Firm Networks and Green Bond Issuances

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Preliminary version

Abstract

This paper examines whether the practice of green bond issuances spreads between issuers via shared directors or executives. Utilizing a public and private firm sample of 793 Northern American and European green bond issuers between 2013 and 2021, we find that issuers who have an interlock with previous green bond issuers (green interlock) are approximately 20% more likely to issue green bonds. The positive association is also observed between other green network characteristics (i.e., network size and centrality) and the propensity of green bond issuances. Further, the observed positive relation is particularly pronounced for issuers who are connected with previous issuers with strong CSR commitments. Additional analysis shows that green interlocks and associated centrality positions are positively associated with firm value and inversely related to issuance costs, demonstrating that the issuance of green bonds is a value-enhancing and cost-efficient practice for issuers with effective networks.

Keywords: Green bonds, Green interlock, Network centrality, Sustainable finance, Corporate social responsibility (CSR)

JEL Classification: M14, G32, G14

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1 Introduction

The firm network can be considered a mechanism of information transmission through which value-improving business innovations can spread (Haunschild & Beckman, 1998). Facilitating the issuance of green bonds, which represents a financial innovation, may derive advantages from a channel of communication or exchange of resources among issuers. This includes considerations such as the financial and social value associated with labelling bonds as green, certifications, and other pertinent factors.

The purpose of this study is to provide evidence with respect to the spread of the practice of green bond issuances. We focus on the role that directors', executives', and officials' (government institutions only) connections played in contributing to the spread of green bond practices. We hypothesize that a firm is more likely to start issuing green bonds if the issuer has a director or top executive who also serves as a director or top executive or official of another organization during the year that the focal firm starting to issue green bonds, or at any point in the preceding five years (referred to as green interlock). Under the same line of conjecture, we also expect that the more firm-level ties with previous green bond issuers (referred to as green network) an issuer has, and the more central the issuer is, the more likely it is to issue green bonds in the subsequent years.

Specifically, after collecting all green bonds from Bloomberg and Climate Bond Initiatives (CBI), we restrict issuers to those in the European and Northern American regions because of the scope in the BoardEx and BvD Orbis, where we filter the complete organizational composition profiles of 793 first-time firm issuers between 2013 and 2021, including 289 public firms and 504 private firms.

Consistent with our testable hypotheses, we find empirical evidence that firm-level green interlocks, green network, and green centrality positions promote the propagation of green bond issuances. The results show that the likelihood of green bond issuances is approximately 20% higher at firms with green interlocks than at firms without green interlocks. The quintile ranks of issuer green centralities and specific centralities measured by degree, betweenness and eigenvector are positively associated with the propensity of green bond issuances. However, we do not find consistent evidence on the relation between issuers' interlocks or connections with all issuers in our entire sample and the tendency to issue green bonds.

Our empirical results of green interlocks can be vulnerable to the endogenous concerns of causal interpretations (Stuart & Yim, 2010). To rule out the alternative possibility that an underlying similarity between the two connected issuers, instead of the connection, causes both to have an elevated proclivity to issue green bonds, we present robust results to alternative interlock measures (i.e., within-industry pairings). Issuers who desire green bond issuances may intentionally recruit employees with green bond issuance experiences. To address this reverse causality, we control for the presence of migrated employees who joins the focal issuer after their previous issuers who have issued green bonds through which they can obtain related experience, and the presence of short-tenured connected employees.

Apart from green interlocks, centrality measures can also suffer from endogeneity attacks, where larger issuers tend to have larger network, resulting in a higher propensity of issuing green bonds. The results are consistent when we compute size-adjusted network measures (i.e., quintile ranks of centrality scores in baseline specifications). Moreover, following Cai et al. (2021) and Fracassi (2017), we estimate a two-stage-least-squares model with the instruments being deaths and sudden departures of directors or executives as exogenous shocks and confirm our baseline findings.

Our empirical findings support the notion that firm networks contribute to the spread of green bond issuances. To scrutinize further the underlying channels of this transmission, we further document that the positive effect of green interlock and network on the propensity of green bond issuances is stronger for firms connected with previous issuers with greater CSR commitment, which demonstrates that the spillover of CSR dedication appears to be a driver of the spread of green bond issuances.

To discern the value of green connections, in later sections, we examine how firm interlocks and network characteristics affect the financial value and costs associated with green bond issuances. Employing an event window of [-3,+3] with multiple asset pricing models, we show that firm value are greater for public green bond issuers with green interlocks, greater network size and higher green centralities, compared to those without green interlocks and with lower centralities. This is demonstrated in the difference in the average cumulative average returns (CARs) across subsamples split by the presence of green interlocks and based on the top versus bottom terciles of centrality measures, which is statistically significant at the 5% level or above. By plotting the evolution of CARs over the event window of [-15,+15], we find CARs for firms without green interlocks or with network size at the bottom tercile decline to below zero or fluctuate around zero, while CARs for firms with an interlock or greater network stably grow over time. The consistent findings across models suggest that whilst it is still disputable that issuing green bonds is viewed by investors as a value-enhancing practice, green bonds issued by firms connected with previous green issuers display consistently greater firm value over time. We also conduct multivariate regression analysis and document that green interlocks and centrality positions are positively and significantly associated with the firm wealth (measured by CARs) generated by the green bond issuances.

To investigate the impact of green network measures on the issuance costs associated with green bond issuances, we capture issuance costs in two dimensions: yield spreads and gross spreads. Utilizing the firm sample, we document a consistently negative impact of green interlocks and centrality ranks on the issuance costs across two measures. The magnitude of such effect on yield spreads is stronger for first-time issues than all issues. This implies that green bond investors value green connections of issuers in the role of mitigating information asymmetry.

Our study makes several contributions to the literature. First, we contribute to the growing stream of scholarly studies examining the effects of social networks in different areas of finance. A growing body of research (e.g., Cai, 2012; Cohen et al., 2008; Engelberg et al., 2012; Stuart & Yim, 2010) examines the role of firm networks in driving corporate financial policies. Our findings reveal that knowledge and experience gained through director networks also influence firm green bond policy. Firm networks serve as conduits for information that influences green bond policies.

Second, our understanding of the impact of firm networks on the likelihood of green bond issuances adds to the literature on the relation between social networks and CSR activities (e.g., Amin et al., 2020; Nandy et al., 2020). Taking the issuance of green bonds as a typical example of CSR involvement (Tang & Zhang, 2020), our study suggests that spreads of green bond practices can be facilitated by expanding firm-level green interlocks and taking more central positions, which can potentially boost firm value and lower financing costs. We provide evidence that the issuance of green bonds as a CSR policy can be a value-enhancing practice for firms with effective networks.

The paper proceeds as follows. Section 2 provides a review of literature on firm networks and green bond issuances as a part of firm financial policies. Section 3 discusses green (full) interlocks, network, and centrality measures and other data used in the paper. Section 4 presents the empirical results and

Section 5 provides various robustness checks. Section 6, 7 and 8 explore possible channels through which green network and centrality benefit issuers. Section 9 concludes.

2 Literature Review

An interlock is a tie created by two or more firms sharing a common individual (Burt, 1980; Mizruchi, 1996). The literature shows that firms have several incentives to form an interlock with others, such as reputation-building (Kang, 2008), environmental adaptation and uncertainty mitigation (Useem, 1984), better access to information and resources (Martin et al., 2015), increased monitoring capabilities (Coles et al., 2015), and inter-learning and diffusion of good corporate practices (Palmer et al., 1993). Individuals are also motivated to develop their network as a signal of their prestige and visibility associated with more career opportunities (Fama, 1980). The resource dependence theory (Pfeffer, 1972) recognizes that a firm's behaviour is constrained by their external environment, where a network of interdependencies with other firms will exert a significant influence on the focal firm's strategies. This requires the firm must respond quickly to a dynamic environment whereby interacting with other firms can help reduce information asymmetry and eliminate market constraints.

Spread effects are evident among interlocking firms who make efforts to mitigate environmental uncertainty. Firms are motivated to mimic their interlocked firms who gain benefits from certain behaviours, such as earnings management and option backdating (Bizjak et al., 2009). They learn from other firms through interlocks and thus corporate policies between interlocked firms tend to be similar (Davis & Greve, 1997).

2.1 Social networks and financial policies

2.1.1 Firm interlocks and financial policies and CSR

The impact of firm interlocks has been demonstrated in the diffusion of numerous financial policies, such as poison pills (Davis, 1991), stock option policies (Bizjak et al., 2009; Reppenhagen, 2010), financial reporting behaviour (Brown, 2011; Chiu et al., 2013), disclosure policies (Cai et al., 2014), investment decisions (Helmers et al., 2017), and accounting policies (Han et al., 2017; Johansen & Pettersson, 2013), etc.

The analysis of Stuart & Yim (2010) demonstrates that firm interlocks in the boardroom affect the companies' likelihood of becoming targets in change-of-control transactions. Extending to investment policies, Cai (2012) presents evidence that a common director shared between acquirers and targets contributes to higher announcement returns in M&A transactions.

In the context of CSR, recent studies find that board interlocks with firms that have superior CSR performance lead to reduced greenhouse gas (GHG) emissions by focal firms (Lu et al., 2021).

2.1.2 The impact of firm network on financial policies and CSR

Firm-level network centrality sheds light on the information advantage to the firm. Chang & Wu (2021) find that well-connected boards have a positive effect on innovation activities and quality. Fracassi (2017) finds that the similarity of the capital investment policy between two companies increases with the number of connections these two share with each other. Firms more centrally located in the network have less idiosyncratic financial policies and hence display greater firm performances.

In the CSR context, by employing the centrality measures to capture the well-connectedness of the firm, Amin et al. (2020) and Nandy et al. (2020) both document a positive relation between networks and CSR performances.

2.1.3 Firm network and bond characteristics

A growing stream of research focuses on the impact of firm networks on sources of financing for firms. Benson et al. (2018) and Skousen et al. (2018) suggest a positive relationship between networks and bond credit ratings, proxied as firms' default risks. Chuluun et al. (2014) extend the impact of board ties to the costs of corporate debt, proxied by the difference between corporate bond yield spreads at issuances with matching treasuries. Qiu et al. (2019), focusing on unique social ties in China, find similar conclusions that the higher centrality regarding top management teams (TMTs) reduces bond yield spreads.

2.2 Green bonds

To tackle the climate crisis, green bonds are introduced as an innovative type of debt instruments that differ from conventional bonds only in that the issuer pledges to use the proceeds to finance projects that are supposed to generate favourable environmental outcomes (ICMA, 2021). Against this backdrop, scholarly literature on green bonds is divided into two mainstreams: the implications and the determinants of green bond issuances.

2.2.1 The implications of green bond issuances

The impact of green bond financing can be summarized to superior financial performances (e.g., Flammer, 2021; Tang & Zhang, 2020) in the form of favourable announcement returns on the stock market, operating performances, and increased institutional ownerships, reduced costs of issuances (e.g., Hyun et al., 2020; Zerbib, 2019), and better ESG performances (e.g., Sinha et al., 2021; Wang et al., 2022; Wei et al., 2022).

One strand of the literature focuses on the effects of green bond issues on ex-post firm performances. Tang & Zhang (2020) and Flammer (2021) find that corporate green bond issuances are associated with positive stock market reactions which attract an investor clientele that values the long term orientation and the environment. Another stream focuses on the pricing of green bonds. Zerbib (2019) presents evidence that pro-environmental preferences can translate into positive market outcomes in lower yield spreads of green bonds. Hyun et al. (2021) argue that a lower issuance cost captured by yield spreads is only identified for certified green bonds, not for self-labelling green bonds.

2.2.2 The determinants of green bond issuances

A growing number of studies have analysed the roles of bond specific characteristics and issuers' financial features in different regions (e.g., Cicchiello et al., 2022; Lin & Su, 2022), national institutions (e.g., Mertzanis & Tebourbi, 2023), and governance characteristics (e.g., Daubanes et al., 2021; García et al., 2023) in the determination of green bond issuances.

Dutordoir et al. (2022) document that firms with lower costs of disclosure, higher reputational gains from labelling themselves as green, and a stronger focus on innovation are more likely to issue green instead of conventional bonds. García et al. (2023) find suggestive evidence of a positive association between board governance (e.g., a higher percentage of female directors and independent directors) and the likelihood of green bond issuances.

2.3 Hypothesis development

The decision of issuing green bonds is considered not only a financial policy in the choice of financing vehicles, but also a CSR policy (Tang & Zhang, 2020). Firm interlocks are demonstrated in prior research to have a positive influence on CSR performances (Amin et al., 2020) and financial policies (Omer et al., 2020). Interlocking members gain experience with respect to the issuance of green bonds. The expertise is comprehensive, cheaper, more credible, flexible and current than the knowledge commonly found in the market. Additionally, this knowledge is difficult to copy or imitate because it is associated with the individual's experience and trustworthiness. Hence, we hypothesize that an organization is more likely to start issuing green bonds if the issuer has a director or executive who also serves as a director or top executive or official (for government institutions only) of another organization during the year that the focal organization starting to issue green bonds, or at any point in the preceding five years (referred to as green interlock).

H1: Issuers with an interlock with previous green bond issuers are more likely to start to issue green bonds.

Amin et al. (2020) and Nandy et al. (2020) reveal the significance of firm network characteristics in determining a firm's CSR policy. They both find that a well-connected firm (measured by centrality positions) is prone to be involved in CSR activities in different country contexts. Hence, we presume that the more ties with previous green bond issuers (referred to green network size) a firm has, and the more central the issuer (referred to green centrality) is, the more likely it is to issue green bonds in the subsequent years.

H2: Issuers with greater green network size and centrality positions are more likely to start to issue green bonds.

3 Data collection, Firm Network Measures and Methodology

3.1 Sample selection

To examine the effect of the new issuers' network with previous green bond issuers on the likelihood of firms beginning to issue green bonds, we match bond issues with corresponding issuer IDs on distinct data sources, including Capital I&Q for financial characteristics, BoardEx for issuer's network and other governance characteristics, Orbis Europe (BvD Orbis) for the supplement of financial and network characteristics, and Thomson Eikon for governance characteristics.

Firstly, after collecting all green bonds issued between 2008 and 2021 from Bloomberg and Climate Bond Initiative (CBI), for each bond issue with available International Securities Identification Numbers (ISINs), we match each ISIN with their company ID on Capitial I&Q and Thomson Eikon. For those ISINs unable to match corresponding issuers on other data sources or issuers with missing ISINs, we manually check the specific issuers.

Secondly, to map our issuer network, we obtain detailed information on top key executives and directors on board from BoardEx. BoardEx, compiled by the Management Diagnostics Limited, works as the leading database on the firm composition for over 28,000 publicly listed and large private firms, and it provides a list of all current and past board positions and current and past employers, with specific information on job description and dates started in the organization and in the current role. Nevertheless, we admit its coverage is more comprehensive for European and Northern American companies, lower for companies in other regions. [3] Hence, our green bond sample is limited to the European and Northern American organizations. We match tickers for publicly listed firms and equity primary issue ISINs for private firms, and for the issuers with missing identifiers, by implementing the Levenshtein algorithm on Python following Engelberg et al. (2013), we match the company name with the BoardEx most recent name and also hand-search issuer names provided by Bloomberg or CBI or have matched by Capital I&Q on the BoardEx website. [4]

We focus on past directors and top-key-executive-level positions because midlevel management are less involved in the overall corporate finance policy decision-making policy (Fracassi, 2017), supplementing the company composition of European companies with the Orbis Europe database (BvD Orbis). [5] After further identifying 138 issuers on BvD Orbis by matching their ISINs and Legal Entity Identifiers (LEIs), the final sample consists of 1038 unique issuers, including 289 public firms, 504 private firms and 245 government institutions. [6] In the subsequent sections, our analysis mainly focuses on the 793 public and private firms whose inter-connections and connections with

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[3] Fernandes et al. (2013) use BoardEx data to primarily compare the U.S., European and Canadian companies in their sample.

[4] Some issuers can be manually found on BoardEx, but it includes very few employees and also has no start and end dates in their roles. For example, Portland Water District, as a U.S. private firm, has its company profile on the BoardEx website, but it only provides one employee's name, age and gender without role descriptions and employment histories available. We drop such issuers as their inclusion may result in the selection bias in the database coverage, which underestimate the network measures.

[5] The Oribis Europe database is compiled by the Bureau van Dijk Electronic Publishing (BvD), which covers over 50 million companies in European countries, of which 99% are private companies. We employ the employee-name-matching algorithm (Falato et al., 2014) based on each employee's last and first name and middle initial to remove duplicate appearances on both BoardEx and BvD Orbis.

[6] Despite the first green bond was issued in late 2008 by World Bank, we specify the sample period as 2013-2021 as there are a handful of issues in the starting phase and most of them are issued by supranational organizations. Spanning our sample period, supranational organizations are only considered when calculating the directors' or executives' concurrent professional network with previous green bond issuers. Moreover, since some of our network measures are calculated over a multi-year moving window (discussed in Section 3.2), it is better to start in 2013, allowing for connections in previous years to accumulate effects.

government institutions are taken into consideration to construct network measures. The analysis of government institutions can be found in Appendix Table IA.2 and 3.

3.2 Measures characterizing issuer interlocks and networks

In this section, we describe our interlock and centrality measures characterizing issuer networks as well as financial and governance characteristics.

3.2.1 Green interlock and network

To define our interlocking relations between previous issuers and new green bond issuers, we follow Stuart & Yim's (2010) approach to code $GREEN\ INTERLOCK_{j,t}$ for issuer j at year t. Specifically, before moving forward to the next issuer-year observation, we check whether the focal issuer j shares a director with a previous green bond issuer i at year t, t-1, t-2, t-3. If yes, then $GREEN\ INTERLOCK_{j,t} = 1$ and if no, $GREEN\ INTERLOCK_{j,t} = 0$. The multi-year moving window is employed because directors carry their previous learning, experience, and contacts with them to the boards on which they currently and subsequently serve and, therefore, the connections in the network need not be contemporaneous to exert influence (Stuart & Yim, 2010).

In a similar manner, we consider a discrete green network variable $GREEN\ NETWORK_{j,t}$, defined as the number of firm-level ties of an issuer j with unique previous green bond issuers who already issue green bonds in prior years over the period between t-3 and t. $GREEN\ NETWORK_{j,t}$, as a directed network measure, allows us to count the number of ingoing connections in which the new green bond issuer is invited to issue green bonds.

[Insert Figure 1 here]

Figure 1 presents an illustrative example and description of how green interlocks are characterized and how we create our green interlock and network variables. The network example in 2021 consists of six issuers (Swedbank, Klovern, Landesbank Baden-Wuerttemberg, NCC Treasury AB, Landshypotek Bank, and Credit Suisse AG) connected with Alandsbanken Abp at the centre node in any year between 2018 and 2021. The inner direction of arrows indicates that these six issuers, who issued green bonds prior to 2021 and are thus previous green bond issuers relative to Alandsbanken Abp, transfer information with respect to green bond issuances through shared directors or executives. We calculate the $GREEN\ INTERLOCK$ of Alandsbanken Abp in 2021 as 1 and the $GREEN\ NETWORK$ as 6.

3.2.2 Green network centrality and full network centrality

Firm-level network centrality sheds light on the information advantage to the firm. Several centrality concepts in the Social Network Analysis (SNA) literature capture different aspects of social and economic networks. Apart from $GREEN\ NETWORK_{j,t}$, we make use of three centrality measures (Degree, Betweenness, and Eigenvector) measured in both the green network composed of previous green bond issuers over the last four-year period ($GREEN\ NETWORK_{j,t}, GREEN\ BETWEEN_{j,t}, GREEN\ EIGEN_{j,t}$) and composed of all issuers in our entire sample at year t ($FULL\ NETWORK_{j,t},\ FULL\ BETWEEN_{j,t},\ FULL\ EIGEN_{j,t}$). The underlying concept is that the higher the number of connections an issuer has with previous green bond issuers or with other issuers in our sample, the more centrally located it is.

To compute the centrality measures each year, we first need to construct an adjacency matrix, which is an N × N matrix (in which N is the number of issuers in the network at year t). Take the green network as an example, each cell in the matrix takes a value of one if two issuers have been interlocked through common directors or executives or officials (for connected government institutions only) over the considered four-year period. In the case of directed networks $GREEN\ NETWORK_{j,t}$, it matters whether another issuer i has influenced the focal issuer j into green bond issuances. In this sense, each cell in the adjacency matrix takes a value of one only if issuer i has influenced issuer j to participate in green bond issuances (i.e., $x_{i,j} = 0\ and\ x_{j,i} = 1$). By contrast, undirected centrality measures, do not consider the information with respect to which green bond issuer is the lead. Thus, at year t, if issuers j and i share a common employee, it follows that $x_{j,i} = x_{i,j} = 1$. Degree, Betweenness, and Eigenvector are also constructed based on the entire sample using undirected networks.

Degree centrality is the most intuitive and straightforward centrality measure. It counts the total direct number of connections that an issuer has within the specified network. Apart from aforementioned $GREEN\ NETWORK_{j,t}$, we also construct another measure of degree centrality based on the entire sample - $FULL\ NETWORK\ _{j,t}$. The formulas of both are below:

$$GREEN\ NETWORK\ _{j,t} \text{ and } FULL\ NETWORK\ _{j,t} = \sum_{j \neq i} x_{j,i} \qquad \text{Eq.[1]}$$

Where $GREEN\ NETWORK_{j,t}$ calculates the issuer's number of links between t-3 and t with unique issuers who have already issued green bonds, and $FULL\ NETWORK\ _{j,t}$ calculates the number of links an issuer has to its adjacent issuers available in our full sample at year t, not just to issuers already issuing green bonds in previous years. For a given issuer j at year t, we take the natural logarithm for both measures to reduce skewness. Analogous to $GREEN\ INTERLOCK_{j,t}$, we calculate another interlock measure, $FULL\ INTERLOCK_{j,t}$, an indicator variable assigning the value of one if the issuer j has any links to any other organization(s) in our full sample at time t, and zero otherwise. This is a general measure of a firm's connectedness in the firm interlock network.

If an issuer has high degree centrality but most of its connections who are not well connected, then the power exercised by the issuer over the network is somewhat limited. If the issuer is tied to other issuers who themselves are well connected (more central), this issuer has a greater influence in the network. This concept is captured by the Eigenvector centrality (Bonacich, 1987), which is a variation of the Degree centrality in which connections are weighted by their relative importance in the network. In other words, Eigenvector does not simply count the number of ties that an issuer has, but it weighs each connection by its centrality. A higher Eigenvector measure indicates that an issuer could be able to disseminate and extract information more efficiently as the information flows through other issuers that are more central and informed.

$$GREEN\ EIGEN_{j,t}\ or\ FULL\ EIGEN_{j,t} = \lambda\ \sum_{i=1}^{N} x_{j,i} e_i \qquad \text{Eq.[2]}$$

Where λ is a constant represented by the biggest eigen-value of the adjacency matrix and e is the eigenvector centrality score.

Betweenness centrality (Freeman, 1977) is measured as the shortest connections through which two issuers are connected and estimating the number of shortest paths passing through the issuer j. It evaluates the positioning advantage of an issuer in the entire network. Given the total number of possible paths between two other issuers, the higher the number of cases in which the shortest path passes through a given issuer, the higher is that issuer's betweenness. Betweenness centrality of issuer j is the sum of its betweenness ratios that defined as the number of geodesic paths from issuer i to issuer k passing through issuer j, divided by the number of geodesic paths from i to k. Formally, the Betweenness measures for issuer j at year t are:

$$GREEN\ BETWEEN_{j,t}\ or\ FULL\ BETWEEN_{j,t} = \sum_{i<k} {p_{jik}}/{p_{ik}} \qquad \text{Eq.[3]}$$

Where the $GREEN\ BETWEEN_{j,t}$ is measured over the period of t-3 and t within the network of unique prior green bond issuers. $FULL\ BETWEEN_{j,t}$ is measured at year t within the network of all issuers available in our entire sample.

3.2.3 Composite network

To make two categories of network centralities comparable over time, following the approach described in Larcker et al. (2013), the sample is divided into five quintiles based on AT (proxy for firm size) each year and then firms are sorted within each AT quintile into quintiles according to each of the three types of centralities. Formally, two composite network scores (ranging from 1 to 5) for each firm are computed below:

$$GREEN\ SCORE_{i,t} = \text{Quint}\left[\frac{1}{3}\left\{\text{Quint}\left(GREEN\ NETWORK_{i,t}\right) + \text{Quint}\left(GREEN\ EIGEN_{i,t}\right) + \text{Quint}\left(GREEN\ BETWEEN_{i,t}\right)\right\}\right] \quad \text{Eq.[4]}$$

$$FULL\ NSCORE_{i,t} = \text{Quint}\left[\frac{1}{3}\left\{\text{Quint}\left(FULL\ NETWORK_{i,t}\right) + \text{Quint}\left(FULL\ EIGEN_{i,t}\right) + \text{Quint}\left(FULL\ BETWEEN_{i,t}\right)\right\}\right] \quad \text{Eq.[5]}$$

3.3 Financial and governance characteristics

We use Capital I&Q to identify green bond issuers' company types. In total, we have 504 private firms and 289 public firms. As private and public firms both are main categories of green bond issuers, varying in terms of operational purposes and profit nature, the sample size in each analysis varies depending on the scope of the sample we examine and model specification we use.

[Insert Table 1 here]

Some firms issue green bonds for more than one year. These observations are removed from the sample after the initial year of green bond issuances to avoid multiple counting of green issues. Table 1 provides summary statistics between 2013 and 2021 for two subsamples of issuers – new green bond issuers identified each year (Panel A) and issuers have not issued green bonds (and will issue green bonds during our sample period) (Panel B), categorized by private firms (*PRIVATE*) and public firms (*PUBLIC*). [7] In each year, more private firms become new green bond issuers than public firms, which imply private institutions play an important role in the green bond market. Panel A and B of Table 1 also report the percentage (%Links) and average number of firm links (Avg links) to other organizations (including government institutions), and the percentage (%Green links) and average

[7] Despite that our green bond sample starts in 2008, when the World Bank issued the first green bond, we follow Bizjak et al's (2009) approach to identify the subsequent year when a firm is identified as a new green bond issuer. It is noteworthy, however, there was only a handful of green bond issues before 2013, and initially mostly issued by municipalities and governments, therefore, our firm sample of new green bond issuers begins in 2013, marking the first public corporate green bond in the market. Moreover, to be consistent across firm types, the sample of private firms also starts in 2013. Spanning the period between 2008 and 2012 in our sample, 4 government institutions and 9 private firms issue green bonds.

number of links to other organizations that have issued green bonds in previous years (Avg green links). Not only the %Links and Avg links, but also the %Green links and Avg green links of *PUBLIC* are generally more than those of *PRIVATE*, suggesting that public firms in our sample tend to have more links on average. Compared with non-green-issuers, the percentage of new green bond issuers having connections with previous green bond issuers and the average of their links are higher. For example, in 2020, 53.13% of private firms and 81.82% of public firms as new green bond issuers are linked through green interlocks with previous green bond issuers, compared to 40.69% (*PRIVATE*) and 67.33% (*PUBLIC*) of non-green-bond issuers. Similarly, new green bond issuers of *PRIVATE* and *PUBLIC* have respectively 4.81 and 7.12 firm links on average to previous issuers in 2020, compared to 4.06 and 6.16 firm links for non-green-bond issuers. Overall, this is consistent with the notion that firm networks play a role in the spread of green bond issuances.

We collect the private and public firm financial data are from Capital I&Q, which is also used by Acharya & Xu (2017) and Shive & Forster (2020) in their studies of the U.S. public and private firms. For the missing financial characteristics in European private firms, we use BvD Orbis to fill the gap, which is also used by Wang et al. (2015). *AT* is measured as the natural logarithm of total assets. Firm profitability (*ROA*) is captured by net income divided by total assets. We use interest-bearing debt divided by total assets to measure firm leverage (*LEV*). For the public firms only, *MTB* is computed as market value over the book value of total assets, where market value of total assets is book value of total assets plus market value of common stock minus book value of common stock. *TANGIBILITY* is measured as net property, plant and equipment (PP&E) scaled by total assets and *FIRM AGE* is the number of years since the firm is founded. We also measure *DEBT MATURITY* as the ratio of long-term debt over total debt to examine the issuers' rollover risks.

Since private firms have a limited coverage in terms of governance characteristics and are different in governance structures and regulations to publicly listed firms, we include governance characteristics as controls for which we have complete data, using private and public firm distinct subsamples (descriptive summary reported in Table 1). We employ *BOARD SIZE* as the total number of directors on board and *%INDEP* as the ratio of independent directors over total number of directors on board to control for board characteristics that are proxies for the strength of monitoring by the board in prior literature. We also control for CEO power using *CEO TENURE*, defined as the total years that CEO serves in this role. For public firms only, *%INST* is measured as the percentage of institutional ownerships.

[Insert Table 2 here]

Panel C, Table 1 presents the summary statistics of network and financial characteristics for all organizations available in our sample, and two distinct categories of organizations - public firms and private firms. On average, public (private) issuers have 1.517 (1.05) firm links with previous green bond issuers (*GREEN NETWORK*), and the difference is larger for *FULL NETWORK* between public (6.739) and private (4.691) firms. Interlocks and network size are not the only aspects public issuers excel over private issuers, but in all other network characteristics, including *BETWEENESS* and *EIGEN* centrality measures.

Table 2 shows the number of non-green-bond issuer-year observations (Non-Green) and the number of green bond issuers (Green) by country and industry in the private and public firm sample, where industries are categorized in terms of their one-digit SIC sector. The number of green bond issuers from the United States is the largest for both private firms (74) and public firms (47), followed by Sweden (56 private and 40 public firms). With respect to industry distributions, there are the largest number of green bond issuers from finance, insurance, and real estate industry, 296 private issuers and 150 public issuers. By contrast, the Agriculture, Forestry and Fishing industry has the smallest number of private (3) and public green bond issuers (1).

3.4 Multiperiod logit models

To identify factors that contribute to the spread of green bond issuances over time, we employ multiperiod logit regressions, which are also applied by prior studies in examining the impact of firm interlock on the adoption of certain financial policies (e.g., Bizjak et al., 2009; Cai et al., 2014). The dependent variable is equal to one for firm-year observations in which the firm initially issues green bonds. After a firm is identified as new green bond issuer, it is dropped from the sample in subsequent years. Our main sample consists of 5559 issuer-year observations between 2013 and 2021 from 793 unique issuers. We include year, industry, geographical region and company type dummy variables in the firm sample regressions. [8] For regressions employing the government institutional sample (Table IA.2), the industry (one-digit SIC) dummy variables are excluded.

[8] We follow Russo et al. (2021) to control for geographical region effect in the research of the determinants of green bond issuances. Our geographical regions include: Northern America, Western Europe, Northern Europe, Eastern Europe, and Southern Europe.

$\text{Green }(0/1)_{j,t} = \beta_0 + \beta_1 \text{Interlock and network measures} + \beta_2 \text{ Firm Controls}_{j,t} + \text{Region Dummies} + \text{Company Type Dummies} + \text{Year Dummies} + \text{Industry Dummies} + \varepsilon_{jt}$ Eq.[6]

$\text{Green }(0/1)_{j,t} = \beta_0 + \beta_1 \text{ Centrality measures} + \beta_2 \text{ Firm Controls}_{j,t} + \text{Region Dummies} + \text{Company Type Dummies} + \text{Year Dummies} + \text{Industry Dummies} + \varepsilon_{jt}$ Eq.[7]

In Eq.(1), interlock and network measures include $GREEN\ INTERLOCK_{j,t}$, $GREEN\ NETWORK_{j,t}$, $FULL\ NETWORK_{j,t}$ and $FULL\ INTERLOCK_{j,t}$ (see definitions in Section 3.2). To reduce skewness, we take the natural logarithm of network measures in regressions. ε_{it} is a random error term.

In Eq.(2), centrality measures include two composite network measures and three undirected network measures: Degree, Eigenvectors (Bonacich, 1972), and Betweenness (Freeman, 1977), measured within the network composed of previous green bond issuers over the last three-year period ($GREEN\ NETWORK_{j,t}, GREEN\ BETWEEN_{j,t}, GREEN\ EIGEN_{j,t}$) or within all issuers at year t ($FULL\ NETWORK_{j,t},\ FULL\ BETWEEN_{j,t},\ FULL\ EIGEN_{j,t}$) in our full sample (See Section 3.2 for more details). ε_{it} is a random error term.

4 Empirical results

4.1 Interlock, network and the propensity of green bond issuances

Table 3 presents the results of logit regressions of green interlock (*GREEN INTERLOCK*), network (*GREEN NETWORK*), all network (*FULL NETWORK*) and interlock (*FULL INTERLOCK*) on the propensity of green bond issuances, utilizing the public and private firm sample. Both columns 1-4 without controls and columns 5-8 with financial controls consistently report positive coefficients of *GREEN INTERLOCK* and *GREEN NETWORK*, significant at the 1% level. The significant and positive coefficient of *GREEN INTERLOCK* indicates that the likelihood that an issuer starts to issue green bonds is significantly and positively associated with the issuer having a director or executive who also serves on an issuer that has previously issued green bonds. And the significantly positive coefficient of *GREEN NETWORK* suggests the more connections with previous green bond issuers, the higher propensity that an issuer starts to issue green bonds. [9] An issuer that is connected to an

[9] Our correlation matrix provided in the Table IA.1 and unreported VIF values less than 10 for each regression suggest that multicollinearity is not a major concern in our study. Results available in the Table IA.3 are also consistent when we utilize the sample of government institutions to replicate the baseline regressions. We also replicate the baseline

issuer within three years of when the issuer starts to issue green bonds has a higher propensity of starting to issue green bonds.

[Insert Table 3 here]

This effect is not only statistically significant, but also economically significant. We report the marginal effects of key variables in the table. Table 3, Column 1 reports the marginal effect of *GREEN INTERLOCK* is 0.1999, suggesting that an issuer link to a previous green bond issuer improves the issuer's likelihood of 19.99% of becoming a new green bond issuer. With control variables in Column 5, the results show that having a connection to previous green bond issuers for firms is 20.24% more likely to issue green bonds. Likewise, as evidenced by *GREEN NETWORK* in Column 6, issuers with one more link with prior green bond issuers are estimated to have a 19.67% increase in the likelihood of becoming a new green bond issuer. The magnitude of the effect of *GREEN INTERLOCK* is slightly larger than that of *GREEN NETWORK*, implying that establishing the first green link is more effective than add one link to pre-existing ones in turning issuers to be green.

Table 3 also presents the results of the impact of *FULL NETWORK* and *FULL INTERLOCK* measured within the entire sample on the propensity of green bond issuances. Despite of statistically significant and positive coefficients at the 1% and 5% level, respectively, as shown in Columns 3-4, the results are sensitive to controlling for firm financial characteristics when employing the firm sample – in Columns 7-8, *FULL NETWORK* and *FULL INTERLOCK* are no longer statistically significant. Consistent with previous research, large and younger firms with higher leverage are more likely to start to issue green bonds.

[Insert Table 4 here]

4.2 Network centrality and the propensity of green bond issuances

Table 4 presents the results of two composite network measures and four centrality measures using the subset of the public and private firms without controls (Columns 1-6) and with controls (Columns 7-12). Firm green centrality is measured by composite network score in Columns 1 and 7, betweenness in Columns 3 and 9, and eigenvector in Columns 5 and 11. In a similar manner, the firm's full network centrality is measured by composite network score in Columns 2 and 8, betweenness in Columns 4 and 10, and eigenvector in Columns 6 and 12. All green centrality

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regressions using the public and private firm sample without taking their connections with government institutions into consideration and the results remain consistent (unreported).

measures are robust to controlling for financial characteristics. The statistically significant results of two composite network measures in the firm sample suggest that an increase in the quintile rank of the green network centrality leads to a higher likelihood of 1.55% of becoming a green bond issuer. This is consistent with the notion that issuers with higher-centrality positions within previous green bond issuers tend to be more inclined to start to issue green bonds. Similarly, we do not observe robust findings for centrality measures measured with the entire network.

Even after controlling for the financial determinants, the coefficients on green interlock and network measures - *GREEN INTERLOCK*, *GREEN NETWORK, GREEN SCORE, GREEN BETWEEN* and *GREEN EIGEN* remain positive and significant. However, for the firm sample, governance characteristics are also found to be associated with the likelihood of green bond issuances (i.e., García et al., 2023). In Table 5 and 6, we control for the additional impact of board and governance characteristics on the propensity of green bond issuances. We consider *BOARD SIZE*, *%INDEP*, *CEO TENURE* as common governance measures for respective subsets of public and private firms and %INST for public firms. We observe in Table 5 that *BOARD SIZE* is significantly and negatively associated with the propensity of private firms' green bond issuances, but such effect is insignificant in the public firm sample, where *%INST* demonstrates a negative effect on the tendency of green bond issuances at the 5% level.

[Insert Table 5 here]

Public and private firm subsamples observe a similar effect of *GREEN INTERLOCK* of approximately 3% on the propensity of green bond issuances. An increase in *GREEN NETWORK* for public (private) firms is associated with an increase of 0.78% (2.69%) in the likelihood of green bond issuances. Establishing any of connections with issuers in our entire sample (*FULL INTERLOCK*) appears to have no significant effect in both firm subsets, but having one more connection for public firms is estimated to be 0.97% more likely to issue green bonds.

[Insert Table 6 here]

An increase in the quintile rank of public (private) firm green centrality is associated with 1% (0.54%) increase in the propensity of green bond issuances. In contrast, we do not find a statistically significant impact of firms' full centrality on the likelihood of green bond issuances.

5 Robustness checks

5.1 Employee-firm matching

Our findings thus far show a consistently positive effect of green interlocks and network on the propensity of green bond issuances. Directors or executives or officials carry their experience of green bond issuances to the current issuers they serve on, and their knowledge influences the green bond issuance decisions at other issuers they join. This causal interpretation, however, may be under attack from potential endogeneity concerns. One concern is endogenous employee-firm matching, as the presence of a common director or executive or official on two issuers could reflect an underlying similarity between the two issuers, and it could be this commonality that causes each to have an elevated propensity to issue green bonds. For example, issuers in the same industry, from the same country, or geographically close are likely to have interlocked executives or directors, and they are also likely to decide to issue green bonds. In this section, we attempt to rule out endogenous employee-firm matching as an alternative explanation.

First, in Panel A, Table 7 employing the firm sample, we measure *GREEN INTERLOCK* over a four-year window based on whether the issuer shares a director or executive with a previous green bond issuer from a different industry in Column (1) and from a different industry and country in Column (2). We continue to find a positive and significant relation between *GREEN INTERLOCK* and the likelihood of green bond issuances even limiting the interlocks to cross-industry pairings and to cross-country and cross-industry pairings.

Second, social interactions among executives and board members are likely to be facilitated by being in the same geographic neighborhood. Geographically close issuers tend to have the same directors or executives and such issuers thus share similar likelihoods of green bond issuances. It is likely that the propensity of issuing green bonds increases if the person held at least one position at a geographically proximate issuer that have previously issued green bonds. To address this concern, we follow Stuart & Yim's (2010) approach to construct a geographic proximity variable (Proximity) by capturing each issuer's proximity in each year to each of connected previous green bond issuer. [10] To compute the distance between each pair of connected issuers, we obtain the location of the

[10] The Proximity variable for firm j at year t is defined as $\sum_{i \neq j} 1/1 + d(i,j)$, where j is the issuer that starts to issue green bonds in a given year t and d(i,j) is the physical distance between issuers i and j. After weighting the contribution of each connected issuer i who has previously issued green bonds, we can then aggregate all weighted contributions across all issuers i, producing a distance-weighted measure of the proximity of all green bond issuances to each focal issuer j.

headquarters of 1076 issuers in our sample in the form of latitude and longitude data from Thomson Eikon. The distance between locations is estimated using the haversine formula. [11] In Column (3), we do not find evidence of geographic clustering in green bond issuances as the Proximity variable that we control for is statistically insignificant. An increase in *GREEN INTERLOCK* continues to increase the predicted propensity of 12.27% of becoming a new green bond issuer.

[Insert Table 7 here]

5.2 Issuer stacking

Another explanation for our findings in terms of *GREEN INTERLOCK* may be that an issuer desiring to issue green bonds may actively appoint employees who serve on the issuers that have previously issued green bonds (referred to as issuer stacking). This effect could reflect a reverse causal process by which management teams that desire green bond issuances recruit employees with green bond issuance experiences to their teams. To address this concern, we follow Stuart & Yim (2010) to examine the impact of migrated directors. Consider the scenarios in Fig.2, Issuers A, B and C are connected through employee x, and Issuer A, is the first to issue green bonds. Green arrows refer to the tenure of employee service in each of three issuers, and green diamonds refer to the years for which issuers B and C have green interlocks because of the employee's green bond experience in Issuer A. Issuer B and C represent the cases of existing employees and migrated employees, respectively. For Issuer B, employee x serves on his/her position before Issuer A starts to issue green bonds. However, in Issuer C, employee x joins his/her position after Issuer A has issued green bonds through which employee x can obtain related experience. We refer to this type of employee in Issuer C as migrated employees. Issuers that desire for green bond issuances may intentionally recruit migrated employees who have specialized experience and knowledge in this field. To alleviate this reverse causality concern, we create a dummy variable, *Migrated*, which assigns the value of one if the issuer has at least one migrated director or executive who joins the issuer after the connected issuer has issued green bonds, and zero otherwise. We find that 1263 issuer-year observations, less than one quarter of our sample, are associated with migrated employees. Column (4) of Panel A, Table 7 shows that migrated employees are not significantly less likely to issue green bonds, not supporting the notion that issuers stack up employees with previous green bond issuance experience to prepare for issuing green bonds. It is noted, moreover, the marginal effect of *GREEN INTERLOCK* remains

[11] The haversine formula gives great-circle distances between two points on a sphere. The distance between locations j and i is calculated as $d_{ji} = R \times 2 \times \arcsin\left(\min\left(1, sqrt(a)\right)\right)$, where R is the earth's radius (approximately 6371 kilometres), $a = (\sin(dlat/2))^2 + \cos(lat_j) \times \cos(lat_i) \times (\sin(dlon/2))^2$. In this expression, $dlat = lat_i - lat_j$ and $dlon = lon_i - lon_j$. Lat_j and lon_j (Lat_i and lon_i) are the latitudes and longitudes of $location_j$ and $location_i$, respectively.

positive and significant at the 1% level, and the magnitude of 20.22% is similar to that in the baseline regression in Column (5) of Panel B, Table 3, implying that the alternative explanation of issuer stacking alone cannot fully explain the positive effect of green interlock on the decision of green bond issuances.

[Insert Figure 2 here]

Second, we tend to believe that interlocking directors or executives with a short tenure in the previous issuers are more likely to be appointed for the sole purpose of issuing green bonds. Thus, we assume that the issuer stacking effect is likely to come from recently appointed employees. In Column (5) of Table 7, we include an interaction term of *GREEN INTERLOCK* with a dummy variable, Tenure less than three years, which assigns the value of one if any of interlocked employees has a tenure of less than three years, and zero otherwise. Employing 1182 issuer-year observations with such short-tenured employees, the findings suggest that although interlocked employees with a service of less than three years are less likely to issue green bonds, the effect is not statistically significant. More importantly, the marginal effect of *GREEN INTERLOCK* continues to be significantly positive, indicating that issuer stacking is not a serious concern in our study.

5.3 Size-adjusted firm network measures

It is commonly acknowledged in literature that board characteristics may not randomly selected variables. Some omitted variables may otherwise determine both board characteristics and the green bond issuance decision. For instance, greater network centrality exists with larger companies that may be related to the proclivity of green bond issuances. One problematic feature of our *GREEN NETWORK*, *FULL NETWORK* and other network centrality measures is that larger firms tend to have a larger group of top management team with a larger network. To separate the effects of firm size and board network on the likelihood of green bond issuances, we follow Larcker et al.'s (2013) approaches to take the residual from cross-sectional regressions of respective *GREEN NETWORK*, *FULL NETWORK*, *GREEN BETWEEN*, *FULL BETWEEN*, *GREEN EIGEN* and *FULL EIGEN* on the log of firm size (AT) and the square of AT. [12]

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[12] We also follow Larcker et al.'s (2013) approaches to rank all firms each into quintiles based on AT and then sort firms within each AT quintile into quintiles based on *GREEN NETWORK*, *FULL NETWORK*, green centrality and full centrality measures. In Section 3.2.3, we construct two composite network measures (*GREEN SCORE* and *FULL NSCORE*) based on this quintile approach and report the results in Columns 1-2 and 7-8 of Table 4. Moreover, consistent results are found for each of quintile centrality measures (unreported).

Panel B, Table 7 reports the coefficients of size-adjusted network measures for the public and private firm sample. We confirm our main findings are unchanged when using the *RESID GREEN NETWORK* and *RESID FULL NETWORK* in Columns (1) and (2). For instance, according to the marginal effect of *RESID GREEN NETWORK,* a point increase is associated with an increase of 19.64% in the likelihood of green bond issuances, resembling to 19.67% reported in the baseline specification in Column (6), Table 3. Issuer green centrality measured by *RESID GREEN BETWEEN* and *RESID GREEN EIGEN* are consistently positive and statistically significant at the 1% level, and the magnitudes of the marginal effects (3.90% and 1.33) resemble those in the baseline regressions. Issuers' full centrality measures - *RESID FULL NETWORK*, *RESID FULL BETWEEN* and *RESID FULL EIGEN*, become insignificant after controlling for financial characteristics in the public and private firm sample, similar to the baseline findings (in Table 3 and 4).

[Insert Table 8 here]

5.4 IV-2SLS estimation

To further address endogeneity concerns in our study, we construct instrumental variables in direct relation to the decreases in connectedness due to director or executive retirements and sudden departures, which are not directly related to green bond issuance decisions. Following Cai et al. (2021) and Fracassi (2017), we consider retirements (*RETIRE*) as a departure at the age of seventy or older and sudden departures (*SUDDEN*) as a departure followed by departures from all other positions within two years.[13] As exogenous shocks, the retirements and sudden departure may allow us to estimate how firm network changes influence the likelihood of green bond issuances.

We define *RETIRE* as an indicator variable taking on a value of one if a director or top executive connected with previous green bond issuers retire at the age of seventy or older, and *SUDDEN* as an indicator variable taking on a value of one if a director or top executive connected with previous green bond issuers depart from their positions followed by departures from all other positions. We assume these two variables would lower green network. In our sample, we collect 301 retirements and 42 sudden departures of directors and executives.

[13] The data on directors' or executives' departure from their current companies is collected from BoardEx Announcement profiles.

Table 8 reports the regression results of the two-stage-least-squares instrumental estimator (2SLS-IV). Panel A presents the first-stage regression results for the public and private firm sample with each interlock and network centrality measure as dependent variables and *RETIRE* and *SUDDEN* as main independent variables. The coefficients of *RETIRE* and *SUDDEN* are negative and significant at the 10% level, suggesting that the unexpected departure of directors or executives due to their retirement or other unexpected reasons lowers the connections for the focal issuer. Panel B displays the second-stage regression results, where we regress *GREEN ISSUE* on fitted values of each interlock and centrality measure estimated from the first-stage regressions. All the columns indicate a positive and significant effect of interlock or centrality on the likelihood of green bond issuances at the 10% level or above. Therefore, our results are consistent when employing the 2SLS-IV estimator. We also provide evidence on the Wald F-test statistics, Wu-Hausman test and Sargan test to be indicative of the validity of our instruments. Specifically, the statistically insignificant p-values of Wu-Hausman test indicate that we cannot reject that the instrumental variable estimator is consistent and we cannot reject the over-identifying restrictions of our second-stage models because p-values of the Sargan test are statistically insignificant, implying that our instruments are distributed independently of each of our independent variables.

[Insert Table 9 here]

5.5 Alternative subsamples

In our main analysis, we aggregate the director- or executive-level connections to the firm-level. It remains a question whether connections through independent non-executive directors and executives play a different role in the facilitation of green bond issuances because their roles and responsibilities are considered to be different - Independent non-executive directors carry out monitoring and advisory responsibilities while executives are in charge of day-to-day operations and management.

To analyse their separate roles in the decision of green bond issuances, two subsets of network samples, connected through independent non-executive directors and through executives, respectively, are constructed, in examining the effect of green interlocks and network centrality on the propensity of green bond issuances. For the sake of brevity, we report results in the Appendix Table IA.4. Panel A reports the results for *GREEN INTERLOCK* and *GREEN NETWORK*, where a similar economic effect is identified between *GREEN INTERLOCK* of executives (21.25%) and independent directors (20.65%). Yet, once firms have established green connections with previous green bond issuers, the accumulative effect of *GREEN NETWORK* appears to be larger for independent directors' connections (21.31%) on the likelihood of green bond issuances, compared to executives (18.89%). This implies that establishing green connections through executives is more effective in improving the likelihood of green bond issuances, and adding one more green connection to pre-existing ones for independent directors is more valuable to issuers.

6 Issuer Network, Connected firm CSR commitment, and Green Bond Issuances

Our empirical findings in previous sections support the notion that firm network contribute to the spread of green bond issuances. To scrutinize further the underlying channels of this transmission, we further test whether the positive effect of green interlock and network on the propensity of green bond issuances is affected by CSR/ESG commitment of connected firms, captured by three proxies. ConnectExeESGcomp is an indicator variable with a value of one if firm i provides ESG-linked compensation for executives, and zero otherwise. ConnectCSRCommittee is an indicator variable with a value of one if firm i has a CSR/sustainability committee, and zero otherwise. ConnectCert is an indicator variable with a value of one if any of connected firms of firm i in year t has issued a green bond with certification, and zero otherwise.

Table 9 replicates the baseline regressions after including the interaction terms of each of these four proxies with *GREEN INTERLOCK* and *GREEN NETWORK* and reports marginal effects and associated standard errors. The positive and significant coefficients of interactions indicate that the augmented effects of a green interlock and green network size are stronger for firms connected with previous issuers with greater CSR commitment, which demonstrates that the spillover of CSR dedication appears to be a driver of the spread of green bond issuances.

7 Issuer Network, Green Bond Issuances, and Firm Value

7.1 Cumulative abnormal returns (CARs)

In this section, we report results from event study analysis that tests whether green interlock and centrality measures boosts the firm value created by the issuance of green bonds. That is, we examine the stock market reaction towards announcements of green bonds and how the stock reactions vary based on the type of interlocked connection and the degree of various network measures. As stock data is only available for public firms, this analysis is limited to public firms.

Following Tang & Zhang (2020), we restrict bond issuers that have at least 300 trading days of returns data prior to announcement dates and 50 trading days after the announcement. [14] We employ three asset pricing models - the capital asset pricing model (CAPM), Fama-French 3 factor model and Fama-French 5 factor model, using an estimation window of 250 trading days, daily abnormal returns (ARs) in Eq. [9] are obtained by subtracting estimated returns on day t for issuer j with parameters estimated in Eq. [8] from the actual stock return on day t for issuer j.

$$R_{j,t} - r_f = \mu_j + \beta_j \left(R_{m,j,t} - r_f\right) + \varepsilon_{j,t} \qquad \text{Eq. [8]}$$

$$AR_{j,t} = R_{j,t} - \hat{R}_{j,t} \qquad \text{Eq. [9]}$$

Where $\left(R_{m,j,t} - r_f\right)$, as the market premium, is the difference between market return ($R_{m,t}$) and 10-year Treasury bond yield (r_f) for stock j in date t, and $(R_{j,t} - r_f)$ is the stock return premium. $R_{m,j,t}$ is the market return, proxied by the market return data on which the firm's stock is listed, collected from Datastream. $\hat{R}_{j,t}$ is the estimated stock return in Eq. [8] for issuer j on day t.

[Insert Table 10 here]

We report results for the three models at the [-3,+3] event window, relative to actual dates of green bond issuance announcements (in days), where t=0 on the day of the announcement. [15] By reporting the differences in average CARs computed in CAPM-adjusted model (Panel A), Fama-French 3 factor model (Panel B) and Fama-French 5 factor model (Panel C) across subsamples split by the presence of *GREEN INTERLOCK*, *FULL INTERLOCK* and based on the top versus bottom terciles of *GREEN NETWORK*, *FULL NETWORK* and full centrality measures), we investigate the drivers of the green bond issuance effect on firm wealth from the perspective of network. Across the three models, we find consistently greater CARs for issuers with a green interlock with previous green bond issuers (*GREEN INTERLOCK*), larger green network (*GREEN NETWORK*), and higher green centrality rank (*GREENSCORE*). Take CAPM-adjusted results as an example. When we split the sample based on whether the issuer has *GREEN INTERLOCK*, we find an average market reaction of 0.2802% for issuers with a green interlock, and -0.2333% for other firms without green interlocks. The difference in average CARs across the two subsamples is 0.5135% (t=-3), which is statistically significant at the 1% level. Similarly, by splitting the sample based on the top versus bottom terciles of *GREEN NETWORK*, we find that the mean CAR is 0.1387% for firms with larger green network, compared to -0.2333% for firms with smaller green network. Such average CAR difference is again significant at the 5% level. In terms of green centrality measures, the results show a higher average CAR for

[14] The announcement dates for green bonds are collected from Bloomberg, and we search on Thomson Eikon and the issuer company's websites to fill the gap in any missing announcement dates, followed by Tang & Zhang (2020).
[15] Unreported results using alternative event windows such as [-5,+5] produce similar results.

issuers with higher green centrality rank (0.1371%) than those for issuers with lower green centrality (-0.1007%), which are statistically significant at the 10% level or above. In the Fama-French 5 factor model, there are also greater CARs observed for issuers with higher green interlocks, network size and centrality rank than those without green interlocks and/or in lower green rank. By contrast, we do not find a consistently and statistically significant difference in mean CARs across the subsamples split by the presence of full interlock and three measures of full network and centrality positions (*FULL INTERLOCK*, *FULL NETWORK, FULL BETWEEN* and *FULL EIGEN*). Nevertheless, akin to the finding of green centrality rank (*GREEN SCORE*), issuers in a higher full centrality rank (*FULL NSCORE*) also exhibit greater CARs than those in a lower rank.

[Insert Figure 3 here]

Fig.3 shows the evolution of CARs computed using four asset pricing models (CAPM-adjusted, Fama-French 3 factor, Fama-French 3 factor and momentum and Fama-French 5 factor models) within a [-15,+15] event window, separated for the issuers with a green interlock or in the top tercile of green network size (green line) and those without an interlock or (blue line) in the lower tercile of network size (red line). The figure shows a sharp difference over the event window, approx. 0.5% between the two groups of observations split by the presence of *GREEN INTERLOCK* and greater than 2% between two groups split by the size of green network (*GREEN NETWORK*). CAPM-adjusted CARs for issuers without a green interlock are declining below zero over time, while those for issuers with an interlock appear to fluctuate around zero. As opposed to issuers in a lower tercile of network size with falling CAPM-adjusted CARs over the window, issuers with greater network size display increasing patterns in CARs. In the other three models, interlocked issuers (with a larger network size) exhibit faster-growing CARs than non-interlocked issuers (with a smaller size). These findings suggest that whilst it is still disputable that issuing green bonds is valued by investors as a value-enhancing practice (either fluctuating CARs or declining CARs to below zero in our results), green bonds issued by firms connected with previous issuers display consistently greater firm value over time in different models.

[Insert Table 11 here]

7.2 Issuer network, Green Bond Issuances, and Firm Value

In this section, we investigate whether the univariate results in Table 10 are robust to a multivariate regression analysis where we control for firm financials and year, industry and region fixed effects for the public firm sample. We estimate regressions of CARs for the public firm sample following the OLS specification below:

$$CARs_{j,t} = \beta_0 + \beta_1\ Interlock\ and\ network\ measures_{jt} + \beta_3\ Issuer\ Controls_{jt} + Country\ Dummies + Industry\ Dummies + Year\ Dummies + \varepsilon_{jt} \quad \text{Eq.[10]}$$

Where the dependent variable $CARs_{it}$ is the cumulative abnormal returns for issue j in year t, calculated using CAPM market-adjusted models over the estimation windows of [-3,+3]. [16] $Interlock\ and\ network\ measures_{jt}$ indicates the respective interlock and network centrality measures for issuer j in year t and ε_{jt} is a random error term.

The results from these regressions are reported in Table 11. Consistent with univariate analysis, we find that *GREEN INTERLOCK* and *GREEN NETWORK* are positively associated with the firm value (measured by CARs) generated by the green bond issuances, significant at the 5% level or above. Furthermore, *GREEN SCORE* and *GREEN BETWEEN* both have a significantly positive effect on the firm value at the 1% and 10% level, respectively. Although *FULL NETWORK* appears to have a positive influence on the firm value as evidenced by the positive coefficient at the 1% significance level, other full centrality measures and ranks do not speak to consistent findings.

8 Green Network, Green Bond Issuances, and Issuance Costs

In this section, we test whether green and full network measures influence the issuance costs associated with green bonds, in other words, whether green bond investors consider network characteristics as a mechanism to lower information asymmetry during the issuance process. We examine this effect in the formula below by investigating two types of issuance costs: yield spreads and gross spreads.

$$YIELDSPREAD_{jt}\ or\ GROSS\ SPREAD_{jt} = \beta_0 + \beta_1\ Interlock\ and\ network\ measures_{jt} + \beta_3 Bond\ Controls_{jt} + Country\ Dummies + Industry\ Dummies + Year\ Dummies + Company\ Type\ Dummies + \varepsilon_{jt} \quad \text{Eq.[11]}$$

Where $YIELDSPREAD_{it}$ is measured as the yield spread in percentage calculated as the difference between the yield on issue for green bond j issued at year t and the comparable Treasury yield on the closest date with similarity. $GROSS\ SPREAD_{jt}$ is measured as the fees paid to underwriter as a fraction of the offering price, collected from Thomson Eikon. ε_{jt} is a random error term.

[16] For the sake of brevity, we report models with the dependent variable as CARs estimated via CARM approach only.

[Insert Table 12 here]

8.1 Yield spreads

Following Flammer (2021), we collect the yield on the issue date from Bloomberg, which reflects the price that the bond is offered on the pricing date, indicative of the financing burden on the issuers. Yield spread, calculated as the difference between the yield on issue for green bond j issued at year t and the comparable Treasury yield on the closest date with similarity, is a proxy for the cost of green bond financing (see e.g., Anderson et al., 2004; Ge & Liu, 2015). We utilize two subsamples of green bond issues: first-time issues and all issues from unique bond issuers. Table 12 reports the OLS results of the effect of issuer interlock and network (Panel A) and green and full centrality measures (Panel B) on the yield spreads. Controlling for bond characteristics, such as *RATING*, *MATURITY* and *AMTISSUED*, we find that firms with a *GREEN INTERLOCK* can lower their costs of green bond financing, especially for their first-time issues with a greater coefficient at the 5% significance level (in column 1) than bonds including subsequent issues. In a similar manner, firms with a larger *GREEN NETWORK* and *FULL NETWORK* are also associated with lower yield spreads of first-time green bonds (Columns 2 and 3), which does not hold when containing subsequent issues in the sample of all bonds (Columns 6 and 7). The magnitude of the effects for first-time issues is larger than those for all unique issues, which is consistent with the notion that the effect on first-time green bond issues tends to be more significant (Flammer, 2021).

In terms of issuer's centrality measures, the findings in Panel B of Table 12 suggest that a higher quintile rank in both green and full centrality, measured by *GREEN SCORE* and *FULL NSCORE,* as well as higher centralities measured by *GREEN BETWEEN* and *FULL BETWEEN* contribute to a lower cost of first-time green bond financing, captured by yield spreads. The effects are larger than that of subsequent bonds. We do not find a negative effect of centralities measured by eigenvector.

[Insert Table 13 here]

8.2 Gross Spread

We also proxy the cost of green bond issuances for Gross Spread, defined as the fees paid to underwriter as a fraction of the offering price. Table 13 presents the regression results of the effect of interlock and centrality measures on the gross spreads of green bond issues. A statistically significant (at the 1% level) and positive coefficient (-0.2318) of *GREEN INTERLOCK* on the gross spreads is documented in Column (1). Despite that the effect of *FULL NETWORK* is not statistically significant, there is a 5% significantly positive association between *FULL INTERLOCK* and the cost of green bonds with the coefficient of -0.1717. Quintile ranks of green centralities and betweenness centralities also have a significant and positive impact on the gross spreads of green bond financing. Overall, our findings suggest that firms with a green interlock and higher centrality positions can have a lower cost of green bond financing.

9 Conclusion

The empirical findings in this paper show that past experiences that can be transmitted across the connections via shared directors or executives or officials (government institutions only) in the firm network contribute to the spread of green bond issuances. Utilizing a sample of 793 Northern American and European green bond issuers between 2013 and 2021, we find that issuers that have interlocks with previous green bond issuers are approximately 20% more likely to issue green bonds. The quintile ranks of issuer green centrality and specific centrality positions measured by degree, betweenness and eigenvector are positively associated with the propensity of green bond issuances. However, we do not find consistent evidence on the relation between connections with all issuers in our entire sample and the firm inclination to issue green bonds. To address the concerns of endogeneity and reverse causality, we test alternative hypotheses of the employee-firm matching and issuer stacking, employ size-adjusted network and centrality measures, and estimate a 2SLS model with the instruments as deaths and sudden departure of employees. These robustness checks confirm our baseline findings.

To scrutinize further the underlying channels of this transmission, we further document that the positive effect of green interlock and network on the propensity of green bond issuances is more pronounced for firms connected with previous issuers with greater CSR commitment, which demonstrates that the spillover of CSR dedication appears to be a driver of the spread of green bond issuances.

Furthermore, we explore possible channels through which green network and centrality benefit issuers. Additional analysis on the CARs and issuance costs captured by yield spreads and gross spreads shows that issuer green interlocks and centrality positions are positively associated with firm value (measured by CARs) and adversely related to issuance costs, demonstrating that the issuance of green bonds can be a value-enhancing and cost-efficient practice for issuers with green networks. Future research can be conducted into the conduits of firm network in developing financial policies and value implications of social imitations for organizations.

References

Acharya, V., & Xu, Z. (2017). Financial dependence and innovation: The case of public versus private firms. *Journal of Financial Economics*, *124*(2), 223–243. https://doi.org/10.1016/j.jfineco.2016.02.010

Amin, A., Chourou, L., Kamal, S., Malik, M., & Zhao, Y. (2020). It's who you know that counts: Board connectedness and CSR performance. *Journal of Corporate Finance*, *64*, 101662. https://doi.org/10.1016/j.jcorpfin.2020.101662

Anderson, R. C., Mansi, S. A., & Reeb, D. M. (2004). Board characteristics, accounting report integrity, and the cost of debt. *Journal of Accounting and Economics*, *37*(3), 315–342. https://doi.org/10.1016/j.jacceco.2004.01.004

Benson, B. W., Iyer, S. R., Kemper, K. J., & Zhao, J. (2018). Director Networks and Credit Ratings. *Financial Review*, *53*(2), 301–336. https://doi.org/10.1111/fire.12157

Bizjak, J., Lemmon, M., & Whitby, R. (2009). Option Backdating and Board Interlocks. *The Review of Financial Studies*, *22*(11), 27.

Bonacich, P. (1972). Factoring and weighting approaches to status scores and clique identification. *The Journal of Mathematical Sociology*, *2*(1), 113–120. https://doi.org/10.1080/0022250X.1972.9989806

Bonacich, P. (1987). Power and Centrality: A Family of Measures. *American Journal of Sociology*, *92*(5), 1170–1182. https://doi.org/10.1086/228631

Brown, J. L. (2011). The Spread of Aggressive Corporate Tax Reporting: A Detailed Examination of the Corporate-Owned Life Insurance Shelter. *The Accounting Review*, *86*(1), 23–57. https://doi.org/10.2308/accr.00000008

Burt, R. S. (1980). Cooptive Corporate Actor Networks: A Reconsideration of Interlocking Directorates Involving American Manufacturing. *Administrative Science Quarterly*, *25*(4), 557–582. JSTOR. https://doi.org/10.2307/2392281

Cai, Y. (2012). Board connections and M&A transactions. *Journal of Financial Economics*, 23.

Cai, Y., Dhaliwal, D. S., Kim, Y., & Pan, C. (2014). Board interlocks and the diffusion of disclosure policy. *Review of Accounting Studies*, *19*(3), 1086–1119. https://doi.org/10.1007/s11142-014-9280-0

Cai, Y., Xu, J., & Yang, J. (2021). Paying by Donating: Corporate Donations Affiliated with Independent Directors. *The Review of Financial Studies*, *34*(2), 618–660. https://doi.org/10.1093/rfs/hhaa056

Chang, C.-H., & Wu, Q. (2021). Board Networks and Corporate Innovation. *Management Science*, *67*(6), 3618–3654. https://doi.org/10.1287/mnsc.2020.3587

Chiu, P.-C., Teoh, S. H., & Tian, F. (2013). Board Interlocks and Earnings Management Contagion. *The Accounting Review*, 30.

Chuluun, T., Prevost, A., & Puthenpurackal, J. (2014). Board Ties and the Cost of Corporate Debt: Board Ties and the Cost of Corporate Debt. *Financial Management*, *43*(3), 533–568. https://doi.org/10.1111/fima.12047

Cicchiello, A. F., Cotugno, M., Monferrà, S., & Perdichizzi, S. (2022). Which are the factors influencing green bonds issuance? Evidence from the European bonds market. *Finance Research Letters*, *50*, 103190. https://doi.org/10.1016/j.frl.2022.103190

Cohen, L., Frazzini, A., & Malloy, C. (2008). The Small World of Investing: Board Connections and Mutual Fund Returns. *Journal of Political Economy*.

Coles, J. L., Wang, A. Y., & Zhu, C. (2015). *Director network and CEO turnover*. University of Utah working paper.

Daubanes, J. X., Mitali, S. F., & Rochet, J.-C. (2021). Why do firms issue green bonds? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3996238

Davis, G. F. (1991). Agents without Principles? The Spread of the Poison Pill through the Intercorporate Network. *Administrative Science Quarterly*, *36*(4), 583–613. JSTOR. https://doi.org/10.2307/2393275

Davis, G. F., & Greve, H. R. (1997). Corporate Elite Networks and Governance Changes in the 1980s. *American Journal of Sociology*, *103*(1), 1–37. https://doi.org/10.1086/231170

Dutordoir, M., Li, S., & Quariguasi Frota Neto, J. (2022). Determinants of Firms' Choice between Green and Conventional Bonds: Why is the Corporate Green Bond Market Still so 'Green'? *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4156431

Engelberg, J., Gao, P., & Parsons, C. A. (2012). Friends with money. *Journal of Financial Economics*, *103*(1), 169–188. https://doi.org/10.1016/j.jfineco.2011.08.003

Engelberg, J., Gao, P., & Parsons, C. A. (2013). The Price of a CEO's Rolodex. *The Review of Financial Studies*, *26*(1), 79–114. https://doi.org/10.1093/rfs/hhs114

Fama, E. F. (1980). Agency Problems and the Theory of the Firm. *Journal of Political Economy*, *88*(2), 288–307. https://doi.org/10.1086/260866

Fernandes, N., Ferreira, M. A., Matos, P., & Murphy, K. J. (2013). Are U.S. CEOs Paid More? New International Evidence. Review of Financial Studies, 26(2), 323–367. https://doi.org/10.1093/rfs/hhs122

Flammer, C. (2021). Corporate green bonds. *Journal of Financial Economics*, *142*(2), 499–516. https://doi.org/10.1016/j.jfineco.2021.01.010

Fracassi, C. (2017). Corporate Finance Policies and Social Networks. *Management Science*, *63*(8), 2420–2438. https://doi.org/10.1287/mnsc.2016.2433

Freeman, L. C. (1977). A Set of Measures of Centrality Based on Betweenness. *Sociometry*, *40*(1), 35–41. https://doi.org/10.2307/3033543

García, C. J., Herrero, B., Miralles-Quirós, J. L., & del Mar Miralles-Quirós, M. (2023). Exploring the determinants of corporate green bond issuance and its environmental implication: The role of corporate board. *Technological Forecasting and Social Change*, *189*, 122379. https://doi.org/10.1016/j.techfore.2023.122379

Ge, W., & Liu, M. (2015). Corporate social responsibility and the cost of corporate bonds. *Journal of Accounting and Public Policy*, *34*(6), 597–624. https://doi.org/10.1016/j.jaccpubpol.2015.05.008

Han, J., Hu, N., Liu, L., & Tian, G. (2017). Does director interlock impact the diffusion of accounting method choice? *Journal of Accounting and Public Policy*, *36*(4), 316–334. https://doi.org/10.1016/j.jaccpubpol.2017.05.005

Haunschild, P. R., & Beckman, C. M. (1998). When Do Interlocks Matter?: Alternate Sources of Information and Interlock Influence. *Administrative Science Quarterly*, *43*(4), 815–844. JSTOR. https://doi.org/10.2307/2393617

Helmers, C., Patnam, M., & Rau, P. R. (2017). Do board interlocks increase innovation? Evidence from a corporate governance reform in India. *Journal of Banking & Finance*, *80*, 51–70. https://doi.org/10.1016/j.jbankfin.2017.04.001

Hyun, S., Park, D., & Tian, S. (2020). The price of going green: The role of greenness in green bond markets. *Accounting & Finance*, *60*(1), 73–95. https://doi.org/10.1111/acfi.12515

Hyun, S., Park, D., & Tian, S. (2021). Pricing of green labeling: A comparison of labeled and unlabeled green bonds. *Finance Research Letters*, *41*, 101816. https://doi.org/10.1016/j.frl.2020.101816

ICMA. (2021). Green Bond Principles. https://www.icmagroup.org/assets/documents/Sustainable-finance/2021-updates/Green-Bond-Principles-June-2021-140621.pdf

Johansen, T. R., & Pettersson, K. (2013). The Impact of Board Interlocks on Auditor Choice and Audit Fees. *Corporate Governance: An International Review*, *21*(3), 287–310. https://doi.org/10.1111/corg.12013

Kang, E. (2008). Director Interlocks and Spillover Effects of Reputational Penalties From Financial Reporting Fraud. *Academy of Management Journal*, *51*(3), 537–555. https://doi.org/10.5465/amj.2008.32626007

Larcker, D. F., So, E. C., & Wang, C. C. Y. (2013). Boardroom centrality and firm performance. *Journal of Accounting and Economics*, *55*(2–3), 225–250. https://doi.org/10.1016/j.jacceco.2013.01.006

Lin, B., & Su, T. (2022). Green bond vs conventional bond: Outline the rationale behind issuance choices in China. *International Review of Financial Analysis*, *81*, 102063. https://doi.org/10.1016/j.irfa.2022.102063

Lu, J., Yu, D., Mahmoudian, F., Nazari, J. A., & Herremans, I. M. (2021). Board interlocks and greenhouse gas emissions. *Business Strategy and the Environment*, *30*(1), 92–108. https://doi.org/10.1002/bse.2611

Martin, G., Gözübüyük, R., & Becerra, M. (2015). Interlocks and firm performance: The role of uncertainty in the directorate interlock-performance relationship. *Strategic Management Journal*, *36*(2), 235–253. https://doi.org/10.1002/smj.2216

Mertzanis, C., & Tebourbi, I. (2023). National culture and green bond issuance around the world. *European Financial Management*, eufm.12419. https://doi.org/10.1111/eufm.12419

Mizruchi, M. S. (1996). What Do Interlocks Do? An Analysis, Critique, and Assessment of Research on Interlocking Directorates. *Annual Review of Sociology*, *22*(1), 271–298. https://doi.org/10.1146/annurev.soc.22.1.271

Nandy, M., Lodh, S., Kaur, J., & Wang, J. (2020). Impact of directors' networks on corporate social responsibility: A cross country study. *International Review of Financial Analysis*, *72*, 101601. https://doi.org/10.1016/j.irfa.2020.101601

Omer, T. C., Shelley, M. K., & Tice, F. M. (2020). Do Director Networks Matter for Financial Reporting Quality? Evidence from Audit Committee Connectedness and Restatements. *Management Science*, *66*(8), 3361–3388. https://doi.org/10.1287/mnsc.2019.3331

Palmer, D. A., Jennings, P. D., & Zhou, X. (1993). Late Adoption of the Multidivisional Form by Large U.S. Corporations: Institutional, Political, and Economic Accounts. *Administrative Science Quarterly*, *38*(1), 100–131. JSTOR. https://doi.org/10.2307/2393256

Pfeffer, J. (1972). Size and Composition of Corporate Boards of Directors: The Organization and its Environment. *Administrative Science Quarterly*, *17*(2), 218. https://doi.org/10.2307/2393956

Qiu, X., Su, Z., & Xiao, Z. (2019). Do social ties matter for corporate bond yield spreads? Evidence from China. *Corporate Governance: An International Review*, *27*(6), 427–457. https://doi.org/10.1111/corg.12294

Reppenhagen, D. A. (2010). Contagion of accounting methods: Evidence from stock option expensing. *Review of Accounting Studies*, *15*(3), 629–657. https://doi.org/10.1007/s11142-010-9128-1

Shive, S. A., & Forster, M. M. (2020). Corporate Governance and Pollution Externalities of Public and Private Firms*. *The Review of Financial Studies*, *33*(3), 1296–1330. https://doi.org/10.1093/rfs/hhz079

Sinha, A., Mishra, S., Sharif, A., & Yarovaya, L. (2021). Does green financing help to improve environmental & social responsibility? Designing SDG framework through advanced quantile modelling. *Journal of Environmental Management*, *292*, 112751. https://doi.org/10.1016/j.jenvman.2021.112751

Skousen, C. J., Song, X. (Jason), & Sun, L. (2018). CEO network centrality and bond ratings. *Advances in Accounting*, *40*, 42–60. https://doi.org/10.1016/j.adiac.2017.12.003

Stuart, T. E., & Yim, S. (2010). Board interlocks and the propensity to be targeted in private equity transactions. *Journal of Financial Economics*, 16.

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? *Journal of Corporate Finance*, *61*, 101427. https://doi.org/10.1016/j.jcorpfin.2018.12.001

Useem, M. (1984), The Inner Circle: Large Corporations and the Rise of Business Political Activity in the US and UK, Oxford University Press, New York, NY.

Wang, C., Xie, F., & Zhu, M. (2015). Industry Expertise of Independent Directors and Board Monitoring. *Journal of Financial and Quantitative Analysis*, *50*(5), 929–962. https://doi.org/10.1017/S0022109015000459

Wang, C.-W., Wu, Y.-C., Hsieh, H.-Y., Huang, P.-H., & Lin, M.-C. (2022). Does green bond issuance have an impact on climate risk concerns? *Energy Economics*, *111*, 106066. https://doi.org/10.1016/j.eneco.2022.106066

Wei, P., Li, Y., & Zhang, Y. (2022). Corporate green bonds and carbon performance: An economic input–output life cycle assessment model-based analysis. *Business Strategy and the Environment*, bse.3267. https://doi.org/10.1002/bse.3267

Zerbib, O. D. (2019). The effect of pro-environmental preferences on bond prices: Evidence from green bonds. *Journal of Banking & Finance*, *98*, 39–60. https://doi.org/10.1016/j.jbankfin.2018.10.012

Fig.1. An illustrated example of the calculation of firm green networks for Alandsbanken Abp in 2021

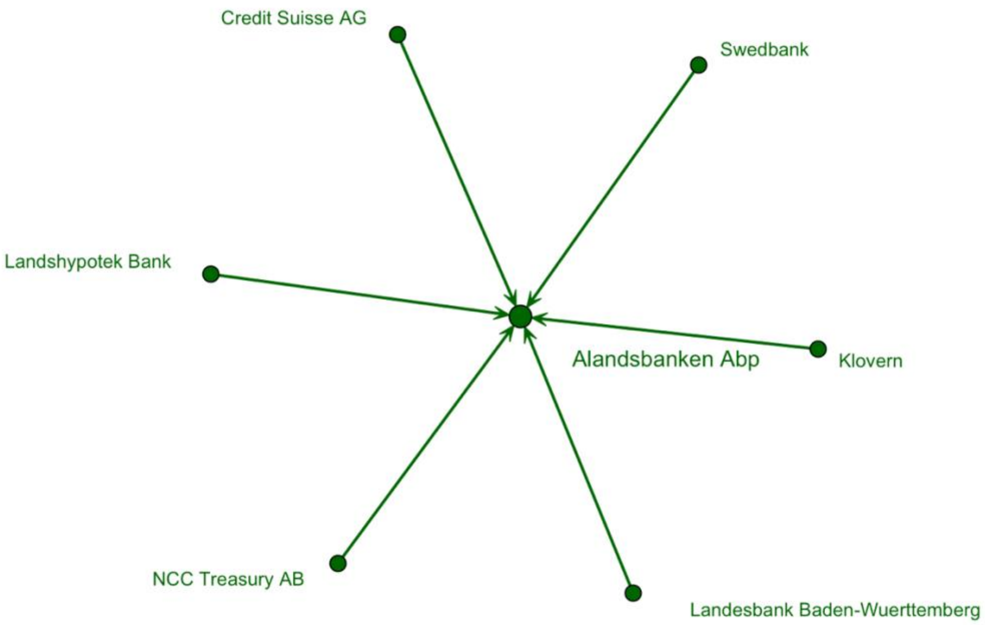

Fig.2. Migrated employees

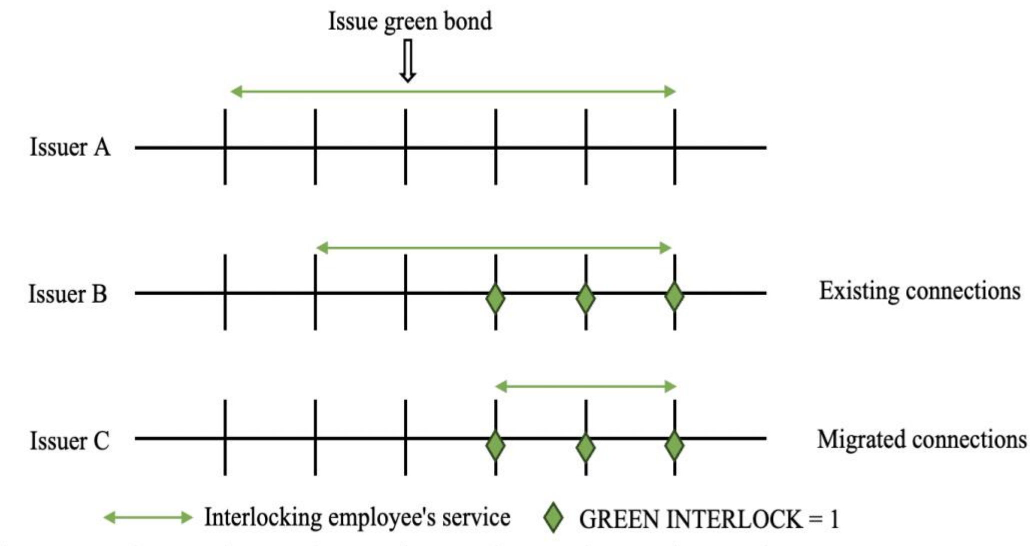

Fig.3 Cumulative abnormal returns (CARs) (%) for green interlocked (top green connected) firms versus non-interlocked (lower connected) firms around green bond issuances

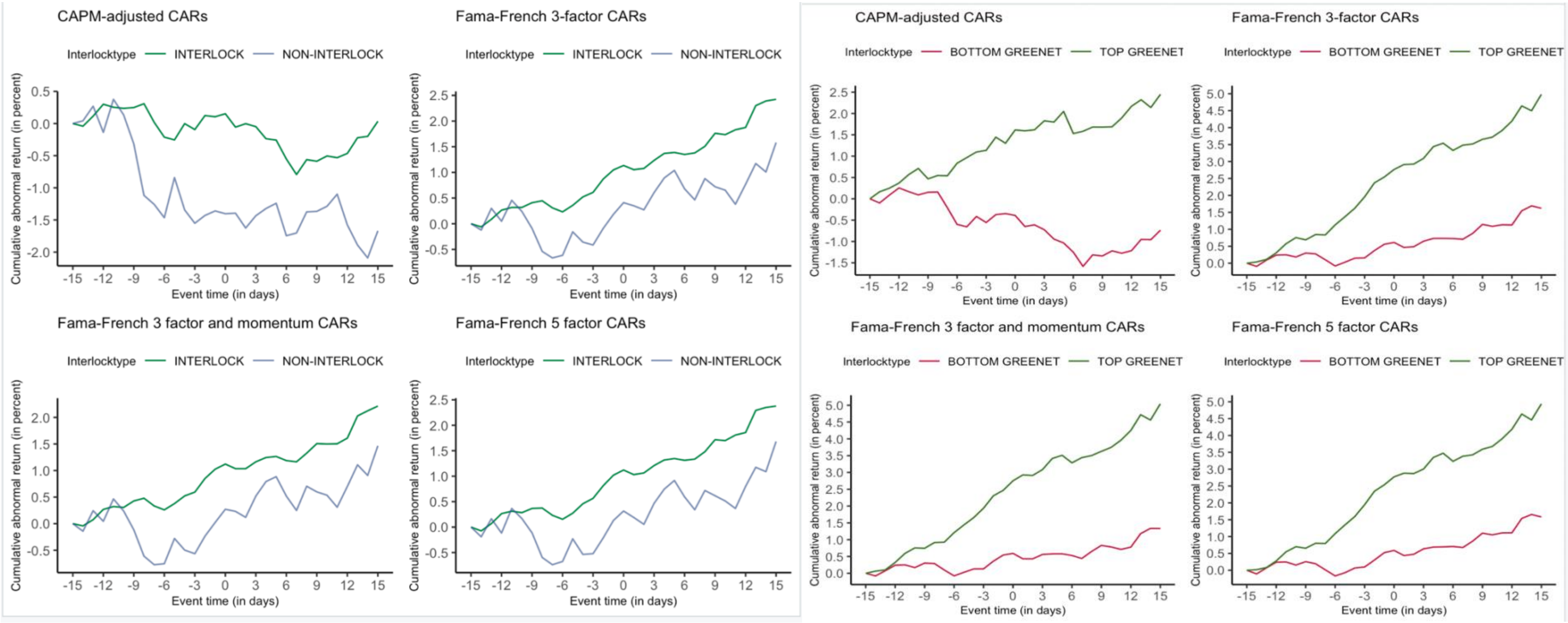

Table 1: Summary statistics comparing issuer links of green bond issuers and non-green-issuers

Table 1, Panel A and B presents the average number of public and private firm links that firms have to other issuers (including government institutions, private and public firms) in our sample and the percentage and number of firm links to previously green bond issuers. Panel A presents the number of new firm issuers starting to issue green bonds each year (New green issuers), the cumulative number of green bond issuers each year (N), the percentage (%Links) and average number of links (Avg links) to other issuers in our sample, and the percentage (%Green links) and average number of links to other issuers in our sample that have issued green bonds in previous years (Avg green links). Panel B presents the same statistics for public and private firms that are in the sample in a given year, but have not issued green bonds. Firms who have issued green bonds will be dropped from the subsequent years. Panel C reports the summary statistics of network and financial characteristics for respective public and private firms.

	Panel A: Green bond issuers						**Panel B: Non-green-bond issuers**				
Year	New green issuers	N	%Link	Avg links	%Green links	Avg green links	Non-green issuers	%Link	Avg links	%Green links	Avg green links
PUBLIC											
2013	2		100.00	10.00	50.00	1.50	287	68.99	6.40	14.29	0.19
2014	9	11	88.89	9.78	88.89	6.44	278	69.78	6.38	25.54	0.37
2015	9	20	55.56	9.78	66.67	6.89	269	72.86	6.47	32.71	0.55
2016	11	31	81.82	10.91	90.91	7.18	258	73.64	6.83	41.09	0.79
2017	22	53	90.91	8.55	90.91	6.36	236	72.03	6.82	44.92	1.00
2018	24	77	75.00	10.50	75.00	7.00	212	72.17	6.67	50.47	1.34
2019	45	122	91.11	10.04	91.11	6.98	167	68.86	5.95	55.69	1.76
2020	66	188	71.21	7.12	81.82	4.98	101	72.28	6.16	67.33	2.27
2021	101	289	73.27	6.73	73.27	4.40					
PRIVATE											
2013	6		100.00	7.33	50.00	1.67	498	48.39	4.25	9.04	0.15
2014	20	26	55.00	5.00	55.00	3.25	478	49.58	4.34	12.76	0.25
2015	24	50	50.00	5.58	66.67	3.79	454	50.44	4.48	18.72	0.40
2016	28	78	46.43	4.21	64.29	2.68	426	52.82	4.78	24.88	0.58
2017	44	122	59.09	4.36	63.64	2.80	382	53.93	5.06	30.89	0.86
2018	48	170	68.75	7.63	75.00	4.98	334	52.69	4.74	33.23	1.05
2019	93	263	58.06	6.13	61.29	3.95	241	49.79	4.33	39.83	1.31
2020	96	359	52.08	4.06	53.13	2.51	145	49.66	4.81	40.69	1.71
2021	145	504	51.03	5.08	51.03	3.41					
Total	793						4766				

Panel C: Network and financial characteristics

	Public firms								Private firms							
Variable	**N**	**Mean**	**SD**	**Median**	**Min**	**Q1**	**Q3**	**Max**	**N**	**Mean**	**SD**	**Median**	**Min**	**Q1**	**Q3**	**Max**
GREEN ISSUE	2097	0.138	0.345	0	0	0	0	1	3462	0.146	0.353	0	0	0	0	1
Firm network measures																
GREEN INTERLOCK	2097	0.435	0.496	0	0	0	1	1	3462	0.282	0.45	0	0	0	1	1
GREEN NETWORK	2097	1.517	84.866	0	0	0	2	56	3462	1.05	246.634	0	0	0	1	111
FULL NETWORK	2097	6.739	400.665	4	0	3	10	88	3462	4.691	1367.921	2	0	0	4	168
FULL INTERLOCK	2097	0.722	0.448	1	0	0	1	1	3462	0.516	0.5	1	0	0	1	1
GREEN BETWEEN	2097	136.427	805040.437	0	0	0	0	2908.577	3462	50.376	383505.034	0	0	0	0	2976.55
FULL BETWEEN	2097	333.432	1372362.317	1	0	0	442.201	2939.355	3462	135.681	711149.943	0	0	0	10.707	2999.737
GREEN EIGEN	2097	0.024	0.042	0	0	0	0.023	1	3462	0.019	0.045	0	0	0	0.001	1
FULL EIGEN	2097	0.038	0.037	0.001	0	0	0.032	0.86	3462	0.026	0.068	0	0	0	0.004	1
Financial Controls																
AT (in log)	1797	9.335	45.083	9.231	2.275	7.814	10.749	14.565	1616	8.883	37.941	8.734	0.483	7.552	10.142	13.798
ROA	1797	0.034	0.01	0.033	-0.273	0.009	0.055	0.213	1616	0.032	0.006	0.029	-0.102	0.004	0.05	0.252
LEV	1797	0.35	0.133	0.341	0	0.218	0.473	0.79	1616	0.446	0.249	0.408	0	0.273	0.61	1.013
DEBT MAT	1797	0.737	0.293	0.808	0.006	0.62	0.924	1	1616	0.761	0.294	0.843	0	0.663	0.935	1
TANGIBILITY	1797	0.263	0.262	0.11	0	0.006	0.487	0.968	1616	0.414	0.341	0.42	0	0.004	0.794	0.988
FIRM AGE	1797	75.284	12253.128	53	0.3	20	124	237.43	1616	63.869	9432.236	45	0.5	17	110	198
MTB	1797	1.67	17.465	1.135	0.026	0.839	1.892	11.754								
Governance Controls																
BOARD SIZE	955	13.229	478.888	12	2	9	16	78	721	21.103	1089.716	16	2	10	26	75
%INDEP	955	0.585	0.314	0.647	0	0.4	0.833	1	721	0.25	0.276	0.106	0	0	0.429	1
CEOTENURE	955	5.885	84.486	5.3	0	2	8.9	24.9	721	6.995	73.404	7.003	0	3.707	10.005	29.3
%INST	955	0.308	0.223	0.249	0	0.145	0.419	0.997								

Table 2: Summary statistics for private and public firms
This table presents the number of non-green-bond issuer-year (Non-Green) observations and green-bond issuer-year (Green) observations by country and one-digit SIC industrial classification.

	PRIVATE		PUBLIC	
	Non-Green	**Green**	**Non-Green**	**Green**
Austria	42	7	55	9
Belgium	38	6	49	7
Bermuda	15	2	35	7
Canada	109	18	87	14
Denmark	59	10	28	5
Estonia	2	1		
Finland	62	10	57	8
France	210	40	105	22
Germany	227	40	159	24
Greece	10	2	31	4
Guernsey			7	1
Hungary	88	12	24	3
Iceland	19	3	22	3
Ireland	25	4	15	2
Italy	91	16	76	14
Jersey	8	1		
Latvia	14	3		
Lithuania	8	1	10	2
Luxembourg	104	16	22	3
Netherlands	245	44	42	7
Norway	300	48	124	18
Poland	20	3	35	5
Portugal	34	5	13	2
Russia	27	4	15	2
Slovenia	9	2		
Spain	139	23	107	16
Sweden	290	56	239	40
Switzerland	120	18	59	9
Ukraine	15	2		
United Kingdom	211	33	89	15
United States	417	74	303	47
Total	2958	504	1808	289

One-digit SIC		**Non-Green**	**Green**
Agriculture, Forestry and Fishing	PRIVATE	23	3
	PUBLIC	8	1
Mining and Construction	PRIVATE	73	13
	PUBLIC	85	12
Manufacturing	PRIVATE	115	18
	PUBLIC	329	53
Transportation and Communications	PRIVATE	726	126
	PUBLIC	332	60
Trade	PRIVATE	52	8
	PUBLIC	30	4
Finance, Insurance and Real Estate	PRIVATE	1743	296
	PUBLIC	958	150
Services	PRIVATE	195	34
	PUBLIC	45	6
Public Administration	PRIVATE	31	6
	PUBLIC	21	3
Total		4766	793

Table 3: Firm interlocks and the propensity of green bond issuances

This table presents the multiperiod logit regression results in examining the effect of green interlock (*GREEN INTERLOCK*), network (*GREEN NETWORK*), full network (*FULL NETWORK*) and interlock (*FULL INTERLOCK*) on the propensity of green bond issuances for private and public firms. Dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Detailed descriptions of independent and control variables are provided in the Appendix. Standard errors clustered by industry and year are reported in parentheses and marginal effects are reported in square brackets. We drop firms from the sample in future years after the year they issue green bonds at the first time. For the sake of brevity, we do not report marginal effects for control variables. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GREEN INTERLOCK	1.5153***				1.5130***			
	(0.1148)				(0.1526)			
	[0.1999]				[0.2024]			
GREEN NETWORK		1.3380***				1.7400***		
		(0.0741)				(0.1090)		
		[0.1397]				[0.1967]		
FULL NETWORK			0.1939***				0.0853	
			(0.0486)				(0.0714)	
			[0.0234]				[0.0115]	
FULL INTERLOCK				0.2743**				-0.1075
				(0.1086)				(0.1519)
				[0.0327]				[-0.0147]
AT					0.1078***	-0.0635	0.1774***	0.2059***
					(0.0384)	(0.0427)	(0.0408)	(0.0387)
ROA					-2.6310*	-1.7500	-2.2390	-2.2510
					(1.5000)	(1.5580)	(1.4690)	(1.4760)
LEV					1.0300***	1.2000***	1.1130***	1.1330***
					(0.3171)	(0.3469)	(0.3065)	(0.3062)
DEBT MAT					0.1298	0.3160	0.1378	0.1550
					(0.2891)	(0.3100)	(0.2837)	(0.2845)
TANGIBILITY					0.2613	0.3301	0.2928	0.2891
					(0.2248)	(0.2366)	(0.2208)	(0.2215)
FIRM AGE					-0.0031**	-0.0027*	-0.0027**	-0.0026**
					(0.0013)	(0.0014)	(0.0013)	(0.0013)
Constant	-6.0488***	-6.9927***	-6.7138***	-7.0465***	-7.1760***	-5.2060***	-7.9630***	-8.1000***
	(1.1481)	(1.1391)	(1.1747)	(1.1399)	(1.3260)	(1.2990)	(1.2760)	(1.2710)
Year	YES	YES	YES	YES	YES	YES	YES	YES
Company Type	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES	YES	YES
N	5,559	5,559	5,559	5,559	3,413	3,413	3,413	3,413
Pseudo R-squared	38.94%	41.53%	36.16%	36.07%	39.97%	47.01%	36.30%	36.27%

Table 4: Network centrality and the propensity of green bond issuances

This table presents the multiperiod regression estimations for private and public firms without controls (Columns 1-6) and with controls (Columns 7-12) in examining the effect of green and full network centrality measures on the propensity of green bond issuances. Dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Detailed descriptions of other variables are provided in the Appendix. Standard errors clustered by industry and year are reported in parentheses and marginal effects are reported in square brackets. For the sake of brevity, we do not report marginal effects for control variables. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GREEN SCORE	0.1279***						0.1929***					
	(0.0363)						(0.0484)					
	[0.0155]						[0.0257]					
FULL NSCORE		0.0434						0.1223*				
		(0.0373)						(0.0528)				
		[0.0053]						[0.0164]				
GREEN BETWEEN			0.3015***						0.3229***			
			(0.0201)						(0.0256)			
			[0.0337]						[0.0395]			
FULL BETWEEN				0.0639***						0.0288		
				(0.0182)						(0.0238)		
				[0.0077]						[0.0039]		
GREEN EIGEN					7.9780***						10.5875***	
					(0.7672)						(1.1060)	
					[0.9312]						[1.3429]	
FULL EIGEN						1.7908**						1.5209
						(0.8937)						(1.1948)
						[0.2181]						[0.2042]
AT							0.1639***	0.2307***	0.0459	0.1815***	0.0973**	0.1843***
							(0.0381)	(0.0399)	(0.0405)	(0.0394)	(0.0392)	(0.0386)
ROA							-2.3666	-2.2648	-2.7250*	-2.3557	-1.3600	-2.1508
							(1.4611)	(1.4870)	(1.5010)	(1.4682)	(1.4809)	(1.4730)
LEV							1.1265***	1.1388***	1.0928***	1.1143***	1.1841***	1.1505***
							(0.3076)	(0.3066)	(0.3244)	(0.3062)	(0.3193)	(0.3071)
DEBT MAT							0.1730	0.1627	0.2903	0.1328	0.4904*	0.1650
							(0.2842)	(0.2845)	(0.2962)	(0.2837)	(0.2955)	(0.2844)
TANGIBILITY							0.2960	0.2756	0.2701	0.2884	0.3279	0.2846
							(0.2213)	(0.2226)	(0.2286)	(0.2209)	(0.2237)	(0.2210)
FIRM AGE							-0.0030**	-0.0025*	-0.0028**	-0.0026**	-0.0028**	-0.0027**
							(0.0013)	(0.0013)	(0.0014)	(0.0013)	(0.0013)	(0.0013)
Constant	-7.2906***	-7.1377***	-6.3396***	-6.9555***	-6.8637***	-6.9672***	-8.2811***	-8.7956***	-6.1549***	-7.9331***	-7.6574***	-8.0444***
	(1.1381)	(1.1466)	(1.1339)	(1.1388)	(1.1388)	(1.1370)	(1.2680)	(1.3132)	(1.2682)	(1.2771)	(1.2770)	(1.2725)
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Company Type	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	5,559	5,559	5,559	5,559	5,559	5,559	3,413	3,413	3,413	3,413	3,413	3,413
Pseudo R-squared	36.08%	37.11%	39.53%	36.12%	37.28%	36.02%	36.80%	36.43%	41.87%	36.30%	39.49%	36.30%

Table 5: Interlock and the propensity of green bond issuances for respective public and private firms

This table presents the multiperiod regression results for respective public firms and private firms in examining the effect of interlock on the propensity of green bond issuances. Dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Detailed descriptions of independent and control variables are provided in the Appendix. Standard errors clustered by industry and year are reported in parentheses and marginal effects are reported in square brackets. For the sake of brevity, we do not report marginal effects for control variables. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	Panel A: Public firms				Panel B: Private firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GREEN INTERLOCK	3.2850***				1.9010***			
	(0.6937)				(0.4524)			
	[0.0342]				[0.0336]			
GREEN NETWORK		4.6890***				2.4190***		
		(0.5377)				(0.3298)		
		[0.0078]				[0.0269]		
FULL NETWORK			0.6520***				0.0552	
			(0.2265)				(0.1758)	
			[0.0097]				[0.0010]	
FULL INTERLOCK				0.8903				-0.1754
				(0.5860)				(0.4538)
				[0.0107]				[-0.003]
AT	0.5617***	0.2911	0.5215***	0.6051***	0.3805***	0.0217	0.4807***	0.5035***
	(0.1520)	(0.1955)	(0.1477)	(0.1439)	(0.1315)	(0.1473)	(0.1365)	(0.1308)
ROA	-9.3640**	-9.7610*	-4.6970	-5.2940	-5.6540	-2.1910	-8.9280	-9.3470
	(4.2680)	(5.2680)	(4.2030)	(4.2450)	(7.2230)	(7.8670)	(7.3720)	(7.3390)
MTB	0.1314	0.1705*	0.0596	0.0783				
	(0.0847)	(0.0978)	(0.0836)	(0.0831)				
LEV	1.0440	2.7450*	1.1290	1.1330	1.8340***	1.7360**	1.8880***	1.9160***
	(1.0330)	(1.5860)	(1.0080)	(0.9938)	(0.7019)	(0.7904)	(0.7059)	(0.7059)
DEBT MAT	0.4629	2.7120**	0.1809	0.1092	0.2245	-0.1278	0.4736	0.5265
	(0.8465)	(1.2300)	(0.8208)	(0.8137)	(0.6528)	(0.7063)	(0.6415)	(0.6443)
TANGIBILITY	1.6660*	2.1550	1.1210	1.0310	1.0940*	1.2390*	0.9962*	0.9828
	(0.9716)	(1.5350)	(0.9486)	(0.9377)	(0.5969)	(0.6725)	(0.5976)	(0.6010)
FIRM AGE	-0.0066*	-0.0035	-0.0059	-0.0055	-0.0031	-0.0009	-0.0027	-0.0027
	(0.0040)	(0.0050)	(0.0038)	(0.0037)	(0.0033)	(0.0035)	(0.0033)	(0.0033)
BOARD SIZE	-0.5726	-0.3270	-0.6333	-0.6691	-0.6912**	-0.6475**	-0.5060*	-0.4691
	(0.5860)	(0.8001)	(0.5299)	(0.5233)	(0.2883)	(0.3124)	(0.2817)	(0.2883)
%INDEP	-0.7759	-1.9990	-0.4015	-0.1155	-1.1790	-2.2160	-0.6570	-0.5540
	(0.7344)	(0.9843)	(0.7079)	(0.6871)	(0.7071)	(0.8238)	(0.6531)	(0.6406)
CEO TENURE	-0.0502	0.3782	-0.0090	-0.0432	0.1527	0.2346	0.1084	0.0949
	(0.2073)	(0.2931)	(0.1994)	(0.1978)	(0.2559)	(0.2855)	(0.2441)	(0.2435)
%INST	-2.1880	-2.7390	-2.2180**	-2.4010*				
	(1.3750)	(1.8360)	(1.3430)	(1.3320)				
Constant	-12.1000***	-14.2800***	-10.7500***	-10.8200***	-8.3830***	-5.9600**	-8.9060***	-8.9190***
	(2.7110)	(3.7800)	(2.5380)	(2.5140)	(2.3880)	(2.5100)	(2.3640)	(2.3600)
Year	YES	YES	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES
N	955	955	955	955	721	721	721	721
Pseudo R-squared	32.74%	60.89%	26.08%	24.89%	32.60%	43.17%	32.60%	32.60%

Table 6: Network centrality and the propensity of green bond issuances for respective public and private firms

This table presents the multiperiod regression estimations for respective public firms and private firms in examining the effect of green and full network centrality measures on the propensity of green bond issuances. Governance control variables are included when conducting regressions, unreported for the sake of brevity. Dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Detailed descriptions of independent and control variables are provided in the Appendix. Standard errors clustered by industry and year are reported in parentheses and marginal effects are reported in square brackets. For the sake of brevity, we do not report control variables. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	Panel A: Public firms						Panel B: Private firms					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GREEN SCORE	1.1710***						0.2849**					
	(0.1809)						(0.1217)					
	[0.0100]						[0.0054]					
FULL NSCORE		-0.0683						0.1531				
		(0.1638)						(0.1298)				
		[-0.0011]						[0.0028]				
GREEN BETWEEN			0.4579***						0.2913***			
			(0.0640)						(0.0621)			
			[0.0049]						[0.0051]			
FULL BETWEEN				0.1201						-0.0629		
				(0.0616)						(0.0596)		
				[0.0019]						[-0.0012]		
GREEN EIGEN					21.3100***						9.2400***	
					(3.3050)						(2.0600)	
					[0.2354]						[0.1523]	
FULL EIGEN						7.0150**						4.7220
						(3.0500)						(2.9160)
						[0.1091]						[0.0872]
Constant	-15.1300***	-10.5600***	-11.1500***	-10.6500***	-10.2900***	-10.9900***	-9.3910***	-9.5740***	-7.9150***	-8.9380***	-8.2420***	-8.4600***
	(2.9130)	(2.5030)	(2.8410)	(2.5070)	(2.6730)	(2.5300)	(2.3700)	(2.4300)	(2.3660)	(2.3640)	(2.4260)	(2.3680)
Controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	955	955	955	955	955	955	721	721	721	721	721	721
Pseudo R-squared	36.90%	24.44%	36.52%	25.15%	35.36%	25.41%	29.60%	28.77%	32.82%	28.72%	32.53%	29.03%

Table 7: Robustness checks

This table presents the multiperiod regression estimations testing the employee-firm matching and board stacking alternative explanations (Panel A) and employing size-adjusted network measures using residual approach (Panel B). The dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Detailed descriptions of independent and control variables are provided in the Appendix. Robust standard errors of coefficients are reported in parentheses and marginal effects are reported in square brackets. Industry, year, region and company type effects are included. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Panel A: Employee-firm matching and board stacking	(1)	(2)	(3)	(4)	(5)
GREEN INTERLOCK (Dif industry)	0.8917***				
	(0.1289)				
	[0.1283]				
GREEN INTERLOCK (Dif industry and country)		0.9763***			
		(0.1317)			
		[0.1385]			
GREEN INTERLOCK			1.9611***	1.5107***	1.3490***
			(0.4564)	(0.1603)	(0.1613)
			[0.1227]	[0.2022]	[0.1803]
Proximity			0.0998		
			(0.1742)		
GREEN INTERLOCK × Migrated				0.7836	
				(0.7766)	
GREEN INTERLOCK × Tenure less than three years					1.2777
					(0.7860)
Migrated				-0.8935	
				(0.7638)	
Tenure less than 3 years					-0.7580
					(0.7744)
Constant	-7.9000***	-7.7500***	-9.4749	-7.2886***	-6.9319***
	(1.3048)	(1.3068)	(10.8600)	(1.3327)	(1.3166)
Controls	YES	YES	YES	YES	YES
Year & Industry & Region & Company Type	YES	YES	YES	YES	YES
N	3,413	3,413	1,076	3,413	3,413
Pseudo R-squared	37.88%	38.15%	17.35%	40.04%	40.36%

Panel B: Size-adjusted network	(1)	(2)	(3)	(4)	(5)	(6)
RESID GREEN NETWORK	1.7220***					
	(0.1090)					
	[0.1964]					
RESID FULL NETWORK		0.0514				
		(0.0718)				
		[0.0069]				
RESID GREEN BETWEEN			0.3169***			
			(0.0256)			
			[0.0390]			
RESID FULL BETWEEN				0.0230		
				(0.0241)		
				[0.0031]		
RESID GREEN EIGEN					10.4700***	
					(1.1310)	
					[1.3322]	
RESID FULL EIGEN						0.6781
						(1.2490)
						[0.0912]
Constant	-7.1830***	-8.0730***	-7.1130***	-8.0430***	-8.3120***	-8.1020***
	(1.2970)	(1.2730)	(1.2640)	(1.2720)	(1.2810)	(1.2730)
Controls	YES	YES	YES	YES	YES	YES
Year & Industry & Region & Company Type	YES	YES	YES	YES	YES	YES
N	3,413	3,413	3,413	3,413	3,413	3,413
Pseudo R-squared	46.66%	36.27%	41.62%	36.28%	39.28%	36.26%

Table 8: IV-2SLS estimations

This table reports regression results of network centrality measures on the likelihood of green bond issuances employing two instrumental variables: retirement and sudden departure of directors or executives. Panel A presents the first-stage regression results while Panel B reports the second-stage regression results. Detailed descriptions of variables are provided in the Appendix. Standard errors clustered by industry and year are reported in parentheses. Industry, year, region, and company type effects are included. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Panel A: First-stage estimations

Dependent variable	GREEN NETWORK	FULL NETWORK	GREEN BETWEEN	FULL BETWEEN	GREEN EIGEN	FULL EIGEN
	(1)	(2)	(5)	(6)	(7)	(8)
RETIRE	-0.0716	-0.1235*	-0.4881**	-0.2468	-0.0114**	-0.0179***
	(0.0495)	(0.0618)	(0.1965)	(0.2000)	(0.0055)	(0.0067)
SUDDEN	-0.3148*	0.5710	1.2149	-0.5691	0.0307	0.0490
	(0.1639)	(0.4295)	(1.2512)	(1.1307)	(0.0198)	(0.0462)
Constant	-0.6978***	-0.8452***	-3.0446***	-3.1657***	-0.0094**	-0.0077*
	(0.0751)	(0.1327)	(0.3324)	(0.2884)	(0.0043)	(0.0044)
Controls	YES	YES	YES	YES	YES	YES
N	3,413	3,413	3,413	3,413	3,413	3,413
Adj R2	0.35	0.43	0.23	0.29	0.27	0.40
Wald F statistics	12.22	21.03	9.0	16.65	18.61	22.77
P values of Wu-Hausman test	0.52	0.27	0.73	0.26	0.58	0.21

Panel B: Second-stage estimations

	(1)	(2)	(3)	(4)	(5)	(6)
FITTED GREEN NETWORK	2.9900**					
	(1.4770)					
	[0.3612]					
FITTED FULL NETWORK		1.4950*				
		(0.7211)				
		[0.2008]				
FITTED GREEN BETWEEN			0.7782**			
			(0.3154)			
			[0.1045]			
FITTED FULL BETWEEN				0.6118		
				(0.3255)		
				[0.0822]		
FITTED GREEN EIGEN					23.8600	
					(12.7500)	
					[3.2045]	
FITTED FULL EIGEN						29.9600
						(16.6500)
						[4.0230]
AT	-0.0997	-0.1622	-0.0457	-0.1579	-0.0036	-0.0177
	(0.1680)	(0.2017)	(0.1357)	(0.1933)	(0.1143)	(0.1259)
ROA	-1.2880	-1.7980	-2.3760	-3.6460**	-0.4161	-0.6760
	(1.5690)	(1.4950)	(1.4720)	(1.6420)	(1.7760)	(1.7210)
LEV	1.0340***	1.0750***	1.0700***	1.1290***	1.5450***	1.2170***
	(0.3096)	(0.3069)	(0.3072)	(0.3061)	(0.3808)	(0.3105)
DEBT MAT	0.4855	0.0899	0.5634	0.1088	0.4043	0.7715*
	(0.3414)	(0.2849)	(0.3627)	(0.2841)	(0.3169)	(0.4514)
TANGIBILITY	0.2868	0.2678	0.2126	0.2597	0.2790	0.3916*
	(0.2213)	(0.2217)	(0.2253)	(0.2220)	(0.2214)	(0.2281)
FIRM AGE	-0.0022*	-0.0024*	-0.0023*	-0.0013	-0.0023*	-0.0024*
	(0.0013)	(0.0013)	(0.0013)	(0.0015)	(0.0013)	(0.0013)
Constant	-4.6690**	-5.8790***	-5.3920***	-5.1540**	-7.4340***	-6.9110***
	(2.2620)	(1.7530)	(1.9160)	(2.0090)	(1.3170)	(1.4270)
Controls	YES	YES	YES	YES	YES	YES
N	3,413	3,413	3,413	3,413	3,413	3,413
Pseudo R-squared	36.35%	36.35%	36.36%	36.36%	36.36%	36.35%
P-value of Sargan test	0.52	0.46	0.66	0.44	0.78	0.83

Table 9: Connected issuers characteristics, green network and green bond issuances

This table presents the multiperiod regression estimations examining whether the effect of green interlock and network on the propensity of green bond issuances is stronger for firms whose connected firms demonstrate greater sustainability or CSR commitments, using three proxies. ConnectExeESGcomp is an indicator variable with a value of one if firm i provides ESG-linked compensation for executives, and zero otherwise. ConnectCSRCommittee is an indicator variable with a value of one if firm i has a CSR/sustainability committee, and zero otherwise. ConnectCert is an indicator variable with a value of one if any of connected firms of firm i in year t has issued a green bond with certification, and zero otherwise. Dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Marginal effects and associated standard errors below in parentheses clustered by industry and year are reported. For the sake of brevity, we do not report control variables. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
GREEN INTERLOCK × ConnectExeESGcomp	0.2947***					
	(0.1301)					
GREEN NETWORK × ConnectExeESGcomp		0.0353**				
		(0.0155)				
GREEN INTERLOCK × ConnectCSRCommittee			0.4983***			
			(0.1583)			
GREEN NETWORK × ConnectCSRCommittee				0.0292*		
				(0.0129)		
GREEN INTERLOCK × ConnectCert					0.9660	
					(1.0492)	
GREEN NETWORK × ConnectCert						0.1071**
						(0.0412)
ConnectExeESGcomp	0.6648	0.1153***				
	(9.1864)	(0.0154)				
ConnectCSRCommittee			0.8458	0.1352**		
			(7.1838)	(0.0572)		
ConnectCert					0.3185	0.1281
					(5.6669)	(0.0913)
GREEN INTERLOCK	0.1357		0.0972		0.2077*	
	(0.1238)		(0.1297)		(0.0993)	
GREEN NETWORK		0.1768***		0.1819***		0.1656***
		(0.0101)		(0.0115)		(0.0092)
Constant	-2.0147***	-1.0109	-1.8319**	-0.8729	-2.1609***	-1.0906
	(0.7635)	(0.7883)	(0.7828)	(0.7780)	(0.7524)	(0.7636)
Controls	YES	YES	YES	YES	YES	YES
Year & Company Type & Industry & Region	YES	YES	YES	YES	YES	YES
N	1,676	1,676	1,676	1,676	3,413	3,413
Pseudo R-squared	41.20%	50.07%	41.91%	51.23%	40.58%	48.81%

Table 10: Cumulative abnormal returns (CARs) at the event window of [-3,+3]

This table reports the differences in average CARs computed in CAPM-adjusted model (Panel A) and Fama-French 5 factor model (Panel B) across subsamples split by the presence of *GREEN INTERLOCK*, *FULL INTERLOCK* and based on the top versus bottom terciles of *GREEN NETWORK*, *FULL NETWORK* and all centrality measures).

Panel A: CAPM-adjusted CARs (%) by the presence of interlocks and tercile of network characteristics

Variables	**CAR (%) by tercile of X (except dummy variables)**		
	Top	Bottom	t-test
X=GREEN INTERLOCK	0.2802	-0.2333	-3***
X=GREEN NETWORK	0.1387	-0.2333	-2.6**
X=FULL NETWORK	0.2270	-0.2142	-2.8***
X=FULL INTERLOCK	0.1431	-0.2142	-2.5**
X=GREEN SCORE	0.1371	-0.1002	-1.8*
X=FULL NSCORE	0.1402	-0.0537	-1.4
X=GREEN BETWEEN	0.0670	-0.1590	-1.6
X=FULL BETWEEN	0.0566	-0.0893	-0.98
X=GREEN EIGEN	0.1149	-0.2840	-2.8***
X=FULL EIGEN	0.1028	-0.1524	-2.1*

Panel B: Fama-French 5 factor CARs (%) by the presence of interlocks and tercile of network characteristics

Variables	**CAR (%) by tercile of X (except dummy variables)**		
	Top	Bottom	t-test
X=GREEN INTERLOCK	0.6624	0.4305	-1.7*
X=GREEN NETWORK	0.8922	0.4305	-2.4**
X=FULL NETWORK	0.6809	0.7912	1.3
X=FULL INTERLOCK	0.7284	0.7912	0.8
X=GREEN SCORE	0.7534	-2.1754	-18***
X=FULL NSCORE	0.7025	-1.6896	-9***
X=GREEN BETWEEN	0.8971	0.7081	-1.5
X=FULL BETWEEN	0.6221	0.6508	-0.3
X=GREEN EIGEN	0.7540	0.5937	1.6
X=FULL EIGEN	0.6958	0.7237	0.4

Table 11: Multivariate analysis of firm network and Cumulative abnormal returns (CARs) at the event window of [-3,+3]

This table presents the multivariate regression results of the impact of interlocks and network centrality measures on firm value measured by CARs. The dependent variable is Cumulative abnormal returns (CARs) at the event window of [-3,+3] computed using the CAPM-adjusted approach. Detailed descriptions of other variables are provided in the Appendix. Standard errors of coefficients clustered by industry and year are reported in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GREEN INTERLOCK	0.0027**									
	(0.0012)									
GREEN NETWORK		0.0017**								
		(0.0007)								
FULL NETWORK			0.0016***							
			(0.0006)							
FULL INTERLOCK				0.0025						
				(0.0016)						
GREEN SCORE					0.0011***					
					(0.0004)					
FULL NSCORE						0.0007				
						(0.0004)				
GREEN BETWEEN							0.0003*			
							(0.0015)			
FULL BETWEEN								0.0003		
								(0.0002)		
GREEN EIGEN									0.0036	
									(0.0039)	
FULL EIGEN										0.0039
										(0.0062)
ROA	-0.0030	-0.0031	-0.0029	-0.0037	-0.0012	-0.0017	-0.0012	-0.0018	-0.0044	-0.0040
	(0.0170)	(0.0168)	(0.0169)	(0.0171)	(0.0168)	(0.0169)	(0.0167)	(0.0169)	(0.0170)	(0.0168)
LEV	0.0024	0.0036	0.0037	0.0026	0.0043	0.0038	0.0031	0.0029	0.0029	0.0030
	(0.0032)	(0.0032)	(0.0032)	(0.0032)	(0.0033)	(0.0032)	(0.0032)	(0.0032)	(0.0033)	(0.0033)
DEBTMAT	-0.0042*	-0.0032	-0.0034	-0.0042*	-0.0031	-0.0034	-0.0038	-0.0038	-0.0035	-0.0035
	(0.0024)	(0.0023)	(0.0023)	(0.0024)	(0.0023)	(0.0023)	(0.0024)	(0.0024)	(0.0023)	(0.0023)
TANGIBILITY	-0.0049***	-0.0048***	-0.0045***	-0.0047***	-0.0050***	-0.0051***	-0.0051***	-0.0049***	-0.0051***	-0.0052***
	(0.0013)	(0.0013)	(0.0014)	(0.0014)	(0.0013)	(0.0014)	(0.0013)	(0.0013)	(0.0014)	(0.0013)
VOL	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***	-0.0002***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Industry	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	1191	1191	1191	1191	1191	1191	1191	1191	1191	1191
Adj R2	0.09	0.09	0.10	0.09	0.09	0.09	0.09	0.09	0.09	0.09

Table 12: Green network and yield spreads

This table examines the effect of interlock measures (Panel A) and network centrality measures (Panel B) on the yield spreads of green bonds utilizing the firm sample. Each panel employs two subsets of green bond issues: first-time issues and all unique issues. Detailed descriptions of independent and control variables are provided in the Appendix. Industry, year, region, and company type effects are included. Robust standard errors clustered by industry and year are reported in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Panel A: Interlock and yield spreads

	First-time issues				All unique issues			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
GREEN INTERLOCK	-0.8385**				-0.5819**			
	(0.4090)				(0.2623)			
GREEN NETWORK		-0.2688***				-0.0878		
		(0.1016)				(0.0728)		
FULL NETWORK			-0.2502***				-0.1082	
			(0.0878)				(0.0623)	
FULL INTERLOCK				-0.4962				-0.2955
				(0.3257)				(0.2323)
RATING	0.1852	0.2033	0.1965	0.1720	-0.1625	-0.1714	-0.1723	-0.1768
	(0.1702)	(0.1686)	(0.1657)	(0.1699)	(0.1429)	(0.1443)	(0.1433)	(0.1431)
MATURITY	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMTISSUED (in log)	0.2196***	0.2464***	0.2432***	0.2255***	0.1098***	0.1085***	0.1072***	0.1104***
	(0.0613)	(0.0619)	(0.0616)	(0.0623)	(0.0264)	(0.0266)	(0.0264)	(0.0268)
N	297	297	297	297	679	679	679	679
Adj R2	0.68	0.68	0.68	0.67	0.65	0.65	0.65	0.65

Panel B: Centrality and yield spreads

	First-time issues						All unique issues					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GREEN SCORE	-0.2009**						-0.1514**					
	(0.0912)						(0.0701)					
FULL NSCORE		-0.2321***						-0.1590***				
		(0.0824)						(0.0600)				
GREEN BETWEEN			-0.0812***						-0.0327			
			(0.0263)						(0.0193)			
FULL BETWEEN				-0.0844***						-0.0535***		
				(0.0229)						(0.0172)		
GREEN EIGEN					-0.4667						0.5748	
					(0.7937)						(0.4739)	
FULL EIGEN						-2.3065						-0.4884
						(1.2208)						(0.6626)
RATING	0.1918	0.1582	0.2312	0.1903	0.1980	0.1939	0.0511	0.0368	0.0721	0.0520	0.0592	0.0606
	(0.1663)	(0.1650)	(0.1654)	(0.1649)	(0.1660)	(0.1654)	(0.1311)	(0.1301)	(0.1305)	(0.1304)	(0.1299)	(0.1311)
MATURITY	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMTISSUED (in log)	0.1101*	0.1146*	0.1186*	0.1220*	0.1082	0.1232*	0.0735***	0.0738***	0.0707***	0.0701***	0.0726***	0.0752***
	(0.0662)	(0.0646)	(0.0666)	(0.0622)	(0.0681)	(0.0712)	(0.0190)	(0.0191)	(0.0191)	(0.0189)	(0.0192)	(0.0190)
N	297	297	297	297	297	297	679	679	679	679	679	679
Adj R2	0.74	0.74	0.74	0.75	0.73	0.74	0.71	0.71	0.71	0.71	0.71	0.71

Table 13: Interlock, network centrality and gross spreads

This table examines the effect of interlock measures and network centrality measures on the gross spreads of green bonds utilizing the entire firm sample. Detailed descriptions of independent and control variables are provided in the Appendix. Industry, year, region, and company type effects are included. Robust standard errors clustered by industry and year are reported in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GREEN INTERLOCK	-0.2318***									
	(0.0883)									
GREEN NETWORK		-0.0064								
		(0.0099)								
FULL NETWORK			0.0052							
			(0.0051)							
FULL INTERLOCK				-0.1717**						
				(0.0822)						
GREEN SCORE					-0.0966**					
					(0.0385)					
FULL NSCORE						-0.0692				
						(0.0345)				
GREEN BETWEEN							-0.0292**			
							(0.0136)			
FULL BETWEEN								-0.0373**		
								(0.0156)		
GREEN EIGEN									0.8261	
									(0.6661)	
FULL EIGEN										0.7398
										(0.7292)
RATING	-0.0864	-0.0799	-0.0785	-0.0870	-0.0936	-0.0905	-0.0758	-0.0778	-0.0766	-0.0818
	(0.0729)	(0.0737)	(0.0736)	(0.0731)	(0.0714)	(0.0729)	(0.0716)	(0.0714)	(0.0730)	(0.0736)
MATURITY	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
AMTISSUED (in log)	-0.2700***	-0.2877***	-0.2945***	-0.2676***	-0.2441**	-0.2521**	-0.2646***	-0.2621***	-0.2644***	-0.2979***
	(0.0937)	(0.0957)	(0.0958)	(0.0953)	(0.0960)	(0.0976)	(0.0960)	(0.0952)	(0.0939)	(0.0996)
N	189	189	189	189	189	189	189	189	189	189
R2	0.66	0.65	0.65	0.66	0.66	0.66	0.66	0.66	0.66	0.65

Appendix

Table A1: Variable descriptions

Variables	**Description**	**Source**
Network and interlock measures		
$GREEN\ INTERLOCK_{j,t}$	An indicator variable taking the value of one if issuer j shares a director or executive with a previous green bond issuer i at year t, t-1, t-2, t-3, and zero otherwise.	
$GREEN\ NETWORK_{j,t}$	Natural logarithm of 1 plus the total number of unique firm-level links over a four-year incubation window to other organizations already issuing green bonds in prior years.	Self-calculation based on BoardEx and BvD Orbis
$FULL\ NETWORK_{j,t}$	Natural logarithm of 1 plus the total number of firm-level links among organizations in a given year t in our full sample.	
$FULL\ INTERLOCK_{j,t}$	An indicator variable takes on a value of one if the issuer has any links to any other organization(s) in our full sample in a given year t, not just to firms already issuing green bonds in previous year, and zero otherwise.	
$GREEN\ BETWEEN_{j,t}$	Betweenness centrality of issuer j is the sum of its betweenness ratios that defined as the number of geodesic paths from issuer s to issuer i passing through issuer j, divided by the number of geodesic paths from s to i. It evaluates the positioning advantage of the focal issuer in the network of green bond issuers who have previously issued green bonds in the preceding years. $\text{Betweenness}_j = \sum_{\substack{s\neq i\neq j\in I \\ s\neq i}} \frac{\sigma_{si}(j)}{\sigma_{si}}$.	
$FULL\ BETWEEN_{j,t}$	$FULL\ BETWEEN_{j,t}$ evaluates the positioning advantage of the issuer in the focal year in the entire network of all issuers included in our sample.	
$GREEN\ EIGEN_{j,t}$	Eigenvector centrality that developed by Bonacich (1987) evaluates the quality and importance of firms' network among organizations who have already issued green bonds before, in which λ is associated maximum eigenvalue while A_{ij} is the adjacency matrix with the value of 1 when firm j and i are connected. $Eigenvector_j = \frac{1}{\lambda}\sum_i A_{ji}e_i$.	
$FULL\ EIGEN_{j,t}$	In a similar manner, $FULL\ EIGEN_{j,t}$ evaluates the quality and importance of organizations' network of all issuers included in our sample.	
$GREEN\ SCORE_{j,t}$	Follow Larcker et al.'s (2013) approaches to rank all firms each year into quintiles based on AT and sort firms within each AT quintile into quintiles based on $GREEN\ NETWORK_{j,t}$, $GREEN\ BETWEEN_{j,t}$, and $GREEN\ EIGEN_{j,t}$, respectively. $\text{GREEN SCORE}_{j,t} = \text{Quint}\left[\frac{1}{3}\{\text{Quint}(\text{GREEN NETWORK}_{j,t}) + \text{Quint}(\text{GREEN BETWEEN}_{j,t}) + \text{Quint}(\text{GREEN EIGEN}_{j,t})\}\right]$	
$FULL\ NSCORE_{j,t}$	$\text{FULL NSCORE}_{j,t} = \text{Quint}\left[\frac{1}{3}\{\text{Quint}(\text{FULL NETWORK}_{j,t}) + \text{Quint}(\text{FULL BETWEEN}_{j,t}) + \text{Quint}(\text{FULL EIGEN}_{j,t})\}\right]$	
Other governance measures		
BOARD SIZE	The number of directors on board.	Thomson Eikon,BoardEx and BvD Orbis
%INDEP	The number of independent directors divided by the number of directors on board.	
CEO TENURE	Number of years that CEO serves in this position.	
%INST	The percentage of institutional ownership.	
Financial characteristics		
AT	The natural logarithm of total assets.	Capital I&Q and BvD Orbis
ROA	Net income divided by total assets.	
LEV	Interest-bearing debt divided by total assets.	
MTB	Market value of equity over book value of equity (public firms only).	
TANGIBILITY	Net Property, Plant and Equipment (PP&E) scaled by total assets.	
FIRM AGE	The number of years since the firm is founded.	
DEBT MAT	The ratio of long-term debt over total debt.	
VOL	Stock price volatility is computed as standard deviation of monthly returns in the fiscal year.	
Bond characteristics		
RATING	An indicator variable taking on a value of 1 if the bond S&P (Moody's) rating is at or over BBB- (Baa3), and zero otherwise.	Bloomberg and CBI
MATURITY	The number of years that a bond takes to mature.	
AMTISSUED (in log)	The total amount of bond issued in dollars (in log).	

Additional Appendix

Table IA.1: Correlation matrix for public and private firms

This table presents the Pearson correlation matrix. Detailed descriptions of independent and control variables are provided in the Table A1. * indicates significance at the 1 percent level.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) GREEN ISSUE	1																
(2) GREEN INTERLOCK	0.28*	1															
(3) GREEN NETWORK	0.40*	0.86*	1														
(4) FULL NETWORK	0.05*	0.64*	0.67*	1													
(5) FULL INTERLOCK	0.03	0.56*	0.49*	0.86*	1												
(6) GREEN SCORE	0.03	0.62*	0.63*	0.52*	0.41*	1											
(7) FULL NSCORE	0.01	-0.59*	-0.57*	-0.91*	-0.81*	-0.64*	1										
(8) GREEN BETWEEN	0.32*	0.58*	0.80*	0.52*	0.34*	0.54*	-0.47*	1									
(9) FULL BETWEEN	0.05*	0.51*	0.54*	0.79*	0.57*	0.43*	-0.78*	0.51*	1								
(10) GREEN EIGEN	0.15*	0.48*	0.68*	0.53*	0.28*	0.44*	-0.43*	0.55*	0.39*	1							
(11) FULL EIGEN	0.01	0.39*	0.50*	0.65*	0.37*	0.36*	-0.56*	0.39*	0.48*	0.64*	1						
(12) AT	0.03	0.25*	0.29*	0.27*	0.23*	0.31*	-0.32*	0.33*	0.38*	0.29*	0.24*	1					
(13) ROA	-0.04	-0.03	-0.05*	-0.03	0.01	0.02	-0.01	-0.02	0.02	-0.09*	-0.09*	-0.04	1				
(14) LEV	0.06*	-0.03	-0.06*	-0.08*	-0.02	-0.12*	0.13*	-0.07*	-0.10*	-0.07*	-0.14*	-0.08*	-0.15*	1			
(15) DEBT MAT	0.04	-0.07*	-0.10*	-0.08*	0.03	-0.11*	0.07*	-0.10*	-0.07*	-0.17*	-0.15*	-0.11*	0.06*	0.19*	1		
(16) TANGIBILITY	0.00	-0.15*	-0.18*	-0.23*	-0.14*	-0.20*	0.25*	-0.14*	-0.18*	-0.20*	-0.24*	-0.24*	0.19*	0.13*	0.27*	1	
(17) FIRM AGE	0.02	0.24*	0.25*	0.35*	0.28*	0.24*	-0.35*	0.22*	0.29*	0.20*	0.26*	0.48*	-0.04	-0.29*	-0.19*	-0.29*	1

Table IA.2: Government institutions

Table IA2, Panel A presents the summary statistics of network and financial characteristics for government institutions. Panel B presents the number of new governmental issuers starting to issue green bonds each year (New green issuers), the cumulative number of governmental green bond issuers each year (N), the percentage (%Links) and average number of links (Avg links) to other organizations (including government institutions, private and public firms) in our sample, and the percentage (%Green links) and average number of links to other organizations in our sample that have issued green bonds in previous years (Avg green links). Panel C presents the statistics for government institutions that are in the sample in a given year, but have not issued green bonds.

Panel A: Descriptive statistics

Variables	N	Mean	SD	Median	Min	Q1	Q3	Max
GREEN ISSUE	1995	0.123	0.328	0	0	0	0	1
GREENINTERLOCK	1995	0.063	0.242	0	0	0	0	1
GREEN NETWORK	1995	0.105	2.092	0	0	0	0	7
FULL NETWORK	1995	0.533	13.097	0	0	0	0	14
FULL INTERLOCK	1995	0.153	0.36	0	0	0	0	1
GREEN BETWEEN	1995	3.564	59494.441	0	0	0	0	1382.313
FULL BETWEEN	1995	9.501	225898.032	0	0	0	0	2847.106
GREEN EIGEN	1995	0.003	0.006	0	0	0	0	0.397
FULL EIGEN	1995	0.002	0.001	0	0	0	0	0.157

	Panel B: Green bond issuers						Panel C: Non-green-bond issuers				
Year	**New green issuers**	**N**	**%Link**	**Avg links**	**%Green links**	**Avg green links**	**Non-green issuers**	**%Link**	**Avg links**	**%Green links**	**Avg green links**
2011	1		0.00	0.00	0.00	0.00	244	14.34	0.47	2.46	0.03
2012	3	4	33.33	2.00	33.33	1.00	241	15.35	0.47	2.07	0.03
2013	2	6	0.00	0.00	0.00	0.00	239	15.06	0.49	2.51	0.03
2014	15	21	13.33	0.80	13.33	0.53	224	15.18	0.53	4.02	0.05
2015	26	47	15.38	0.62	15.38	0.38	198	14.65	0.49	5.05	0.07
2016	22	69	13.64	0.36	13.64	0.18	176	16.48	0.60	6.25	0.09
2017	25	94	16.00	0.88	16.00	0.64	151	15.89	0.54	7.95	0.11
2018	25	119	16.00	0.48	16.00	0.28	126	14.29	0.57	7.94	0.11
2019	28	147	3.57	0.07	3.57	0.04	98	17.35	0.71	11.22	0.19
2020	45	192	17.78	0.58	17.78	0.29	53	18.87	0.64	16.98	0.26
2021	53	245	16.98	0.64	16.98	0.40					
Total	245						1750				

Table IA.3: Interlock, network centrality and the propensity of green bond issuances for government institutions

This table presents the multiperiod regression estimations for government institutions in examining the effect of interlock, network and centrality measures on the propensity of green bond issuances. Dependent variable takes on a value of one if the institution issues green bonds in a given year, and zero otherwise. Detailed descriptions of independent and control variables are provided in the Appendix Table A1. Robust standard errors of coefficients are reported in parentheses and marginal effects are reported in square brackets. We drop government institutions from the sample in future years after the year they issue green bonds at the first time. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
GREEN INTERLOCK	0.4783*									
	(0.2388)									
	[0.0408]									
GREEN NETWORK		0.6208**								
		(0.2741)								
		[0.0443]								
FULL NETWORK			-0.1397							
			(0.1585)							
			[-0.0100]							
FULL INTERLOCK				-0.2322						
				(0.2362)						
				[-0.0155]						
GREEN SCORE					1.4510***					
					(0.1164)					
					[0.0334]					
FULL NSCORE						1.6692				
						(0.1332)				
						[0.0294]				
GREEN BETWEEN							-0.0963			
							(0.2901)			
							[-0.0069]			
FULL BETWEEN								-0.2033		
								(0.1778)		
								[-0.0145]		
GREEN EIGEN									5.7482	
									(5.4196)	
									[0.4108]	
FULL EIGEN										-15.3547
										(10.5415)
										[-1.0931]
Constant	-5.2292***	-5.2164***	-5.2693***	-5.2675***	-11.9411***	-12.8919***	-5.2687***	-5.2592***	-5.2624***	-5.2732***
	(1.2960)	(1.2956)	(1.2978)	(1.2978)	(1.5624)	(1.6306)	(1.2979)	(1.2977)	(1.2976)	(1.2981)
Year	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Region	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	1,995	1,995	1,995	1,995	1,995	1,995	1,995	1,995	1,995	1,995
Pseudo R-squared	0.30	0.31	0.29	0.28	0.30	0.28	0.31	0.29	0.29	0.29

Table IA.4: Board and executive interlocks and network

This table presents the multiperiod regression estimations for the network sample connected through independent non-executive directors and the sample connected through executives in examining the effect of green interlock (Panel A) and network centrality (Panel B) on the propensity of green bond issuances. Dependent variable (*GREEN ISSUE*) takes on a value of one if the firm initially issues green bonds in a given year, and zero otherwise. Detailed descriptions of independent and control variables are provided in the Appendix. Industry, year, region, and company type effects are included. Robust standard errors of coefficients are reported in parentheses. *, ** and *** denote statistical significance at the 10%, 5% and 1% level, respectively.

Panel A: Green interlock and network	**Independent non-executive directors**		**Executives (Top management teams)**	
	(1)	(2)	(3)	(4)
GREEN INTERLOCK	1.3910***		1.3840***	
	(0.1398)		(0.1414)	
	[0.2065]		[0.2125]	
GREEN NETWORK		1.8100***		1.5610***
		(0.1167)		(0.1142)
		[0.2131]		[0.1889]
Constant	-7.0000***	-5.9380***	-7.3210***	-6.5370***
	(1.3060)	(1.2960)	(1.3060)	(1.2930)
Controls	YES	YES	YES	YES
N	3,413	3,413	3,413	3,413
Pseudo R-squared	0.40	0.46	0.40	0.43

Panel B: Network centrality	**Independent non-executive director centrality measures**						**Executive centrality measures**					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
GREEN SCORE	0.5491***						0.5005***					
	(0.0573)						(0.0559)					
	[0.0668]						[0.0620]					
FULL NSCORE		0.2208***						0.1551**				
		(0.0551)						(0.0552)				
		[0.0295]						[0.0209]				
GREEN BETWEEN			0.3145***						0.3169***			
			(0.0258)						(0.0258)			
			[0.0392]						[0.0393]			
FULL BETWEEN				0.0605**						0.0127		
				(0.0239)						(0.0261)		
				[0.0082]						[0.0017]		
GREEN EIGEN					7.3740***						7.9950***	
					(1.1340)						(1.2850)	
					[0.9819]						[1.0555]	
FULL EIGEN						-0.0655						1.9400
						(0.9162)						(1.3130)
						[-0.009]						[0.2626]
Constant	-8.7260***	-8.3800***	-6.3510***	-7.9530***	-7.7230***	-8.0770***	-8.8980***	-8.2270***	-6.2870***	-8.0320***	-7.9690***	-8.0660***
	(1.2810)	(1.2750)	(1.2570)	(1.2710)	(1.2610)	(1.2610)	(1.2930)	(1.2660)	(1.2570)	(1.2640)	(1.2640)	(1.2610)
N	3,413	3,413	3,413	3,413	3,413	3,413	3,413	3,413	3,413	3,413	3,413	3,413
Pseudo R-squared	0.40	0.37	0.41	0.37	0.38	0.36	0.39	0.37	0.42	0.36	0.38	0.36

Fig.IA1: CARs for interlocked firms versus non-interlocked firms around green bond issuances