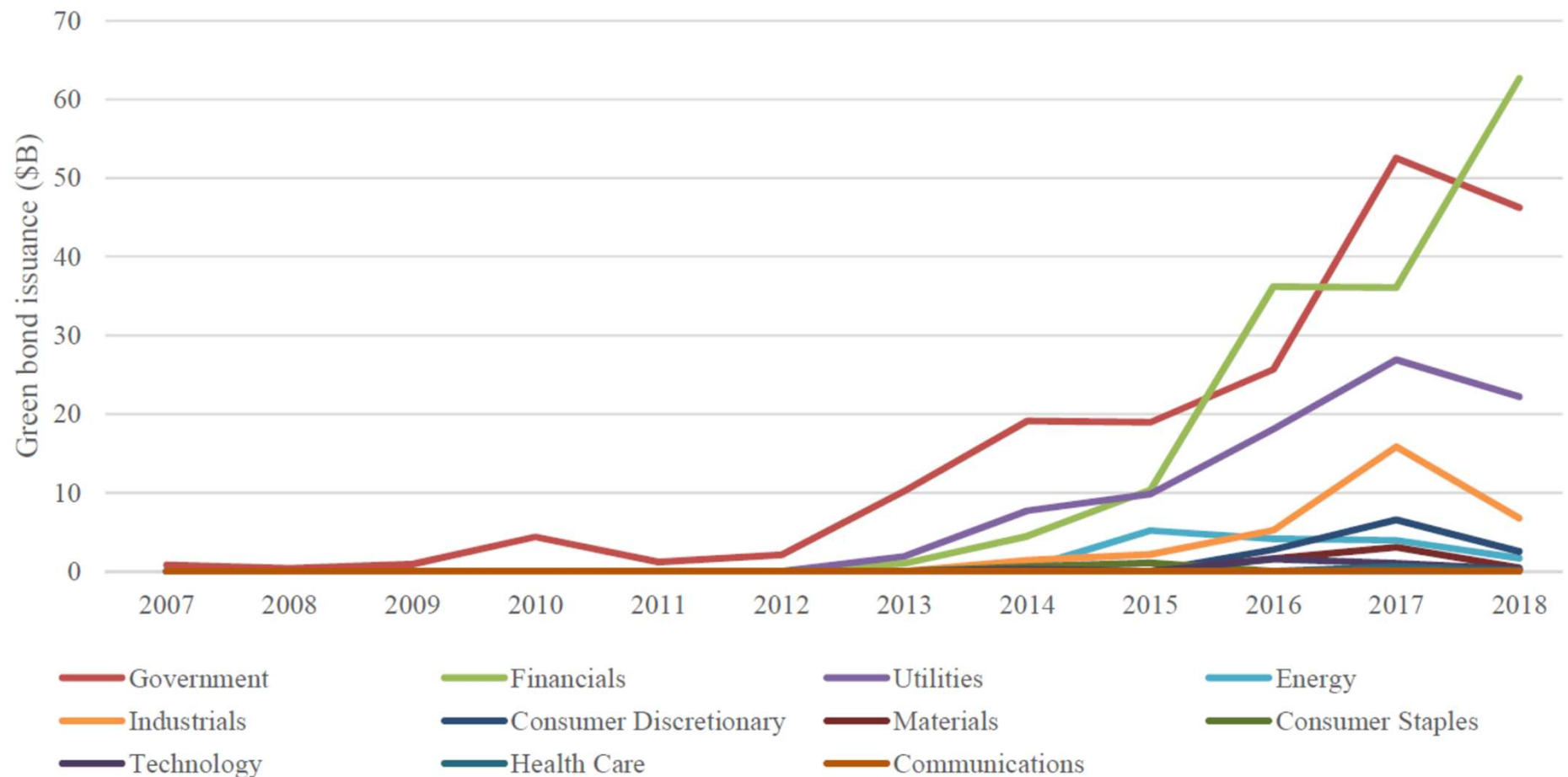
# Evolution of Green Bonds across Regions (in \$B)



# Green Bond Issuance across Industries

| Industry               | \$B Green bonds | # Green bonds | Share of<br>green bonds (\$) | Share of<br>green bonds (#) |
|------------------------|-----------------|---------------|------------------------------|-----------------------------|
| Government             | 182.6           | 638           | 0.071%                       | 0.181%                      |
| Financials             | 150.9           | 570           | 0.236%                       | 0.058%                      |
| Utilities              | 86.8            | 259           | 2.071%                       | 1.449%                      |
| Industrials            | 31.4            | 93            | 0.553%                       | 0.288%                      |
| Energy                 | 15.4            | 230           | 0.325%                       | 1.897%                      |
| Consumer Discretionary | 12.3            | 31            | 0.239%                       | 0.098%                      |
| Materials              | 5.2             | 19            | 0.144%                       | 0.119%                      |
| Technology             | 3.2             | 5             | 0.169%                       | 0.067%                      |
| Consumer Staples       | 1.9             | 6             | 0.071%                       | 0.064%                      |
| Health Care            | 0.7             | 3             | 0.028%                       | 0.047%                      |
| Communications         | 0.1             | 1             | 0.002%                       | 0.013%                      |
| Other                  | 0.0             | 0             | 0.000%                       | 0.000%                      |
| Total                  | 490.4           | 1,855         | 0.138%                       | 0.126%                      |

# Evolution of Green Bonds across Industries (in \$B)





# Summary Statistics at Green Bond Level

|                       | 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%         |

# Summary Statistics at Green Bond Level

|                  | Green bonds | Ordinary bonds |
|------------------|-------------|----------------|
| 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%          |

# Agenda

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2. The Green Bond Market
  - Issuance by corporations and governments (global)
  - Issuance by municipalities (US only)
3. Corporate Green Bonds
  - Implications for financial performance
  - Implications for environmental performance
4. Role of Private Governance (Certification)
5. Conclusion and Implications for Public Policy

# Green Municipal Bonds over Time (US only)

| Year  | \$B Green<br>muni bonds | # Green<br>muni bonds | \$B Ordinary<br>muni bonds | # Ordinary<br>muni bonds | Share of green<br>muni bonds (\$) | Share of green<br>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%                           |

# Green Municipal Bonds by State (US only)

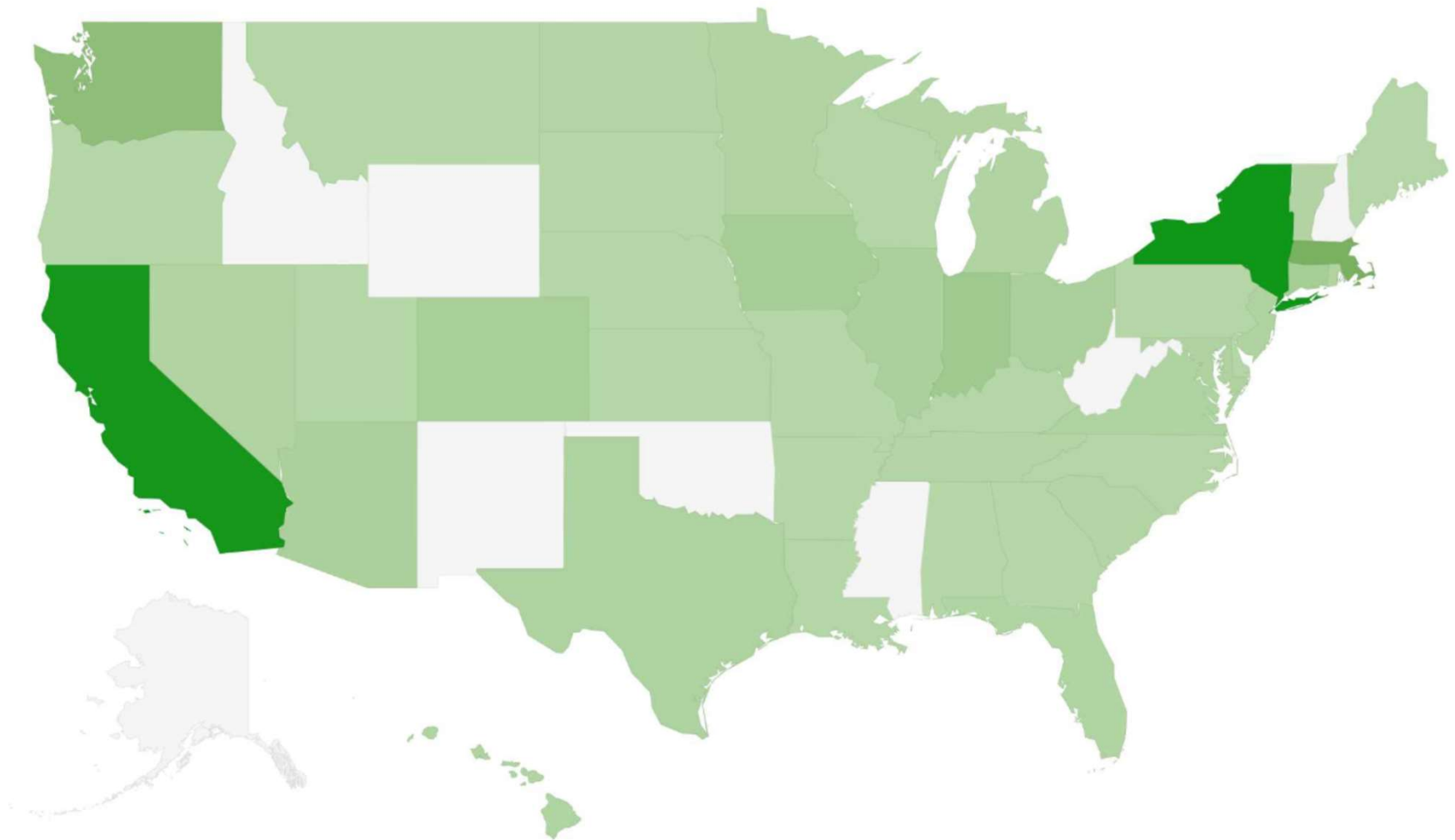
| State                | \$B Green<br>muni bonds | # Green<br>muni bonds | \$B Ordinary<br>muni bonds | # Ordinary<br>muni bonds | Share of green<br>muni bonds (\$) | Share of green<br>muni bonds (#) |
|----------------------|-------------------------|-----------------------|----------------------------|--------------------------|-----------------------------------|----------------------------------|
| 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%                           |



# Green Municipal Bonds by State (US only)

|                |      |       |         |           |        |        |
|----------------|------|-------|---------|-----------|--------|--------|
| 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% |

# Green Municipal Bonds by State (in \$B)



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4. Role of Private Governance (Certification)
5. Conclusion and Implications for Public Policy



# Corporate Green Bonds (based on Flammer, 2018)

- Data:
  - Bloomberg's fixed income database
  - Green bonds issued by public firms
    - Across the world
    - 5 years (January 1, 2013—December 31, 2017)
  - Final sample:
    - 217 corporate green bonds issued by public firms

# Agenda

1. Introduction
2. The Green Bond Market
  - Issuance by corporations and governments (global)
  - Issuance by municipalities (US only)
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    - Stock Market Reaction
    - Operating Performance
  - Implications for environmental performance
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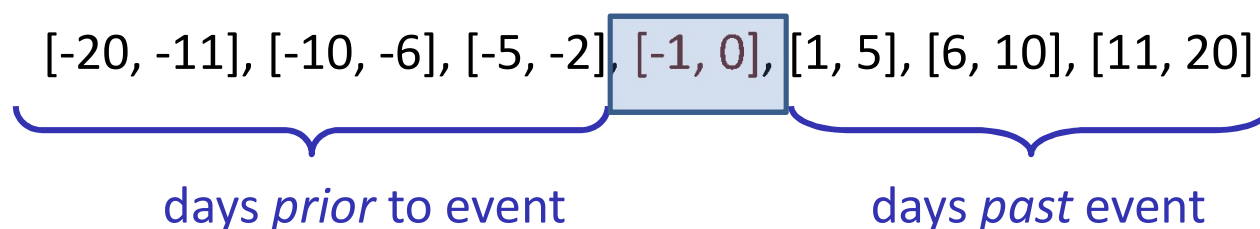
# Stock Market Reaction to Announcement

- Event study

- Analyze stock market reaction to corporate news

- Announcement of corporate green bond issuance
    - By public companies

- Time intervals:



- For each firm, compute cumulative abnormal returns (CAR) using market model



# Stock Market Reaction to Announcement

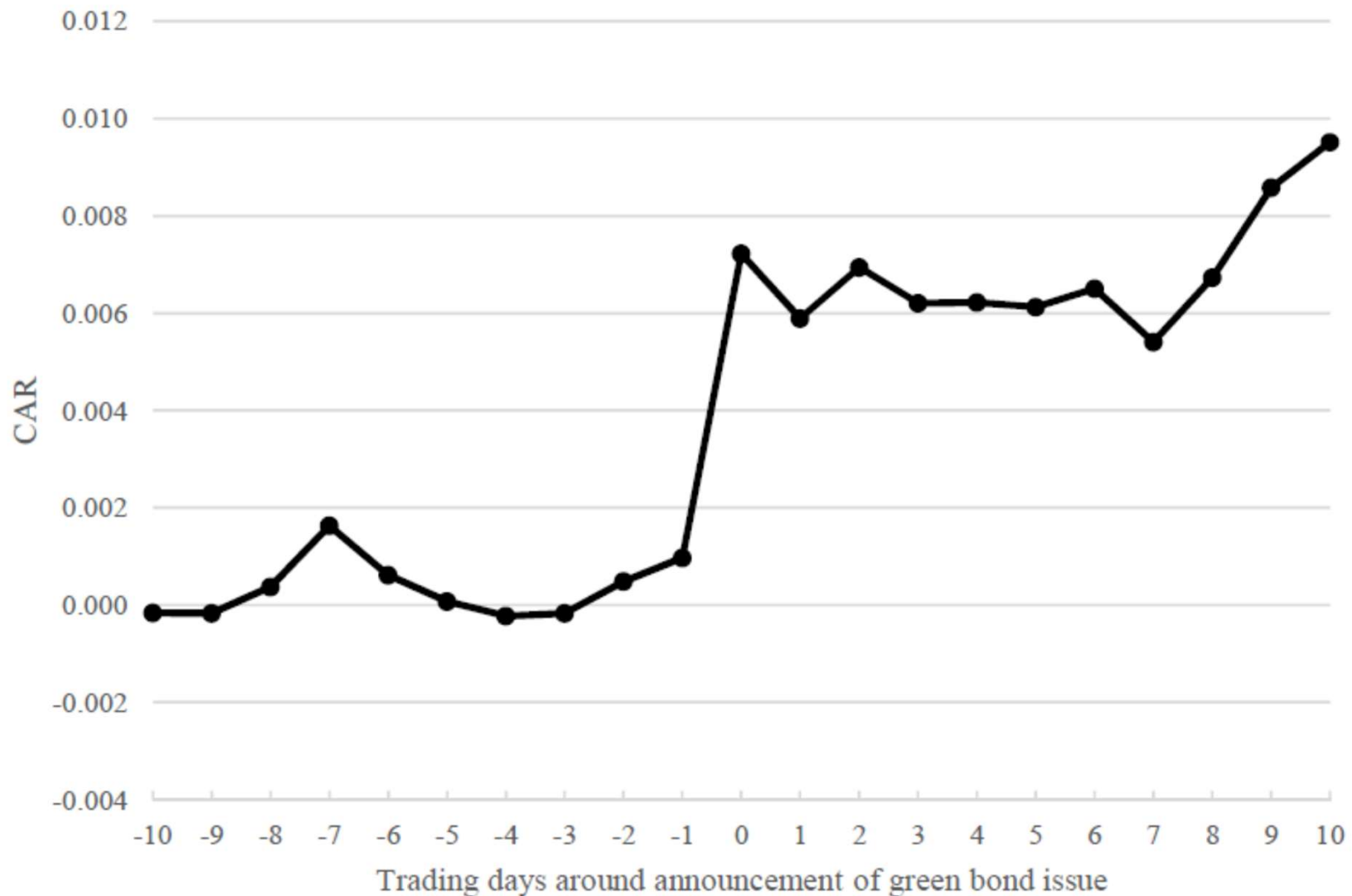
|                     | Event time | CAR     | Std. Err. |
|---------------------|------------|---------|-----------|
|                     | [-20, -11] | 0.120   | 0.975     |
|                     | [-10, -6]  | 0.257   | 0.509     |
|                     | [-5, -2]   | -0.013  | 0.487     |
| <b>Announcement</b> | [-1, 0]    | 0.673** | 0.278     |
|                     | [1, 5]     | -0.106  | 0.625     |
|                     | [6, 10]    | 0.328   | 0.659     |
|                     | [11, 20]   | -0.281  | 1.140     |

Stock return in excess of “normal” market return is **0.67%**

Stock market expects green bonds to contribute to **value creation**



# Stock Market Reaction to Announcement



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# Methodology

- Empirical Challenge: Endogeneity

- Issuance of corporate green bonds likely **endogenous** with respect to dependent variable  $y$  (e.g., firm value)

*Companies that aim to improve their environmental rating may take actions to reduce their emissions, and at the same time, issue green bonds.*

*Better governed firms may be more sustainable. At the same time, they may more likely issue green bonds.*

- Ideally: need an ~~instrument~~ for issuance of green bonds
- 2<sup>nd</sup> best: build a **plausible counterfactual** of how firm-level outcomes would evolve absent the issuance of green bonds

# Methodology

- Matching

- Each firm that issues a green bond (“treated” firm) is matched to a similar “control” firm ex ante
- Selection criteria:
  - All public firms that issue bonds (but not green bonds)
  - Same country
  - Same 2-digit SIC industry group
  - Select nearest neighbor – i.e. firm with lowest Mahalanobis distance to treated firm – on basis of 14 characteristics prior to issuance:

|                               |  |
|-------------------------------|--|
| ○ Size                        | ○ $\Delta$ Size                        |
| ○ Tobin’s Q                   | ○ $\Delta$ Tobin’s Q                   |
| ○ ROA                         | ○ $\Delta$ ROA                         |
| ○ Leverage                    | ○ $\Delta$ Leverage                    |
| ○ Firm’s environmental rating | ○ $\Delta$ Firm’s environmental rating |
| ○ Firm’s social rating        | ○ $\Delta$ Firm’s social rating        |
| ○ Firm’s governance rating    | ○ $\Delta$ Firm’s governance rating    |



# Summary Statistics Treated and Matched Control Firms

|  |                 | Obs. | Mean   | Median | Std. Dev. | <i>p</i> -value<br>(diff. in means) | <i>p</i> -value<br>(diff. in medians) |
|--|-----------------|------|--------|--------|-----------|-------------------------------------|---------------------------------------|
| <i>Panel A. Matching characteristics</i> |                 |      |        |        |           |                                     |                                       |
| Log(assets)                              | Green bond      | 106  | 11.085 | 10.813 | 2.451     | 0.280                               | 0.461                                 |
|  | Matched control | 106  | 10.993 | 10.773 | 2.276     |                                     |                                       |
| Return on assets                         | Green bond      | 106  | 0.056  | 0.053  | 0.048     | 0.243                               | 0.680                                 |
|  | Matched control | 106  | 0.058  | 0.051  | 0.047     |                                     |                                       |
| Tobin's Q                                | Green bond      | 106  | 1.172  | 1.023  | 0.393     | 0.202                               | 0.527                                 |
|  | Matched control | 106  | 1.140  | 1.012  | 0.286     |                                     |                                       |
| Leverage                                 | Green bond      | 106  | 0.286  | 0.242  | 0.161     | 0.189                               | 0.131                                 |
|  | Matched control | 106  | 0.309  | 0.286  | 0.162     |                                     |                                       |
| Environment rating (ASSET4)              | Green bond      | 76   | 83.37  | 91.36  | 16.01     | 0.311                               | 0.783                                 |
|  | Matched control | 76   | 82.39  | 91.18  | 16.29     |                                     |                                       |
| Social rating (ASSET4)                   | Green bond      | 76   | 79.81  | 90.36  | 21.16     | 0.364                               | 0.921                                 |
|  | Matched control | 76   | 79.05  | 90.41  | 22.09     |                                     |                                       |
| Governance rating (ASSET4)               | Green bond      | 76   | 66.40  | 73.73  | 23.69     | 0.705                               | 0.424                                 |
|  | Matched control | 76   | 66.15  | 70.93  | 22.64     |                                     |                                       |

# Summary Statistics Treated and Matched Control Firms

|  |                 | Obs. | Mean   | Median | Std. Dev. | <i>p</i> -value<br>(diff. in means) | <i>p</i> -value<br>(diff. in medians) |
|--|-----------------|------|--------|--------|-----------|-------------------------------------|---------------------------------------|
| <i>Panel A. Matching characteristics</i> |                 |      |        |        |           |                                     |                                       |
| $\Delta$ Log(assets)                     | Green bond      | 106  | 0.022  | 0.030  | 0.158     | 0.632                               | 0.668                                 |
|  | Matched control | 106  | 0.020  | 0.027  | 0.116     |                                     |                                       |
| $\Delta$ Return on assets                | Green bond      | 106  | 0.001  | -0.001 | 0.019     | 0.296                               | 0.810                                 |
|  | Matched control | 106  | 0.000  | -0.001 | 0.016     |                                     |                                       |
| $\Delta$ Tobin's Q                       | Green bond      | 106  | -0.002 | -0.002 | 0.159     | 0.316                               | 0.753                                 |
|  | Matched control | 106  | 0.001  | -0.003 | 0.121     |                                     |                                       |
| $\Delta$ Leverage                        | Green bond      | 106  | 0.003  | 0.000  | 0.033     | 0.596                               | 0.811                                 |
|  | Matched control | 106  | 0.002  | 0.001  | 0.046     |                                     |                                       |
| $\Delta$ Environment rating (ASSET4)     | Green bond      | 76   | 3.897  | 0.955  | 9.958     | 0.916                               | 0.870                                 |
|  | Matched control | 76   | 3.899  | 0.960  | 9.972     |                                     |                                       |
| $\Delta$ Social rating (ASSET4)          | Green bond      | 76   | 4.051  | 1.415  | 9.675     | 0.302                               | 0.338                                 |
|  | Matched control | 76   | 3.775  | 1.460  | 9.283     |                                     |                                       |
| $\Delta$ Governance rating (ASSET4)      | Green bond      | 76   | 3.901  | 3.065  | 10.719    | 0.772                               | 0.474                                 |
|  | Matched control | 76   | 3.773  | 3.100  | 10.499    |                                     |                                       |

# Summary Statistics Treated and Matched Control Firms

|  |                 |    | Obs.   | Mean   | Median | Std. Dev. | p-value<br>(diff. in means) | p-value<br>(diff. in medians) |
|--|-----------------|----|--------|--------|--------|-----------|-----------------------------|-------------------------------|
| <i>Panel B. Other characteristics</i>        |                 |    |        |        |        |           |                             |                               |
| CO <sub>2</sub> emissions / assets           | Green bond      | 69 | 77.87  | 17.91  | 168.12 | 0.245     | 0.503                       |                               |
|  | Matched control | 69 | 75.10  | 17.26  | 181.06 |           |                             |                               |
| Green patents / total patents                | Green bond      | 43 | 0.140  | 0.000  | 0.254  | 0.776     | 0.982                       |                               |
|  | Matched control | 43 | 0.128  | 0.000  | 0.152  |           |                             |                               |
| LT-index (U.S. only)                         | Green bond      | 32 | 0.793  | 0.747  | 0.148  | 0.481     | 0.510                       |                               |
|  | Matched control | 32 | 0.755  | 0.745  | 0.156  |           |                             |                               |
| Institutional ownership (U.S. only)          | Green bond      | 32 | 0.416  | 0.402  | 0.372  | 0.409     | 0.717                       |                               |
|  | Matched control | 32 | 0.428  | 0.411  | 0.348  |           |                             |                               |
| Ownership by long-term investors (U.S. only) | Green bond      | 32 | 0.071  | 0.049  | 0.089  | 0.106     | 0.220                       |                               |
|  | Matched control | 32 | 0.057  | 0.035  | 0.084  |           |                             |                               |
| Ownership by green investors (U.S. only)     | Green bond      | 32 | 0.040  | 0.016  | 0.037  | 0.632     | 0.554                       |                               |
|  | Matched control | 32 | 0.038  | 0.014  | 0.052  |           |                             |                               |
| Δ CO <sub>2</sub> emissions / assets         | Green bond      | 69 | -0.773 | -0.024 | 19.947 | 0.757     | 0.971                       |                               |
|  | Matched control | 69 | -0.708 | -0.019 | 20.703 |           |                             |                               |
| Δ Green patents / total patents              | Green bond      | 43 | 0.004  | 0.000  | 0.162  | 0.878     | 0.980                       |                               |
|  | Matched control | 43 | 0.001  | 0.000  | 0.193  |           |                             |                               |
| Δ LT-index (U.S. only)                       | Green bond      | 32 | 0.009  | 0.005  | 0.118  | 0.749     | 0.597                       |                               |
|  | Matched control | 32 | 0.004  | 0.005  | 0.106  |           |                             |                               |

- Control firms are **very similar** to treated firms, and hence, likely provide **reliable counterfactual** of how treated firms would have behaved absent issuance of green bond

# Difference-in-Differences Approach

- “Treatment”:
  - Issuance of green bond
- Difference-in-differences methodology:
  - Before versus after issuance of green bond
  - Treatment versus control group
- Treatment group:
  - Public firms issuing green bond
- Control group:
  - Matched public firms issuing bond (but not green bond)

# Difference-in-Differences Approach

BEFORE 2016

AFTER 2016



Firm outcome **treated** firm T



Firm outcome **treated** firm T



Firm outcome **control** firm C



Firm outcome **control** firm C

Difference after versus before (treated firm):  $\Delta y_T = y_{\text{After}, T} - y_{\text{Before}, T}$

Difference after versus before (control firm):  $\Delta y_C = y_{\text{After}, C} - y_{\text{Before}, C}$

---

Difference-in-differences:  $\Delta(\Delta y) = \Delta y_T - \Delta y_C$

# Difference-in-Differences Approach

$$y_{it} = \alpha_i + \alpha_{ct} + \alpha_{st} + \beta \times \text{Green bond}_{it} + \varepsilon_{it}$$

- $y_{it}$  : outcome variable of interest of firm  $i$  in year  $t$ .
- $\alpha_i$  : firm fixed effects
- $\alpha_{ct}$  : country-year fixed effects
- $\alpha_{st}$  : 2-digit industry-year fixed effects
- Green bond: dummy variable equal to one for treated firms
- $\varepsilon$  : error term (standard errors clustered at 2-digit SIC industry level)



# Financial Performance

Firm value increases by  
 $0.028/1.172 = 2.4\%$

## Financial performance

|                                  | Tobin's Q          |                    | ROA                |                    |
|----------------------------------|--------------------|--------------------|--------------------|--------------------|
| Green bond                       | 0.028**<br>(0.012) |                    | 0.005**<br>(0.002) |                    |
| Green bond (pre-issue year)      |                    | 0.003<br>(0.013)   |                    | 0.001<br>(0.003)   |
| Green bond (short-term, 1 year)  |                    | 0.026**<br>(0.013) |                    | 0.002<br>(0.003)   |
| Green bond (long-term, 2+ years) |                    | 0.029**<br>(0.014) |                    | 0.006**<br>(0.003) |
| Firm fixed effects               | Yes                | Yes                | Yes                | Yes                |
| Country-year fixed effects       | Yes                | Yes                | Yes                | Yes                |
| Industry-year fixed effects      | Yes                | Yes                | Yes                | Yes                |
| Observations                     | 971                | 971                | 1,005              | 1,005              |
| R-squared                        | 0.89               | 0.89               | 0.86               | 0.86               |



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# Environmental Performance

|                                  | Environmental performance                                 |         |   |            |
|----------------------------------|---|---------|---|------------|
|                                  | Environment rating  |         | CO <sub>2</sub> emissions / assets              |            |
| Green bond                       | 6.132**   |         | -16.977**                                       |            |
|                                  | (2.619)   |         | (7.130)   |            |
| Green bond (pre-issue year)      |   | 0.448   |   | 1.228      |
|                                  |   | (2.722) |   | (7.986)    |
| Green bond (short-term, 1 year)  |   | 4.407   |   | -9.168     |
|                                  |   | (2.885) |   | (7.411)    |
| Green bond (long-term, 2+ years) |   | 7.283** |   | -21.585*** |
|                                  |   | (2.988) |   | (8.071)    |
| Firm fixed effects               | Environmental rating improves by <b>8.8%</b> in long-term |         | Emissions decrease by <b>27.7%</b> in long-term |            |
| Country-year fixed effects       |   |         |   |            |
| Industry-year fixed effects      |   |         |   |            |
| Observations                     | 795   | 795     | 600   | 600        |
| R-squared                        | 0.88  | 0.88    | 0.92  | 0.92       |



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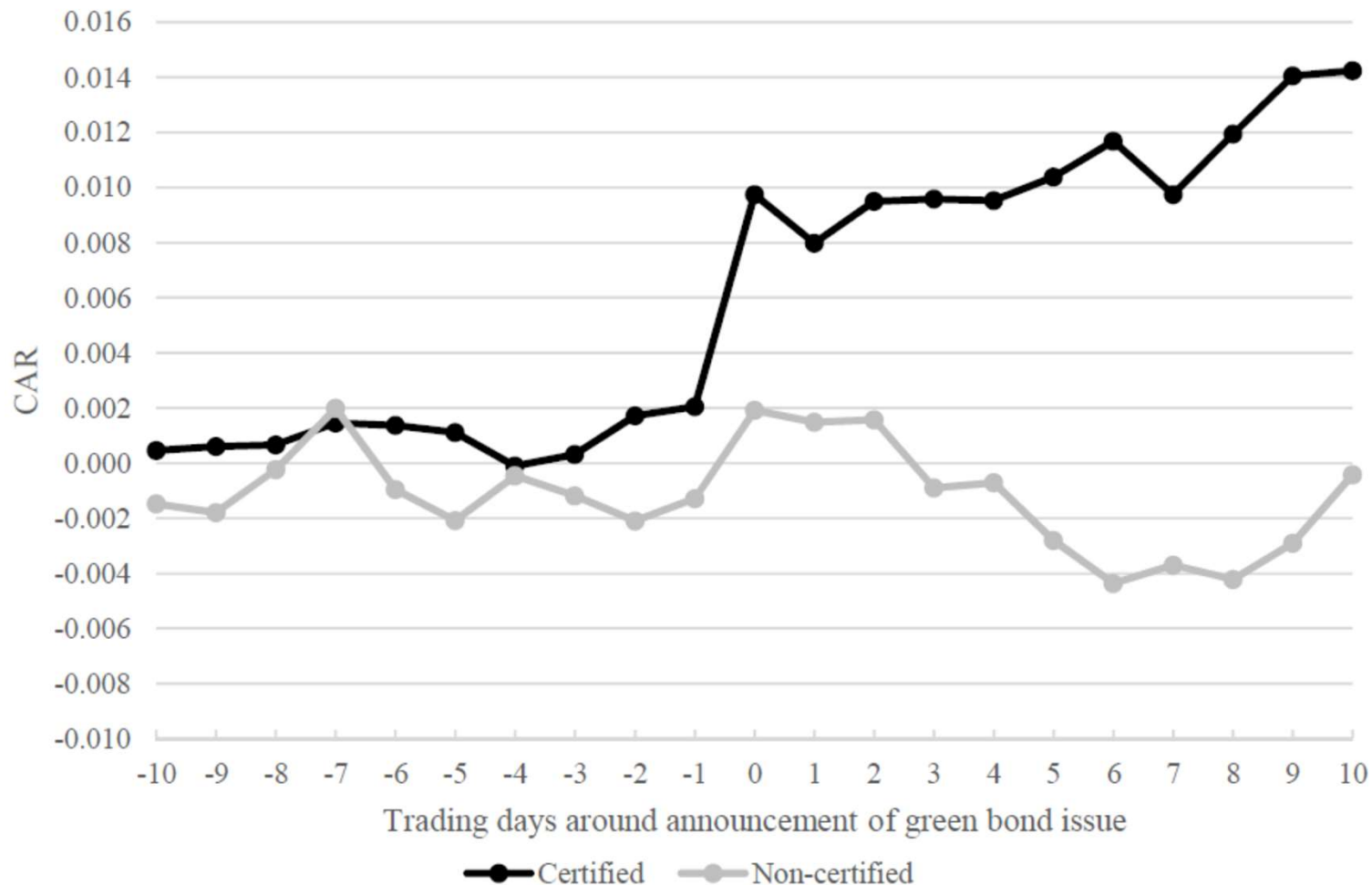
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# Certification

- **No public governance** of green bond market
    - From a legal perspective, no difference between green and conventional bonds → firms cannot be sued if proceeds are used for non-green projects
  - Instead, green bond market **relies on private governance** (e.g., certification, reputation)
    - **Certification** by independent third parties:
      - E.g., Sustainalytics, Vigeo Eiris, Ernst & Young, CICERO
      - About 2/3 of green bonds are certified
- **Results are only significant for certified green bonds!**

# Certification

- Stock Market Reaction



# Certification

- Corporate Financial and Environmental Performance

|  | Tobin's Q          | ROA                | Environment rating | CO <sub>2</sub> emissions / assets |
|--|--------------------|--------------------|--------------------|------------------------------------|
| <i>Certified vs. non-certified green bonds</i> |                    |                    |                    |                                    |
| Green bond × certified                         | 0.032**<br>(0.014) | 0.006**<br>(0.003) | 7.165**<br>(2.893) | -19.354**<br>(7.714)               |
| Green bond × non-certified                     | 0.021<br>(0.013)   | 0.004<br>(0.003)   | 4.201<br>(2.701)   | -11.849<br>(7.330)                 |
| Firm fixed effects                             | Yes                | Yes                | Yes                | Yes                                |
| Country-year fixed effects                     | Yes                | Yes                | Yes                | Yes                                |
| Industry-year fixed effects                    | Yes                | Yes                | Yes                | Yes                                |
| Observations                                   | 971                | 1,005              | 795                | 600                                |
| R-squared                                      | 0.89               | 0.86               | 0.88               | 0.92                               |

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# Conclusion

- Do green bonds deliver on their promise? Or are they merely a greenwashing tool?
  - Green bonds have **real impact**, and are **not merely a tool of greenwashing**
    - i) Increase financial performance
    - ii) Improve environmental performance
  - Results suggest
    - **Green bonds** serve as **effective financing tool** to create long-term value and improve environmental footprint
      - ➔ could serve as a **powerful tool against climate change**
    - **Certification** can serve as important **governance mechanism** in absence of public governance
      - ➔ Yet, does not imply that certification is the most effective governance regime

# Implications for Public Policy

- Challenges of Green Bonds

- Absence of government regulation

- 1) **Ambiguous definition** of “green”

- ➔ Complicates certification

- 2) **Multiple taxonomies** (international and national)

- E.g., Green Bond Principles (GBP), Climate Bonds Standard (CBS)

- Lack of universal rules and standardization

- ➔ May impede effectiveness, efficiency, and integrity of the market

- 3) **Binary certification** (certified vs. not certified)

- Limited informativeness

- ➔ A tiered certification (similar to credit ratings) might be more informative



# Implications for Public Policy

## 4) **Additionality**

- Would the green projects have been conducted even without the green bond financing?
- Similar discussion in context of carbon offsets
- ➔ “Additionality” certification?

- Several of these challenges can likely be mitigated by public governance
  - (Current) **lack of public governance** is likely **sub-optimal**
  - A **mix of public and private governance** might be ideal
  - Need **more research and policy discussion** on the **optimal design** of the governance of the green bond market



# Thank You!

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