Alliance Effectiveness And Spillovers In Climate Investments: Evidence From Net-Zero Banking Alliance (NZBA)

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Abstract

Banks are pivotal for the global climate and energy transition. Alliances like the Net-Zero Banking Alliance (NZBA) were one way of facilitating coordination among banks to reduce informational asymmetries pertaining to low-carbon capital-intensive technologies. We examine whether participation in NZBA was associated with structural shifts in bank lending away from fossil fuels toward renewable energy, and whether such effects propagate through syndicated lending networks to non-members. We conduct a technological level analysis of lending to fossil fuel projects and renewable energy projects using comprehensive loan-level data covering energy and utilities sectors from 2011 to 2024. We find that NZBA member banks significantly reduced fossil fuel corporate lending and increased renewable energy project lending following the alliance's formation in 2021. However, we detect no robust effects in loan pricing. Additionally, non-members with greater exposure to systemically important large NZBA banks reduced fossil fuel lending post-2021. In contrast, we find no evidence that network exposure induced renewable energy lending expansion among non-members. The results contribute to the conditional and uneven impact of climate finance alliances, emphasizing the effective signaling role of large bank alliances in restricting negative behavior if not inducing positive one in rest of the banks.

Key words: climate finance, climate policy, financial alliances, bank syndication, bank networks, renewable energy.

1. Introduction

Banks play a central role in the global climate and energy transition by providing long-term financing to capital-intensive energy investments. In particular, they support the deployment of low-carbon technologies while reallocating credit away from fossil fuel activities in response to climate policy shifts (Cojoianu et al. 2023; Rickman et al. 2024). The transition process disproportionately disadvantages early mover banks, even those with higher project screening quality or with policy support that may mitigate some early technological risks (Waidelich and Steffen 2024; Waidelich et al. 2025; Gasparini and Tufano 2025). Accordingly, heightened risk from technological shift prevalent in the climate technological transition requires systemic coordination (Battiston et al. 2017; Jung et al. 2025). One mechanism for such coordination is the formation of financial alliances, which aim to reduce information asymmetries, facilitate knowledge sharing, and establish common standards among member institutions (Kobayashi and Takaguchi 2018; Gasparini and Tufano 2025).

Climate-related alliances apply this broader institutional logic to novel low-carbon climate technologies, especially those in the energy sector. Climate-related alliances are expected to enhance communication and coordination across financial institutions to standardize expectations and reduce uncertainty surrounding transition and technological risks through net-zero commitments, enhanced disclosure, and common benchmarks. These functions are expected to facilitate cooperation and collective engagement in targeted sectors by creating a common institutional framework (Godlewski et al. 2012; Gumber and Steffen 2025). The facilitation enables peer learning and information exchange, enabling institutions to pool expertise and co-finance complex or capital-intensive projects, thereby diversifying risk and mitigating informational frictions (Kempa et al. 2021; Godlewski et al. 2012; Dennis and Mullineaux 2000; Schmidt 2014). The ultimate expectation is that such alliances structurally shift capital allocation to greener assets by conveying credible commitment to shared strategic objectives, such as emissions mitigation (Ullah, n.d.; Svetek 2022) and gradually help redirect credit toward sectors perceived as strategically aligned and away from activities facing heightened long-term risks.

Within possible financial alliances, we focus on the Net-Zero Banking Alliance (NZBA) that came into existence in 2021 but ceased to operate in 2025[1] due to regulatory constraints and political pressures. The NZBA introduced specific, time-bound requirements for banks to reallocate capital

[1] The NZBA announced that it would cease operating as a membership-based coalition following a series of high-profile withdrawals. Member banks voted to restructure the initiative into a non-membership framework that provides technical guidance on target-setting and transition planning. These withdrawals were driven in part by the sharp political shift in the United States in 2025, and by growing concerns that sectoral targets or fossil-fuel financing constraints could create legal exposure or conflict with banks' fiduciary obligations.

with sector-specific decarbonization targets for 2030 and 2050[2]. Unlike its predecessor frameworks such as the UN Principles for Responsible Banking (PRB), which provided an overarching framework for aligning banking strategies with the Sustainable Development Goals and the Paris Agreement, the NZBA asked member banks to establish quantitative targets for reducing financed emissions and to make explicit commitments to scale up sustainable finance by aligning their lending portfolios with net-zero objectives (Sastry et al. 2024). However, it remains unclear whether such a voluntary climate finance alliance translated into actual changes in bank lending behavior, particularly within energy and utilities sectors where financing needs are large and transition risks are concentrated. Thus, this paper examines whether the formation of the NZBA is associated with a reallocation of global syndicated lending away from fossil fuel activities and toward renewable energy finance, and whether the increase (decrease) in participation has a spillover signaling effect on non-member banks through syndicated networks.

We conduct this study with a global assessment of credit allocation using Bloomberg's comprehensive loan-level data set which provides detailed information on financing activities in the energy and utility industries globally. Specifically, we limit our sample set to capital investments in energy sector, which includes coal, oil and gas, and power generation, including renewables, aiming to examine how NZBA participation may influence lending behavior in these high-emission areas. We also control for bank size bias to overcome self-selection bias among large banks as found in our data like other studies. We further integrate the official NZBA membership dataset to distinguish member banks from non-members. This combined approach enables us to evaluate whether NZBA membership, either directly or indirectly via bank syndicates, is associated with a meaningful redirection of capital within member and non-member banks.

We find that NZBA member banks significantly reduce fossil fuel corporate lending and expand renewable energy project finance relative to comparable non-member banks following the formation of the alliance. Next, we find evidence of network spillover among non-member banks with greater exposure to NZBA members through syndicated lending networks. We find that non-members reduce fossil fuel lending more strongly after 2021. However, we do not observe any significant results on their renewable energy lending, which may be explained owing to transactions structures wherein renewable energy investments carry higher risk due to project financing structures.

Accordingly, our work makes numerous contributions. First, our econometric assessment confirms that voluntary net-zero commitments translate into tangible changes in capital allocation rather than symbolic climate pledges. Second, we also give empirical evidence on the spillover effect of the fossil fuel phasing-out progress via syndicated lending network, supporting analysis from Rickman et al. (2024) that large banks should take more responsibilities in the fossil fuel

[2] Initial 2030 targets must focus on the most greenhouse-gas-intensive sectors in each bank's portfolio. Within three years of joining, members were expected to set targets for most of the nine priority sectors outlined by the NZBA, including energy systems (power generation, oil & gas, and coal) and carbon-intensive sectors.

phasing-out progress. We address this gap by embedding banks in interbank syndicated lending networks and explicitly examining whether alliance-related signals propagate to non-member institutions through repeated co-lending relationships. This network-based perspective extends the analysis from individual commitment effects to system-level transmission mechanisms. Third, this study contributes to the literature on peer effects in corporate social responsibility (CSR) and sustainable finance by showing that banks' climate-related lending behavior is influenced not only by their own commitments but also by the behavior of directly connected peer banks in syndicated lending relationships. The paper provides new evidence on how capital reallocation practices diffuse through financial networks via broader network exposure.

2. Literature Review and Hypothesis Development

2.1 Literature Review

2.1.1 Impact of climate business alliance on members

A growing literature examines whether voluntary climate alliances and sustainability initiatives influence financial institutions' behavior. Existing studies document mixed evidence regarding the effectiveness of such alliances. Gasparini and Tufano (2025) find mixed results when examining 424 publicly traded financial institutions across eleven climate alliances. They find that climate alliances are positively associated with emissions reductions and green lending expansion but insignificant on fossil fuel phasing-out, improving risk-adjusted returns, or curbing anti-climate lobbying. Likewise, Dimson et al. (2018) and Slager et al. (2023) find that PRI signatories increase sustainable investment in low-carbon sectors and help to target climate commitments focusing on 553 collaborative shareholder on firm-level. Bolton and Kacperczyk (2025) find a small emissions reduction on companies participating in SBTi and CDP. However, several scholars highlight limited or negligible impacts on climate business alliances. Kim and Yoon (2023) show that PRI membership does not help improve the ESG performance. Sastry et al. (2024) focus on European banks and finds that joining the Net-Zero Banking Alliance (NZBA) does not lead banks to adjust either their lending volumes or loan pricing. This observation echoes the skepticism of Gasparini and Tufano (2025), who argue that voluntary alliances generally fail to significantly impact core financial strategies. Furthermore, Marquis et al. (2016) and Bolton and Kacperczyk (2025) find that voluntary climate commitments and alliances function more as symbolic or reputational devices than as mechanisms capable of inducing structural decarbonization.

While these studies focus more on the effect of alliance on emissions reduction or higher ESG scores, we still lack understanding on whether voluntary alliances can induce a systemic reallocation of credit away from fossil fuels and toward renewables, such as those brought via behavioral propagation through network spillovers. They highlight self-selection bias among members, though this is expected as a self-selection among large actors is necessary precondition for building alliance influence. Studies that are critical on ESG performance

improvement also suffer from greenwashing and do not focus on material capital investments that truly reduce system level emissions instead of shift portfolios within the banking system (Kim and Yoon 2023). As a corollary, none of the studies focus on technological level shifts in lending portfolios wherein loan expansion to low-hanging renewable energy projects such as to solar PV and wind onshore projects are far easier than disinvestments in fossil fuel assets. Finally, existing research does not consider spillover effects of alliances. In principle, while an alliance focuses on influencing the decision of its members, it also upholds standards that it wants applicable to the whole industry. Additionally, it also desires the expansion of the alliance by way of including additional members in the future. Thus, it is prudent to expect spillovers from alliances or alliance members to non-members.

2.1.2 Network Spillovers and Peer Effects

Financial institutions are embedded in syndicated lending networks, where banks repeatedly co-finance projects and exchange information, risk assessments, and lending practices (Engelberg et al. 2012; Godlewski and Sanditov 2018; Karolyi 2018). Information can be transmitted through syndicated lending networks and peer connections. As a result, climate-related information associated with alliances such as the Net-Zero Banking Alliance may spill over from member banks to non-member banks if they participate in the same syndicate or share common lending partners. Godlewski and Sanditov (2018) show that more central lending syndicates generate stronger market certification effects, and information produced within these syndicates tends to receive greater attention from outside market participants. Engelberg et al. (2012) and Karolyi (2018) show that personal ties in lending relationships improve terms, affect lender choice, and shape real outcomes, which suggests that information in credit markets often diffuses through embedded relationships rather than through public disclosure alone. Therefore, NZBA member banks can plausibly influence non-members not only by publicly announcing net-zero or fossil-fuel phase-out positions, but also by carrying these views into repeated syndication relationships where deal-level interaction, due diligence, and co-monitoring make information transmission more likely.

Besides, the climate-related commitment can also be influenced by peer effect. Cao (2019) show that CSR policies spread across firms through competitive peer effects that when one firm adopts CSR, rivals respond strategically rather than remaining passive observers. Bolton and Kacperczyk (2025) similarly show that corporate climate commitments are affected by peer pressure and national commitment environments. Moreover, the effect of climate-related commitment can also be transferred spillover from lenders to borrowers (Hasan et al. 2026). Therefore, non-member banks may update their own beliefs and policies after observing member banks adopt sectoral targets, tighten fossil-fuel language, or change transition-risk management, even if the non-members never join the alliance themselves. Waidelich et al. (2025) show that banks' financing experience creates spillovers to other banks, and the dissemination of lending knowledge is central to whether green credit scales in a green-finance setting. Papari et al. (2026) complement this by showing that financial learning in transitions operates not only through learning-by-doing, but also through learning-by-interacting, especially at the interface between niche projects and incumbent financiers. As a result, once some banks acquire and apply climate-

related lending knowledge, part of this knowledge can spill over to other banks through repeated interactions and accumulated lending experience. In this context, the Net-Zero Banking Alliance can serve as an accelerator for the diffusion of climate-related information and practices.

2.2 Hypothesis Development

The existing literature suggests that the effect of climate alliances on capital allocation in energy industry and financial intermediation remains unclear. In particular, it is not well understood whether such alliances induce a reallocation of credit across energy financing or whether their influence extends beyond formal membership through financial networks.

In this paper, we conceptualize the impact of climate alliances as operating through a layered transmission mechanism. First, alliance membership may directly affect banks' lending decisions through commitment and portfolio alignment requirements. Second, banks that directly co-lend with alliance members may adjust their behavior through repeated interactions, learning, and coordination in syndicated lending relationships, giving rise to local peer effects. Third, alliance-related practices may diffuse more broadly through the syndicated lending network, generating spillover effects beyond direct partnerships.

Accordingly, we organize our empirical analysis around the following hypothesis:

> Hypothesis 1 (Divestment): NZBA member banks are expected to reduce their lending exposure (smaller loan volume or higher loan price) to fossil fuel projects to a greater extent than non-member banks, reflecting efforts to lower financed emissions and realign portfolios with net-zero targets
>
> Hypothesis 1.1 (Divestment): NZBA non-member banks are expected to reduce their lending exposure (smaller loan volume or higher loan price) to fossil fuel projects if they are found to syndicate or be proximate with member banks than those non-member banks that do not, reflecting effects of broader influence from NZBA on non-member banks.
>
> Hypothesis 2 (Scaling-up): NZBA member banks are expected to expand their lending to renewable energy projects more rapidly than non-member banks (larger loan volume or lower loan price), thereby increasing the share of low-carbon assets within their overall loan portfolios.
>
> Hypothesis 2.2 (Scaling-up): NZBA non-member banks are expected to expand their lending to renewable energy projects more rapidly (larger loan volume or lower loan price), if they are found to syndicate or be proximate with member banks than those non-member banks that do not, reflecting effects of broader influence from NZBA on non-member banks.

3. Data

We use Bloomberg loan database to source deal information data from 2011 to 2024 covering transactions in the energy and utility sectors (Bloomberg L.P. 2025). The loan database includes loan level information covering loan value, maturity, spreads where available, loan purpose, and lender and borrower information. The loan database is complemented with financial institution classification using the Bloomberg Industry Classification Standard (BICS) to classify them into banks and non-banks, with our focus being on banks within those who lend. We classify an entity as a "bank" if it is a commercial bank, a policy or development bank, or an export credit agency that provides credit, guarantees, or trade finance. Sovereign wealth funds, government ministries, insurance companies, asset managers, and non-financial corporates are classified as non-banks. The banks are further classified as members or non-members of NZBA using official NZBA annual reports. We also extract bank and borrower financials from Bloomberg Terminal.

Our data collection yields a total of 16,177 loans which are reduced for reporting incompleteness (bank names not present) and technology classification as shown in Table 1. While fossil fuel subsectors are clearly identified within the energy sector for technology classification, renewable energy assets (such as solar and wind) are not explicitly distinguished. Therefore, a keyword-based classification approach is applied to loan descriptions to identify renewable energy projects. The final restricted sample of deals with complete lender disclosure yields a final dataset of 11,290 unique loan transactions, comprising 5,175 renewable energy loans and 6,115 fossil fuel loans.

Within the final set of loans, we recognize 4,981 loans with exact lending distribution among the participants whereas 6,309 loans are reported without lending distribution. Additionally, we identify revolving loans as facilities involving multiple lender groups or multiple signing dates, for which lender-specific exposures are typically not disclosed. Therefore, for loans that are revolving or lack loan distribution information, we allocate the total value equally among all participating lenders. This equal-split assumption is widely adopted in the syndicated loan literature when lender-level allocations are unobserved (Rickman et al. 2024; Alperovych et al. 2022; Gumber et al. 2025). In contrast, for loans with valid share distribution data, we allocate the transaction amount proportionally according to the reported lender shares, thereby preserving observed heterogeneity in lender exposure. We acknowledge the bias that may result from our assumption and discuss model specification and robustness checks ahead.

Next, we bifurcate loans between project finance and non-project-finance (referred to as *corporate finance structures ahead)* lending as presented in Table 1. This asymmetric filtering is motivated by the fundamentally differing transaction models of the two sectors as depicted in Table 1. Renewable energy projects frequently adopt project finance arrangements, especially wind and solar since project finance offers investors a mechanism to de-risk their balance sheets by isolating individual investments within legally and financially separate entities, commonly structured as special purpose vehicles (SPVs) (Baldauf and Jochem 2024; Steffen 2018, 2020). By contrast, large-scale fossil fuel investments, such as coal- and gas-fired power plants, have traditionally been financed through corporate finance structures that rely on the sponsoring firm's balance sheet and broader cash flow base rather than project-level risk segregation (Baldauf and

Jochem 2024). As a result, fossil fuel and renewable energy investments tend to exhibit systematically different financing patterns, with corporate finance dominating fossil fuel lending and project finance playing a more central role in renewable energy deployment, reflecting both technological characteristics and market design considerations (Egli et al. 2018; Steffen 2020; Gumber et al. 2025).

Table 1. Loan-level data summary from 2011-2024

2011-2024	**Total Loans**	**RE Loans**	**FF Loans**
Deals (including incomplete records)	16,177	6,812	9,365
Deals (complete records)	11,290	5,175	6,115
Deals (Project Finance)	4,768	3,590	1,178
Deals (non-Project Finance)	6,522	1,585	4,937
Spreads	5,665	1,156	4,509
Spreads (Project Finance)	908	547	361
Spreads (non-Project Finance)	4,757	609	4,148

RE: renewable energy; FF: fossil fuel

Finally, we construct a balanced panel of loan- and bank-level observations suitable for empirical analysis by excluding banks without any issued or participated loans between 2016 and 2020. Starting from a universe of 1,863 financial institutions (see Table 2), of which 1,078 are banks[3], our loan-level data cover 857 banks engaged in fossil fuel corporate-level lending and 408 banks participating in renewable energy project finance. We further exclude banks that exhibit no active lending activity during the 2016–2020 period, resulting in the omission of 184 banks from the fossil fuel corporate-level lending sample and 60 banks from the renewable energy project finance sample. We further restrict the sample to banks with available country identifiers and bank-level financial information, including total assets.

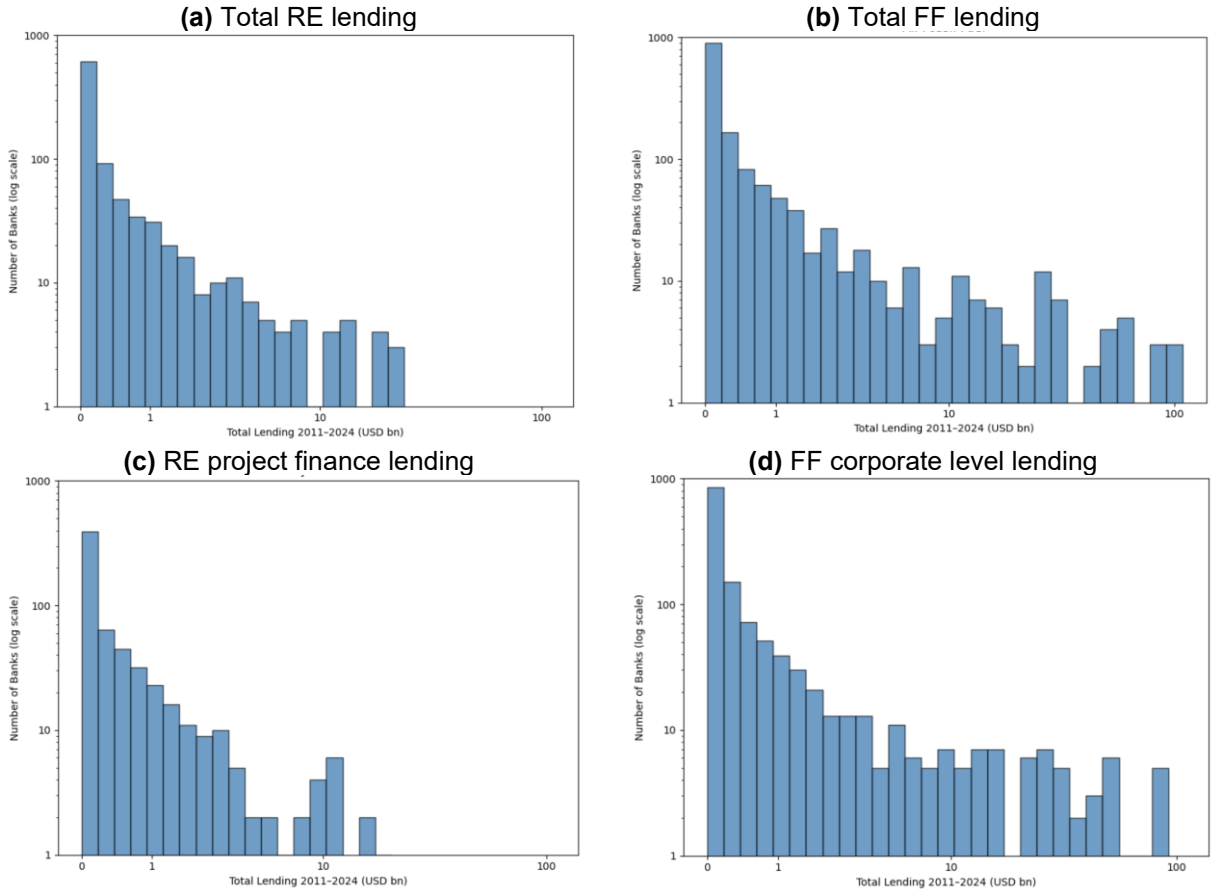
Table 2. Bank-level data summary from 2011-2024

The number of financial institutions in the whole data sample	1863	
The number of banks in the whole data sample	1078	
	Fossil Fuel (Corporate level)	*Renewable Energy (Project Finance)*
Banks in data sample	857	408
Banks with active lending activity between 2016 and 2020	673	348
Banks with active lending activity between 2016 and 2020 and have available bank-level financial data	495	275

[3] We exclude non-bank financial institutions after allocating transaction amounts to individual loan lenders.

After merging loan records with bank financial data, the final analytical sample comprises 495 banks in the fossil fuel lending sample and 275 banks in the renewable energy project finance sample. The distribution of project and corporate level differentiation for renewable energy and fossil fuel lending in depicted in Figure 1. These banks are subsequently matched with official Net-Zero Banking Alliance (NZBA) membership records to distinguish between member and non-member institutions in the empirical analysis (see Table 2). However, as we discuss ahead, we further restrict the sample due to parallel trend assumptions seen on the full sample strategy discussed in Section 3.

Figure 1. Total lending amount for RE and FF



3.1. Net-Zero Banking Alliance (NZBA)

We obtain the list of NZBA members from the alliance's official progress reports[4], which provide detailed information on member names, countries of domicile, joining dates, and asset size (see

[4] Net-Zero Banking Alliance 2024 Progress Report.

Appendix A). We then use this information to identify NZBA-affiliated banks in both the loan-level and bank-level datasets.

3.2. Loan spread analysis

Among the 11,290 loans, we also find 5,665 loans with non-missing loan spread information, including 4509 fossil fuel loans and 1156 renewable energy loans (see Table 1). To reduce data loss, we conduct partial analysis of loans with spread information. To ensure cross-currency comparability, all loan spreads are normalized into a USD-equivalent interest rate, using data exclusively obtained from the Bloomberg Terminal. For floating-rate loans, non-USD benchmark rates are converted into USD equivalents using cross-currency basis swaps (CCBS) corresponding to the loan currency and tenor. This adjustment accounts for deviations from covered interest parity and allows floating-rate contracts denominated in different currencies to be expressed on a comparable USD basis. For fixed-rate loans, we normalize interest rates by first netting out the country-specific sovereign yield associated with the loan currency and maturity and then adding back the corresponding USD government bond yield of the same maturity. Formally, the USD-equivalent rate for a fixed-rate loan is constructed as:

$$r_{equiv}^{USD} = (r_{fixed}^{local} - r_{gov}^{local}) + r_{gov}^{USD}$$

Equation 1

where r_{fixed}^{local} denotes the fixed coupon rate in the local currency during the year of loan issuance, r_{gov}^{local} is the local government bond yield, and r_{gov}^{USD} is the matched USD government bond yield. All yield and swap data used in this normalization procedure are sourced from Bloomberg.

4. Method

Besides discussing descriptive results, we execute difference-in-differences (DiD) to exploit the formation of the NZBA as a common policy shock in 2021. We discuss the application of DiD framework in this section.

4.1. Identification Strategy

For hypothesis 1 and 2, our empirical strategy investigates whether participation in the Net-Zero Banking Alliance (NZBA) is associated with (I) a reallocation of lending away from fossil fuel (FF) activities toward renewable energy (RE) investments, and (ii) changes in the pricing of debt through loan spreads. We compare lending behavior before and after the formation of the NZBA between member banks and non-member banks with a DiD framework.

This research design exploits the formation of the NZBA as a common policy shock in 2021 and contrasts post-2021 lending outcomes of NZBA member banks with those of otherwise comparable non-member banks. It allows us to identify whether NZBA commitments influence banks' portfolio composition and the cost of capital they provide to different energy sectors. While we initially considered loan spreads as an additional outcome of interest, event-study diagnostics indicate violations of the parallel trend assumption for loan pricing. Therefore, we focus the baseline analysis on fossil fuel corporate lending as reflected in equation 2 and renewable energy project finance lending as reflected in equation 3 below. All baseline specifications include bank fixed effects and country-by-year fixed effects, with standard errors clustered at the bank level.

The baseline specification for fossil fuel corporate-level analysis and renewable energy project finance analysis is given by:

$$FF_{ict} = \beta_{1(NZBA_i \times Post_t)} + X_i + \alpha_i + \delta_{ct} + \epsilon_{ict}$$

Equation 2

$$RE_{ict} = \beta_{2(NZBA_i \times Post_t)} + X_i + \alpha_i + \delta_{ct} + \epsilon_{ict}$$

Equation 3

where FF_{ict} denotes the total fossil fuel corporate lending of bank i in country c and year t, measured as the allocated loan amount aggregated across syndicated deals and RE_{ict} denotes the total renewable energy project finance lending of bank i in country c and year t, measured as the allocated loan amount aggregated across syndicated deals. $NZBA_i$ is an indicator equal to one if bank i is a member of the Net-Zero Banking Alliance and zero otherwise. $Post_t$ is a post-treatment indicator equal to one for years after the formation of NZBA and zero for pre-treatment years, with the baseline policy year set to 2021. X_i denotes a vector of time-varying bank-level control variables, including return on assets (ROA), the loan loss reserve ratio (LLR), and leverage

(Jung et al. 2025). These variables are included to account for heterogeneity in banks' financial conditions that may independently affect lending behavior. In particular, ROA serves as a proxy for bank profitability and internal capital generation, the loan loss reserve ratio captures credit risk and asset quality, and leverage reflects balance sheet structure and funding constraints. Controlling for these dimensions helps mitigate omitted variable bias by isolating the effect of NZBA participation from concurrent changes in banks' financial performance and risk profiles.

The specification includes bank fixed effects α_i, which control for time-invariant heterogeneity across banks, such as size, business model, and long-run risk preferences. We also include country-by-year fixed effects δ_{ct} to absorb macroeconomic conditions, regulatory changes, and energy market shocks that are common to all banks operating within the same country-year. Standard errors are clustered at the bank level to account for serial correlation in lending behavior over time. The coefficient of interest, β_1 and β_2 captures the average change in fossil fuel corporate lending and renewable energy project finance by NZBA member banks relative to non-member banks following NZBA formation.

4.2. Spillovers: Network Structure

To examine spillovers from NZBA to non-NZBA banks (hypothesis 1.1 and 2.1), we construct dynamic syndicated bank–bank lending networks for global syndicated energy lending market based on interactions among constituent banks observed in syndicated loan transactions from Bloomberg, covering both fossil fuel and renewable energy lending. Each bank is treated as a node in the network. An undirected tie between two banks is defined if they jointly participate in at least one syndicated loan within a given rolling window. We drop duplicate bank names within each loan and loans involving a single bank do not generate network links, ensuring that network connections reflect genuine interbank co-lending relationships rather than mechanical duplication. We construct the network using annual rolling five-year trailing windows to capture persistent interbank relationships rather than short-term co-financing activity (Alperovych et al. 2022; Gumber and Steffen 2025; Kobayashi and Takaguchi 2018). For instance, the network for year t is based on all syndicated loans signed between t-5 and t-1. This approach smooths year-specific volatility and ensures that network measures reflect accumulated interaction histories rather than contemporaneous lending decisions. We construct the lending network using a count-based weighting scheme, where edge weights measure the number of syndicated loans jointly undertaken by a bank pair within a rolling window, capturing the frequency of repeated interbank interactions. The set of all such ties forms the prevailing count-weighted syndication network, which can be represented as an adjacency matrix[5].

[5] Formally, an N × N adjacency matrix (A = f(i, j)) is formed by N distinct banks in the network, where each element f(i, j) denotes a tie between banks i and j, and function f defines the weight of the tie.

4.2.1 Network Measurement

We first compute degree centrality and eigenvector centrality for each bank–bank co-lending network. Degree centrality summarizes the scale of a bank's direct syndication linkages and serves as a proxy for the number of relationships an actor in the network has (Hochberg et al. 2007; Godlewski et al. 2012). Under the premise that repeated co-lending interactions facilitate information exchange, a higher degree implies more channels through which practices and signals can circulate. Eigenvector centrality captures a bank's embeddedness in the network core by considering the quality of these ties (Bonacich and Lloyd 2001; Hochberg et al. 2007, 2015; Alperovych et al. 2022).

We then construct NZBA-specific variants of these measures. First, NZBA degree is defined as the number of a bank's co-lending ties with NZBA members, capturing the intensity of its direct exposure to alliance participants. Second, we decompose eigenvector centrality to extract the component attributable to NZBA neighbors, which measures the extent to which bank i's network position is supported by links to central NZBA institutions. In our setting, eigenvector contributed from NZBA members help to capture the extent to which a bank's network position is shaped by its links to influential NZBA members. The higher contribution from NZBA members, the more information can be spread via the connections. Appendix D provides additional details on computational steps followed in determining degree and eigenvector centrality. We acknowledge that these two indicators cannot capture the indirect effect from NZBA members via non-member banks such as two or more steps diffusion or indirect communication heard via industry networks (Hochberg et al. 2007; Alperovych et al. 2022).

4.3. Spillover Effect Estimation Strategy

We estimate spillover effects to non-NZBA members using a Poisson Pseudo–Maximum Likelihood (PPML) framework with fixed effects to examine whether exposure to NZBA banks through syndicated lending networks influences the lending behavior of non-NZBA banks. PPML is useful since syndicated loan markets are non-negative, highly right-skewed, and characterized by a substantial mass of zero observations, as many banks do not participate in each lending segment in certain years (see Appendix E). Thereafter, we restrict the spillover analysis to non-NZBA banks when assessing spillover effects.

The dependent variable is fossil fuel (FF), corporate-level lending and renewable energy (RE) project finance lending at the bank-year level, measured in million USD, thereby preserving the economic scale of lending activities and allowing zero observations to remain in the sample.

Formally, we estimate the following model:

$$E[\,FF_{it} \mid X_{it}, \alpha_i, \gamma_t\,] = exp(\beta_1 X_{it} + \alpha_i + \gamma_t)$$

Equation 4

$$E[\, RE_{it} \mid X_{it}, \alpha_i, \gamma_t \,] = exp(\beta_2 X_{it} + \alpha_i + \gamma_t)$$

Equation 5

where FF_{it} or RE_{it} denotes fossil fuel corporate-level lending or renewable energy project finance lending by bank i in year t, and X_{it} represents one of the network centrality measures capturing spillover exposure. Specifically, we enter the following variables separately to avoid multicollinearity and to isolate distinct network channels: NZBA-specific degree centrality, and eigenvector centrality contributed by NZBA members.

The specification includes bank fixed effects α_i and year fixed effects γ_t. Standard errors are clustered at the bank level like before. Moreover, we estimate the model for the full sample period (2016–2024) and additionally conduct split-sample analyses for the pre-transition period (2016–2020) and the post-transition period (2021–2024). This approach allows us to assess whether network spillovers intensify following the consolidation of NZBA commitments in 2021.

5. Results

5.1. NZBA membership and lending shifts

Our analysis is guided by the fact that member banks of NZBA are large and they play a central role in the global energy transition due to their substantial capital bases, international reach, and reputational visibility (Rickman et al. 2024). The lending behavior of the these top tier of lenders plays a decisive role in determining the scale of renewable energy investment as well as the pace at which fossil fuel financing is phased out (Baldauf and Jochem 2024). This results in a selection bias, first due to the alliance's desire to include large influential banks, and second due to banks' own reputation risk management to align with alliances that align with domestic policy positions. We confirm this in our data where the distribution of banks' lending volumes for both renewable energy and fossil fuel is highly skewed, with the top 30 banks accounting for more than half of the total lending between 2011 and 2024. Moreover, the top 20% of banks account for over 80% of the lending volume as we discussed later in this section.

These top banks, headquartered mostly in developed markets, especially Europe, possess greater experience and established portfolios in low-carbon technologies and face larger climate mitigation scrutiny which makes them more inclined to join coordinated climate initiatives (Benincasa 2021; Reghezza et al. 2022; Sastry et al. 2024). Except for European Investment Bank, a policy driven state investment bank, large European Banks are found to have been members of the NZBA. The composition of these top 30 leading lenders, however, differs substantially. Japanese banks, such as MUFG, Sumitomo Mitsui Financial Group, and Mizuho Financial Group, feature consistently among the largest financiers in both fossil fuel and renewable energy lending, a pattern that is also observed for major Chinese institutions such as the Bank of China and ICBC although Chinese banks were not NZBA members. By contrast, major US banking groups, including JPMorgan Chase, Citi, Bank of America, are disproportionately represented in fossil fuel financing relative to renewable energy lending. European banks exhibit the opposite profile, appearing more prominently among the leading lenders to renewable energy than to fossil fuel assets as expected due to domestic policy preferences (see Figure 2).

In terms of renewable energy lending market, project finance accounts for most of the renewable energy lending, representing 69.37% of total RE loan counts. This dominance is consistent with the financing structure of renewable energy deployment, where capital-intensive projects are typically financed through project-specific structures (Gumber and Steffen 2025; Steffen 2018, 2020). Figure 3 further illustrates the evolution of average renewable energy loan transactions per bank over time for NZBA and non-NZBA banks. NZBA members consistently provide larger average loan amounts relative to non-members, and the gap widens notably after 2018. For NZBA banks, average project-finance loan allocations rise steadily, with pronounced peaks around 2019 and 2023, suggesting an increasing strategic commitment to renewable energy financing. In contrast, non-NZBA banks maintain relatively small and stable average loan sizes with limited variation over time. Therefore, the predominance of project finance in renewable energy lending

and the substantially higher average loan amounts provided by NZBA banks indicate higher risk propensity on part of NZBA members.

Figure 2. Lending changes and market share of RE and FF investment for participant banks

(**a)** average annual lending changes of RE project finance for pre-NZBA (2016-2020) and post-NZBA (2021-2024) and market share of banks in post-NZBA period; **(b)** average annual lending changes of FF non-project finance for pre-NZBA (2016-2020) and post-NZBA (2021-2024) and market share of banks in post-NZBA period)

(a) **(b)**

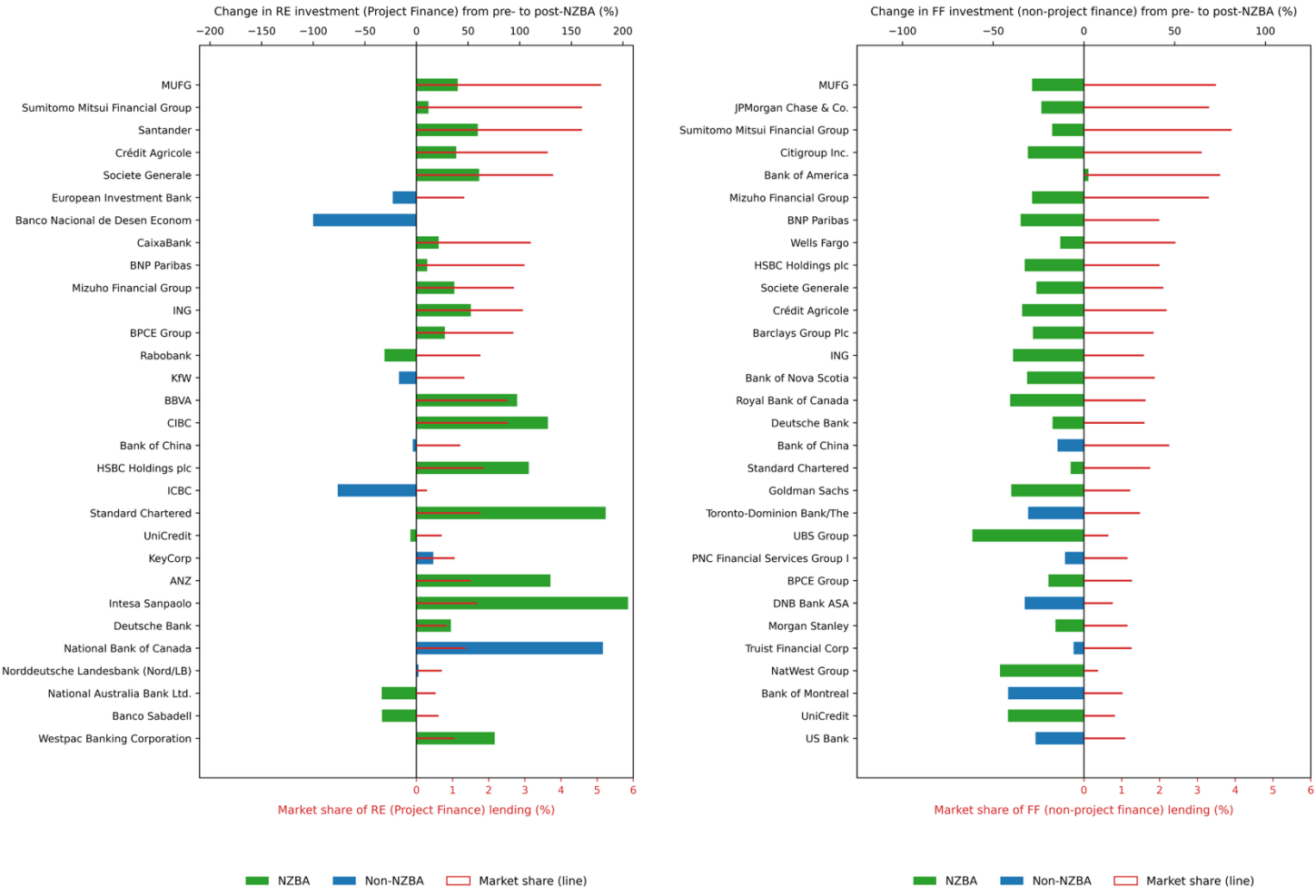
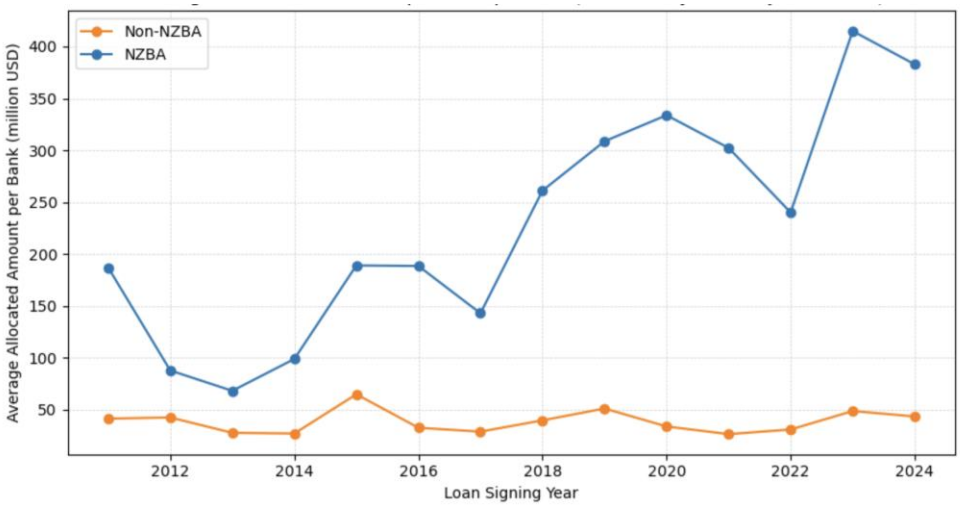
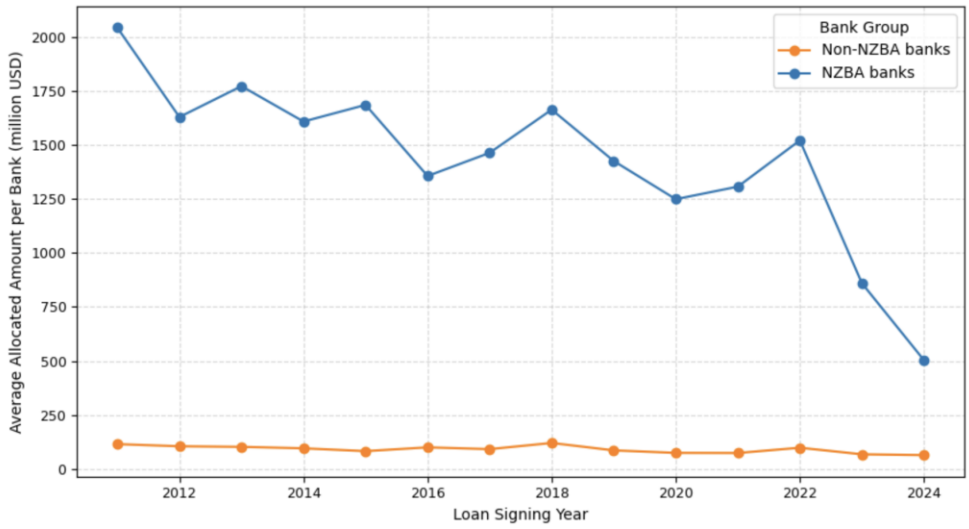


Figure 3. Renewable Energy Loans (Project Finance) Transaction per Bank, 2011–2024



In the case of fossil fuel lending, corporate-level finance loans account for 80.74% of total loan counts, which is consistent with the expectation that fossil fuel firms rely primarily on corporate-level borrowing rather than project-specific financing. Figure 4 illustrates the evolution of average fossil fuel loan transactions per bank over time for NZBA and non-NZBA banks after excluding project finance lending. NZBA banks exhibit substantially higher average loan amounts throughout the sample period. Their lending shows a marked downward trend particularly after 2021 suggesting a gradual retrenchment from large-scale fossil fuel financing among NZBA members following the alliance's establishment.

Figure 4. Fossil Fuel Loan (Corporate-level) Transaction per Bank, 2011–2024



5.2. NZBA membership and loan spread

We first summarize the aggregate evolution of loan spreads for fossil fuel and renewable energy loans and then, we also restrict our data sample to fossil fuel corporate-level lending and renewable energy project finance lending to make a comparison. Figure 5(a) shows the overall spread of fossil fuel and renewable energy loans that differ substantially after 2017. Fossil fuel loan spreads increase steadily, whereas renewable energy loan spreads decline gradually before rising again after 2021, generating a clear and persistent divergence that is consistent with existing evidence on the relative cost of debt for fossil fuel and renewable energy firms that documents an initial phase of volatility followed by a more pronounced financing advantage for renewable energy (Kempa et al. 2021). This partial convergence in the cost of debt later reflects the increasing maturity and large-scale deployment of renewable energy technologies, which reduces the need for concessional financing as projects become more standardized and commercially viable (Gumber et al. 2025). As renewable investments transition from niche to mainstream assets, banks gradually withdraw preferential pricing, often a result of policy support measures, leading to a normalization of borrowing costs even as fossil fuel assets continue to face elevated transition-related risk premiums. However, with Figure 5(b), project-financed renewable energy loans showcase persistent advantage vis-vis corporate fossil fuel loans. In context of our finding in Section 4.1, this is driven by higher lending from large established NZBA banks capable of managing project-financed risks while they shy away from fossil fuel lending due to higher perceived transition risks.

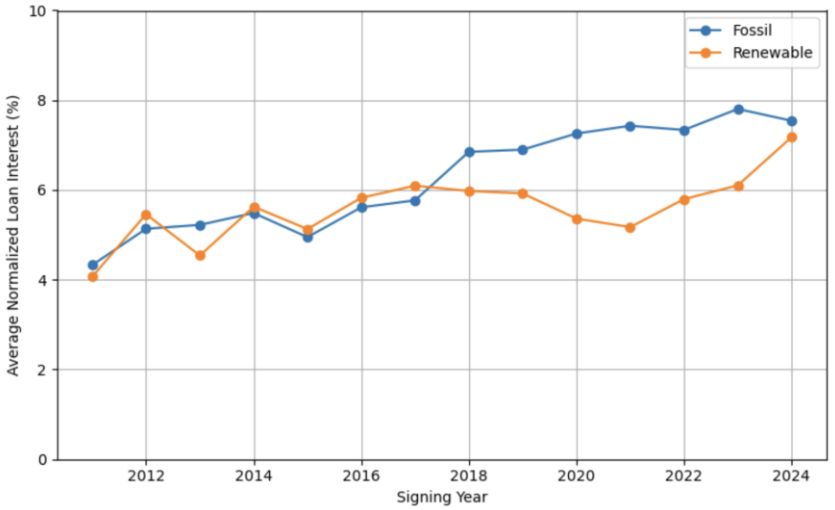
Building on these aggregate dynamics, we also examine whether syndicate leadership linked to the Net Zero Banking Alliance is associated with differential loan pricing. We define a loan as NZBA-arranged when NZBA member banks constitute more than half of the arrangers in the syndicate, reflecting the group of lenders most directly involved in structuring and pricing the facility. Then, loans with NZBA arranger majorities are generally associated with lower loan spreads than loans without NZBA arranger majorities, consistent with the interpretation that NZBA-linked arrangers are large banks and they may facilitate stronger screening, reputational certification, or standardized climate-related risk management (Harjoto et al. 2006; Sastry et al. 2024; Gasparini and Tufano 2025; Ross 2010; Godlewski et al. 2012).

However, renewable energy project finance exhibits a distinct post 2021 pattern as seen in Figure 5(d). Renewable project finance loans without NZBA arranger majorities display lower spreads than those with NZBA arranger majorities after 2021. Possible explanations include policy withdrawal of concessional terms that makes projects riskier in countries of NZBA member operations whereas non-NZBA member countries such as China where renewable energy expansion occurs drive down the spreads. Also, renewable energy technologies mature, competition among lenders intensifies for standardized and lower-risk renewable projects, compressing spreads particularly for non NZBA-led syndicates who must accept lower returns to find deals in a NBZA crowded market. We also find similar results when spreads are weighted for loan amount (see Appendix F1).

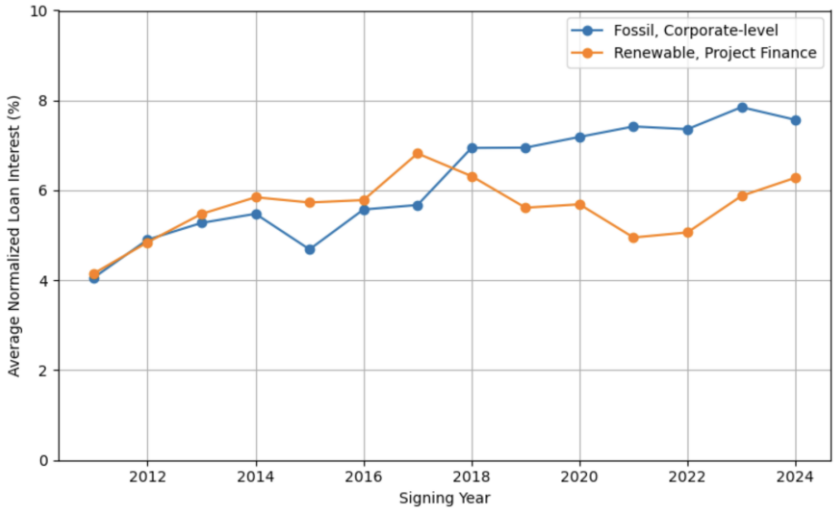
Furthermore, we also examine whether the formation of the NZBA is associated with changes in loan pricing among European banks (see Appendix G). However, the event-study diagnostics indicate that the parallel trends assumption does not hold for either fossil fuel corporate-level lending or renewable energy project finance in the European sample (see Figure E3, Appendix E), which prevents a credible causal interpretation within the DiD framework. We therefore refrain from drawing causal conclusions from the spread analysis and interpret the evidence as descriptive only. In addition, we do not further restrict the sample to European Union banks, as doing so would substantially reduce the number of observations and weaken the representativeness of the loan spread sample.

Figure 5. Average loan spreads

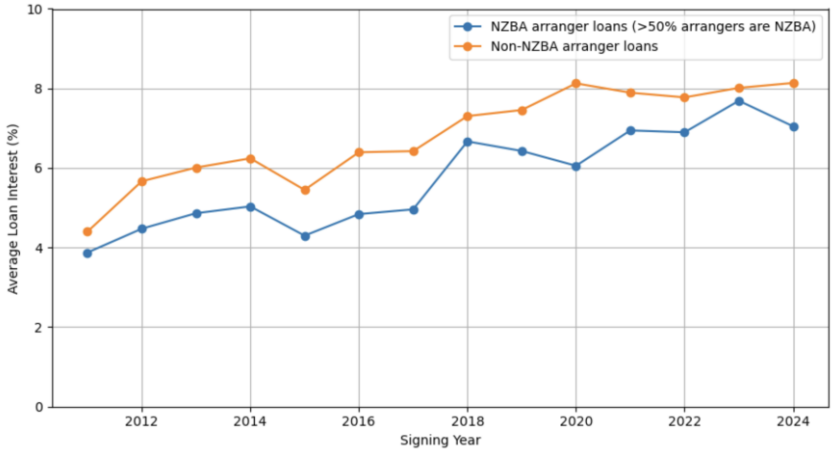
(a) fossil fuel lending and renewable energy lending, 2011–2024



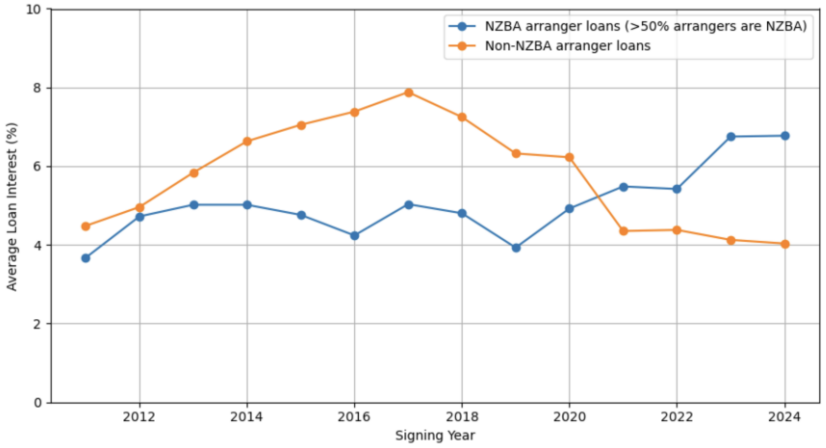
(b) fossil fuel corporate-level lending and renewable energy project finance lending, 2011–2024



(c) Fossil fuel corporate-level finance lending for NZBA arranger loans and non-NZBA arranger loans, 2011–2024



(d) Renewable energy project finance lending for NZBA arranger loans and non-NZBA arranger loans, 2011–2024

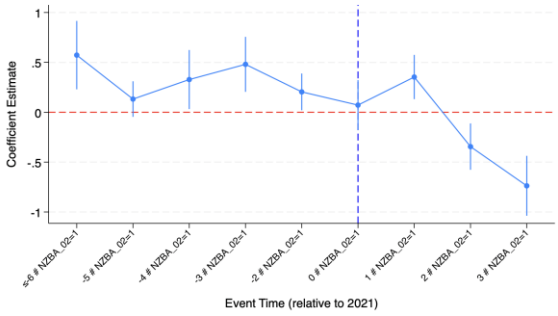


5.3. Membership DiD Effects

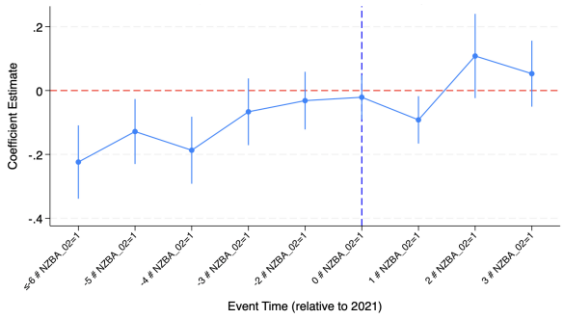
Following the above descriptive examination, we test hypothesis 1 and 2 to assess whether NZBA banks divest from fossil fuels and increase allocation to renewable energy assets. However, we run into three key challenges. First, pre-treatment lending dynamics differ significantly between NZBA and non NZBA banks, indicating that the parallel trends assumption does not hold in the full sample (see Figure 6). Second, both fossil fuel corporate lending and renewable energy project finance lending is not a common or continuous activity for all banks. Large banks issue fossil fuel and renewable energy loans at much larger scale and exhibit substantially greater continuity over time, while smaller banks participate sporadically or not at all. As a result, many small banks have limited or zero exposure to fossil fuel lending or renewable energy lending, which mechanically generates irregular and discontinuous lending paths. Third, these differences reflect a deeper structural distinction between large and small banks that goes beyond scale alone. Large banks play a central role in financing capital intensive energy projects and are often responsible for new energy investment, supporting energy supply and energy security during the transition period. Their lending decisions are therefore shaped not only by climate related commitments, but also by institutional mandates, size of capital pool, and macro financial considerations (Bongini et al. 2015; Geddes et al. 2018; Rickman et al. 2024; Gasparini et al. 2024; Gasparini and Tufano 2025). In contrast, smaller banks are less exposed to large scale energy projects and follow fundamentally different lending trajectories, even in the absence of NZBA participation.

Figure 6. Event Study with bank and country-year fixed effect for fossil fuel and renewable energy (transaction amount, full sample)

(a) Fossil fuel corporate-level lending (transaction amount, full sample)



(b) Renewable energy project finance lending (transaction amount, full sample)



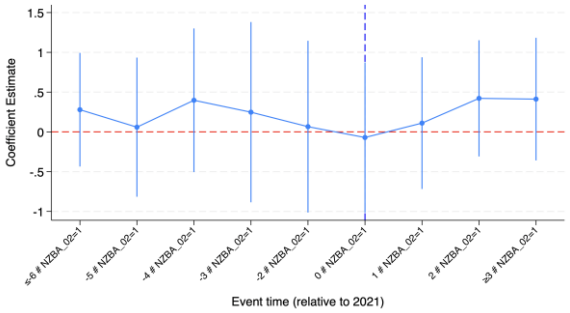
Therefore, standard DiD model on the full sample is not economically meaningful (Laeven and Levine 2007). We define systemically important banks as those with total assets exceeding USD 250 billion. This threshold is motivated by the U.S. regulatory framework following the Economic Growth, Regulatory Relief, and Consumer Protection Act of 2018, which raised the asset threshold for enhanced prudential standards from USD 50 billion to USD 250 billion (Mountain, Travis P 2018). Thus, we restrict the analysis to large banks defined as the average total assets larger than 250 billion dollars from 2011 to 2024 to construct a more credible counterfactual and improve comparability. This restriction is implemented separately for the fossil fuel and renewable

energy lending samples. Following this procedure, the renewable energy lending sample comprises 82 banks, including 50 NZBA members and 32 non-NZBA banks, while the fossil fuel corporate lending sample consists of 98 banks, of which 53 are NZBA members and 45 are non-NZBA banks.

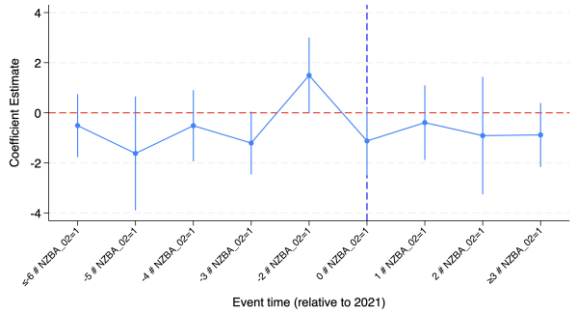
We further examine loan spread dynamics to test Hypotheses 1 and 2, evaluating whether NZBA banks price fossil fuel loans at higher spreads while offering relatively lower spreads for renewable energy projects. Event-study diagnostics show that the parallel trends assumption holds only for fossil fuel corporate-level lending and not for renewable energy project finance (see Figure 8). Moreover, even within the fossil fuel segment, the standard DiD estimates on loan spreads are statistically insignificant. We do not further restrict the spread sample to large banks, as doing so would substantially reduce the number of observations and compromise representativeness, particularly in the renewable project finance market.

Figure 8. Event Study with bank and country-year fixed effect for fossil fuel and renewable energy (loan spread, full sample)

(a) Fossil fuel corporate-level lending (loan spread, full sample)



(b) Renewable energy project finance lending (loan spread, full sample)



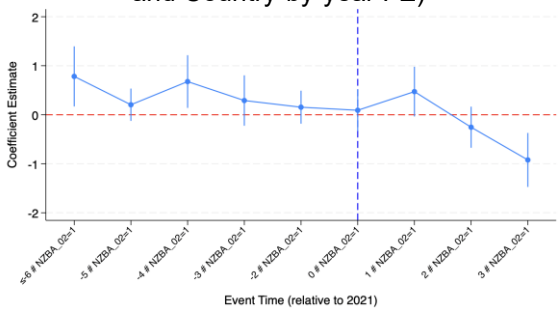
5.3.1 DiD Analysis on Restricted Sample

Within the group of large banks, pre-treatment lending dynamics are substantially more aligned. As seen in Figure 9, event study evidence and near term pre trend tests fail to reject the parallel trends assumption, for both fossil fuel corporate funding and renewable energy project finance. Table 3 presents the standard difference-in-differences estimates based on the restricted sample of large banks. The coefficient on NZBA × Post is negative and statistically significant at the 1% level in the fossil fuel corporate lending specification, indicating that NZBA member banks reduced their fossil fuel lending relative to comparable non-member banks following the alliance's formation. The magnitude of the estimate suggests an average decline of approximately 0.654 billion USD in annual fossil fuel corporate lending by member banks (Bank FE and Country-by-year FE). In contrast, the corresponding coefficient in the renewable energy project finance specification is positive and significant at the 5% level, implying that NZBA participation is associated with an increase in 0.121 billion USD in renewable energy lending relative to non-members (Bank FE and Country-by-year FE). The empirical results remain robust when we

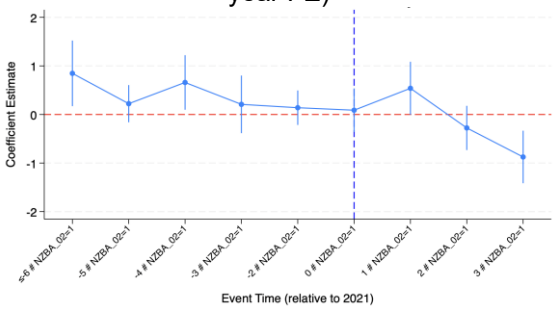
implement a CEM-DiD specification using pre-treatment lending and bank total assets as matching variables (see Appendix C).

Figure 9. Event Study for Fossil Fuel Corporate Transaction Analysis and Renewable Energy Transaction Analysis (restricted sample with threshold of 250 billion USD)

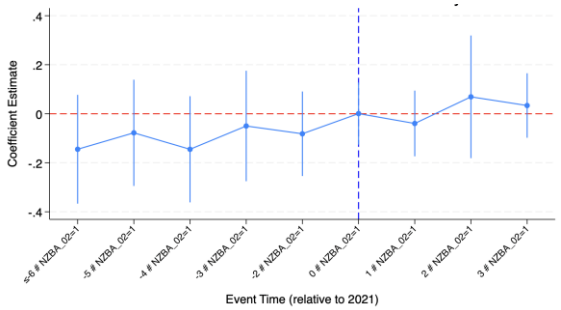
(a) Fossil fuel corporate-level lending (Bank FE and Country-by-year FE)



(b) Fossil fuel corporate-level lending (Country-by-year FE)



(c) Renewable energy project finance lending (Bank FE and Country-by-year FE)



(d) Renewable energy project finance lending (Country-by-year FE)

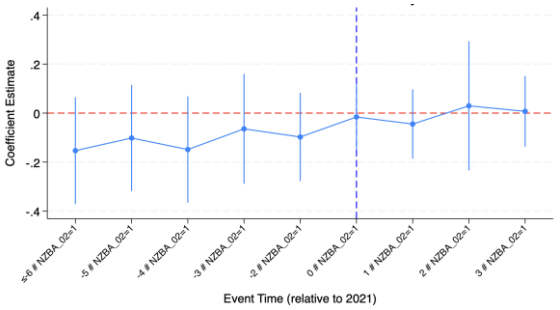


Table 3. Standard DiD Economic results (restricted sample)

Variable	***FF Corporate level***		***RE Project Finance***	
$NZBA \times Post$	-0.663***	-0.654***	0.110**	0.121**
Return on Asset	-4.348	-26.588	8.742	-2.232
Loan Loss Reserves / Loans	11.500	2.018	1.112	-1.455
Leverage	3.420	-1.670	-0.697	-0.280
Constant	-2.865	3.298	0.717	0.523
N	1166	1166	961	961
Controls	Y	Y	Y	Y
Bank FE	N	Y	N	Y
County by year FE	Y	Y	Y	Y
Adj R2	0.411	0.841	0.440	0.723

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Furthermore, we conduct an empirical analysis when restricting sample to banks located in Europe or located in EU, respectively (see Appendix G). We include bank fixed effect α_i and year fixed effect δ_t rather than country-by-year fixed effects in both Europe and EU empirical analysis. This specification reflects our assumption that banks across European countries are exposed to broadly common time-varying macroeconomic and policy shocks at the regional level. It is also consistent with the empirical strategy adopted by Sastry et al. (2024). In the fossil fuel analysis, both subsamples satisfy the parallel trends assumption (see Figure G1, Appendix G). The empirical results further indicate a statistically significant reduction in fossil fuel lending following the formation of the NZBA in both the Europe and EU samples (see Table G1, Appendix G). Moreover, when we restrict the sample period to end in 2022, consistent with the time window used in Sastry et al. (2024), the estimated effect becomes statistically insignificant (see Table G2, Appendix G). This suggests that the reduction in fossil fuel lending associated with NZBA membership emerges more clearly when a longer post-treatment period is considered.

By contrast, the renewable energy transaction analysis fails to satisfy the parallel trends assumption in both the Europe and EU subsamples (see Figure G2, Appendix G), making the DiD estimates difficult to interpret causally. The event-study graphs show that renewable energy lending was already on an upward trajectory prior to the formation of the NZBA, implying that the observed post-2021 increase is likely part of a pre-existing trend rather than a discrete alliance effect. This is plausible given that renewable energy deployment in Europe had already been supported by strong climate policy, maturing technologies, and expanding investment pipelines before 2021. Therefore, the evidence suggests that NZBA did not create a clear structural break in renewable lending within Europe, but rather coincided with an ongoing expansion that had started earlier.

5.4. Spillovers to non-NZBA Members

We examine network spillovers by focusing on non-NZBA institutions and measuring their exposure to NZBA members through syndicated lending relationships. We proxy exposure with degree contributed from NZBA and eigenvector centrality contributed from NZBA as discussed in Section 3. Visually we find NZBA member banks consistently occupy central positions within the dense core across all years (see figure F3, Appendix F), and the overall network becomes increasingly cohesive over time. The core appears more integrated and less fragmented in later years, suggesting that energy finance lending has evolved toward a more unified and system-wide structure. Therefore, NZBA banks constitute a central component of the structural backbone implying that strategic adjustments by these institutions may diffuse broadly through interbank connections (Godlewski et al. 2012; Godlewski and Sanditov 2018; Rickman et al. 2024). These are then examined with our PPML strategy.

The network measures are constructed using a five-year rolling window. Therefore, the first year for which the network-based variables can be computed is 2016 (based on the 2011–2015 window). We therefore estimate PPML models with bank and year fixed effects over 2016–2024, and separately for the pre-NZBA (2016–2020) and post-NZBA (2021–2024) subperiods (see Tables 4 and 5). We employ year fixed effects rather than country by year fixed effects because the spillover mechanism operates through global syndicated lending networks that transcend national boundaries. NZBA related adjustments are largely coordinated among internationally active banks and reflected in common shifts in risk assessment, underwriting standards, and deal participation across countries. Therefore, year fixed effects provide a more appropriate level of control by accounting for global macro-financial shocks while preserving the variation needed to identify interbank spillover effects (Onali et al. 2017; Huang et al. 2020).

The results are economically and statistically significant spillovers in fossil fuel corporate level lending. In the post-2021 period, both NZBA exposure measures enter with negative and highly significant coefficients, indicating that non-NZBA banks more closely connected to NZBA members reduce fossil fuel lending to a greater extent. The coefficient on NZBA contributed eigenvector centrality is −21.16 in the post-NZBA period. Given the exponential structure of the PPML model, this estimate implies that increases in exposure to structurally central NZBA banks are associated with economically large percentage reductions in fossil fuel lending. Evaluated at realistic changes in the measure (e.g., a 0.01 increase), the estimate corresponds to an approximate 21% decline in fossil fuel lending, indicating that spillovers transmitted through highly central NZBA institutions play a substantial role in shaping banks' post-transition lending adjustments. However, we do not further restrict the sample to European or European Union banks, as such a restriction would substantially reduce the sample size and limit the statistical power and representativeness of the spillover analysis.

Table 4. PPML Economic results for fossil fuel corporate lending (non-NZBA members)

FF Corporate Level Lending (million USD)

	(1) Full sample		(2) Pre sample (2016-2020)		(3) Post sample (2021-2024)	
Degree contributed from NZBA	0.0002**		0.0003*		-0.0009***	
	(0.0001)		(0.0002)		(0.0003)	
Eigenvector contributed from NZBA		3.4863*		8.3996*		-21.1641***
		(2.0390)		(4.9958)		(7.1274)
Bank FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	2948	2948	1508	1508	1056	1056

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In renewable energy project finance, however, we do not observe statistically significant spillover effects. Exposure to NZBA members does not translate into measurable increases in renewable lending among non-member banks.

Table 5. PPML Economic results for renewable energy project finance lending (non-NZBA members)

RE Project Finance Lending (million USD)

	(1) Full sample		(2) Pre sample (2016-2020)		(3) Post sample (2021-2024)	
Degree contributed from NZBA	-0.0001		0.0004		-0.0005	
	(0.0002)		(0.0003)		(0.0009)	
Eigenvector contributed from NZBA		-2.4306		10.7085		-0.8894
		(5.5830)		(7.1276)		(25.0769)
Bank FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Observations	1141	1141	532	532	450	450

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In summary, the evidence suggests that NZBA influence diffuses primarily through the contraction of fossil fuel lending rather than through a network-driven expansion of renewable financing. Network connections appear effective in transmitting signals of withdrawal and risk reassessment, but less effective in generating new investment capabilities, highlighting an important asymmetry in how climate-related financial norms propagate through interbank relationships.

6. Discussion & conclusion

This paper investigates whether participation in the Net-Zero Banking Alliance (NZBA) is associated with changes in banks' energy related lending behavior and whether the spillover effect will be transmitted via network structure and affect lending behavior on non-NZBA members. Our analysis focuses on two dimensions emphasized in the policy debate, which are the divestment from fossil fuel activities and the scaling-up of renewable energy finance. The empirical evidence yields several important insights regarding the scope, channels, and limits of voluntary climate finance alliances.

6.1 Divestment in Fossil Fuel Corporate Lending and Scaling-Up of Renewable Energy Lending

Our standard DiD results provide evidence in support of *Hypothesis 1 and Hypothesis 2.* We find that NZBA member banks significantly reduce fossil fuel corporate lending and expand renewable energy project finance lending relative to comparable non-member banks following NZBA formation when restricting the analysis to systemically important banks, defined as the top 20 percent of banks by pre-treatment (2016-2020) average assets. Economically, the findings suggest that NZBA membership is associated with a reallocation of lending portfolios away from fossil fuel activities and toward renewable energy financing among the large banks that dominate global energy finance. Therefore, NZBA appears to operate as a coordination mechanism that reinforces collective divestment behavior among internationally active, systemically important banks.

However, our findings contrast with Sastry et al. (2024), who find no evidence that NZBA participation reduces fossil fuel lending relative to non-members (see Appendix G). This is expected since they focuses on European banks, where climate-related regulatory pressure, disclosure requirements, and supervisory expectations are relatively stringent prior to NZBA formation (Rickman et al. 2024). In such institutional environments, NZBA commitments may impose limited or negligible additionality beyond existing policy frameworks. A second explanation relates to the time horizon of analysis. Their study covers the period from September 2018 to December 2022, which captures only the early phase of NZBA implementation (see Appendix G). Our event-study evidence indicates that lending adjustments emerge gradually rather than immediately as seen with a rapid rise in investments post 2022 seen in Figure 3. This lag is consistent with the time required for large banks to restructure long-term fossil fuel exposures and reallocate capital (Gasparini and Tufano 2025; Gasparini et al. 2024; Geddes et al. 2018). We do acknowledge that this effect is not detectable in the full sample. When small and medium-sized banks are included, the parallel trends assumption fail, and estimated treatment effects become difficult to interpret. This highlights that divestment effects associated with NZBA are concentrated among large banks (Rickman et al. 2024; Gasparini and Tufano 2025) as was expected.

6.2 Spillover Effects on Non-members

Our PPML results present evidence on spillover effects of divestment from fossil fuel corporate level lending, supporting *Hypothesis 1.1*. It is consistent with a network-based transmission mechanism that when central NZBA banks scale back participation in fossil fuel deals, syndicated banks can get a withdrawal signal in such transactions and may adjust their own portfolios to remain aligned with evolving market standards and risk perceptions. The absence of similar effects in the pre-NZBA period supports the interpretation that this contraction is associated with the post-NZBA environment rather than reflecting pre-existing trends (Dennis and Mullineaux 2000; Alperovych et al. 2022; Sufi 2007; Cai et al. 2018; Scheffer et al. 2009; Rickman et al. 2024).

However, our results don't show evidence on accelerating renewable energy project finance expansion on non-members which cannot support *Hypothesis 2.1*. This asymmetry reflects structural differences between exiting fossil fuel activities and expanding into renewable finance. While reducing fossil fuel exposure can occur through the non-renewal or downsizing of existing relationships, renewable project finance requires specialized expertise, long-term project evaluation capacity, and the ability to structure complex, capital-intensive transactions (Egli et al. 2018; Kempa et al. 2021; Sufi 2007; Steffen 2020; Schmidt 2014). This is consistent with our finding that renewable energy project finance activity is concentrated among a relatively small group of large, well-capitalized banks. This is likely due to renewable project finance being a specialized market segment characterized by higher entry costs, limited deal pipelines, and strong scale economies in due diligence and risk management (Schmidt 2014; Steffen 2018; Steffen et al. 2018). As a result, participation in renewable lending is less easily replicable through syndication exposure alone and remains primarily driven by internal capabilities and access to projects, rather than by network-based spillovers.

6.3 Implications

Our results contribute to the ongoing debate on the effectiveness of alliances in shifting financial behavior. Our case of NZBA highlights the effectiveness of alliances. While alliances will always resemble a selection bias, they are effective signaling mechanisms to restrict negative behavior if not induce positive one for the rest of the market. We observe this with lower coal lending but not an increase in renewable lending by non-NZBA banks. This effect has a corollary for decline policy, wherein institutional legitimization and group advocacy is necessary to decline unsustainable technologies (Bergek et al. 2008; Markard 2020; Bento et al. 2025).

Next, our results confirm the asymmetric role of banks in the energy transition. Large, systemically important banks account for the majority of fossil fuel corporate lending and renewable energy project finance lending (Rickman et al. 2024; Campiglio et al. 2018; Shears et al. 2025; Ross 2010; Geddes et al. 2018; Gumber et al. 2025). This suggests that global energy transition responsibilities are inherently uneven across the banking sector. Uniform expectations across banks may therefore be misaligned with their actual capacity to affect aggregate transition outcomes.

As a corollary, recent withdrawals of several large global banks from NZBA illustrate the fragility of voluntary alliances when climate objectives come into tension with energy security concerns and political pressures. In other words, the effectiveness of both the direct (DiD) and indirect (spillover) channels from voluntary climate finance initiatives is shaped by the regional regulatory and political context in which banks operate. The voluntary coordination alone thus is insufficient to sustain fossil fuel phase-out without consistent regulatory support as sustained by European countries (Gasparini et al. 2024; Schmidt 2014). Notwithstanding the fragility, this study contributes to the climate finance literature by showing that the impact of net-zero banking alliance (NZBA) is conditional rather than universal. The effectiveness depends on the interaction between bank size, network position, and lending structure. Meaningful progress in the energy transition therefore requires not only voluntary commitments by leading financial institutions but also institutional frameworks capable of anchoring and scaling these changes across the broader financial system.

Reference

Alperovych, Yan, Anantha Divakaruni, and Sophie Manigart. 2022. “Lending When Relationships Are Scarce: The Role of Information Spread via Bank Networks.” *Journal of Corporate Finance* 73 (April): 102181. https://doi.org/10.1016/j.jcorpfin.2022.102181.

Baldauf, Thomas, and Patrick Jochem. 2024. “Project Finance or Corporate Finance for Renewable Energy? An Agent-Based Insight.” *Journal of Economic Interaction and Coordination* 19 (4): 759–805. https://doi.org/10.1007/s11403-024-00425-z.

Banerjee, Abhijit, Arun G. Chandrasekhar, Esther Duflo, and Matthew O. Jackson. 2013. “THE DIFFUSION OF MICROFINANCE.” *Science*.

Battiston, Stefano, Antoine Mandel, Irene Monasterolo, Franziska Schütze, and Gabriele Visentin. 2017. “A Climate Stress-Test of the Financial System.” *Nature Climate Change* 7 (4): 283–88. https://doi.org/10.1038/nclimate3255.

Benincasa, Emanuela. 2021. “Climate Policy and Cross-Border Lending: Evidence from the Syndicated Loan Market.” *Economic and Political Studies* 9 (4): 463–76. https://doi.org/10.1080/20954816.2021.1976904.

Bento, Nuno, Alejandro Nuñez-Jimenez, and Noah Kittner. 2025. “Decline Processes in Technological Innovation Systems: Lessons from Energy Technologies.” *Research Policy* 54 (3): 105174. https://doi.org/10.1016/j.respol.2025.105174.

Bergek, Anna, Staffan Jacobsson, Bo Carlsson, Sven Lindmark, and Annika Rickne. 2008. “Analyzing the Functional Dynamics of Technological Innovation Systems: A Scheme of Analysis.” *Research Policy* 37 (3): 407–29. https://doi.org/10.1016/j.respol.2007.12.003.

Bloomberg L.P. 2025. “Loan Search LSRC (Renewable and Utility Loans Database).”

Bolton, Patrick, and Marcin Kacperczyk. 2025. “Firm Commitments.” *Management Science*, July.

Bonacich, Phillip, and Paulette Lloyd. 2001. “Eigenvector-like Measures of Centrality for Asymmetric Relations.” *Social Networks* 23 (3): 191–201. https://doi.org/10.1016/S0378-8733(01)00038-7.

Bongini, Paola, Laura Nieri, and Matteo Pelagatti. 2015. “The Importance of Being Systemically Important Financial Institutions.” *Journal of Banking & Finance* 50 (January): 562–74. https://doi.org/10.1016/j.jbankfin.2014.07.006.

Cai, Jian, Frederik Eidam, Anthony Saunders, and Sascha Steffen. 2018. “Syndication, Interconnectedness, and Systemic Risk.” *Journal of Financial Stability* 34 (February): 105–20. https://doi.org/10.1016/j.jfs.2017.12.005.

Campiglio, Emanuele, Yannis Dafermos, Pierre Monnin, Josh Ryan-Collins, Guido Schotten, and Misa Tanaka. 2018. “Climate Change Challenges for Central Banks and Financial

Regulators." *Nature Climate Change* 8 (6): 462–68. https://doi.org/10.1038/s41558-018-0175-0.

Cao, Jie. 2019. "Peer Effects of Corporate Social Responsibility." *Management Science*.

Cojoianu, Theodor F., Andrea G. F. Hoepner, Fabiola I. Schneider, Michael Urban, Anh Vu, and Dariusz Wójcik. 2023. "The City Never Sleeps: But When Will Investment Banks Wake up to the Climate Crisis?" *Regional Studies* 57 (2): 268–86. https://doi.org/10.1080/00343404.2021.1995601.

Dennis, Steven A., and Donald J. Mullineaux. 2000. "Syndicated Loans." *Journal of Financial Intermediation* 9 (4): 404–26. https://doi.org/10.1006/jfin.2000.0298.

Dimson, Elroy, Oğuzhan Karakaş, and Xi Li. 2018. "Coordinated Engagements." *SSRN Electronic Journal*, ahead of print. https://doi.org/10.2139/ssrn.3209072.

Egli, Florian, Bjarne Steffen, and Tobias S. Schmidt. 2018. "A Dynamic Analysis of Financing Conditions for Renewable Energy Technologies." *Nature Energy* 3 (12): 1084–92. https://doi.org/10.1038/s41560-018-0277-y.

Engelberg, Joseph, Pengjie Gao, and Christopher A. Parsons. 2012. "Friends with Money." *Journal of Financial Economics* 103 (1): 169–88. https://doi.org/10.1016/j.jfineco.2011.08.003.

Gasparini, Matteo, Matthew C. Ives, Ben Carr, Sophie Fry, and Eric Beinhocker. 2024. "Model-Based Financial Regulations Impair the Transition to Net-Zero Carbon Emissions." *Nature Climate Change* 14 (5): 476–81. https://doi.org/10.1038/s41558-024-01972-w.

Gasparini, Matteo, and Peter Tufano. 2025. *An Empirical Examination of Business Climate Alliances: Effective and/or Harmful?*

Geddes, Anna, Tobias S. Schmidt, and Bjarne Steffen. 2018. "The Multiple Roles of State Investment Banks in Low-Carbon Energy Finance: An Analysis of Australia, the UK and Germany." *Energy Policy* 115 (April): 158–70. https://doi.org/10.1016/j.enpol.2018.01.009.

Godlewski, Christophe J., and Bulat Sanditov. 2018. "Financial Institutions Network and the Certification Value of Bank Loans." *Financial Management* 47 (2): 253–83. https://doi.org/10.1111/fima.12197.

Godlewski, Christophe J., Bulat Sanditov, and Thierry Burger-Helmchen. 2012. "Bank Lending Networks, Experience, Reputation, and Borrowing Costs: Empirical Evidence from the French Syndicated Lending Market." *Journal of Business Finance & Accounting* 39 (1–2): 113–40. https://doi.org/10.1111/j.1468-5957.2011.02269.x.

Gumber, Anurag, Florian Egli, and Bjarne Steffen. 2025. "Technology Innovation and Financial Development: Measuring the Financial Maturity of Renewable Energy Technologies." Preprint, SSRN. https://doi.org/10.2139/ssrn.5068405.

Gumber, Anurag, and Bjarne Steffen. 2025. “Lending over the Technology Lifecycle: Strategies for Information Search by Banks in Renewable Energy Project Finance.” *Journal of Climate Finance* 13 (December): 100073. https://doi.org/10.1016/j.jclimf.2025.100073.

Harjoto, Maretno, Donald J. Mullineaux, and Ha-Chin Yi. 2006. “A Comparison of Syndicated Loan Pricing at Investment and Commercial Banks.” *Financial Management* 35 (4): 49–70. https://doi.org/10.1111/j.1755-053X.2006.tb00159.x.

Hasan, Iftekhar, Haekwon Lee, Buhui Qiu, and Anthony Saunders. 2026. “Climate-Related Disclosure Commitment of the Lenders, Credit Rationing, and Borrower Environmental Performance.” *Review of Accounting Studies* 31 (1): 74–117. https://doi.org/10.1007/s11142-025-09918-z.

Hochberg, Yael V., Laura A. Lindsey, and Mark M. Westerfield. 2015. “Resource Accumulation through Economic Ties: Evidence from Venture Capital.” *Journal of Financial Economics* 118 (2): 245–67. https://doi.org/10.1016/j.jfineco.2015.06.008.

Hochberg, Yael V., Alexander Ljungqvist, and Yang Lu. 2007. “Whom You Know Matters: Venture Capital Networks and Investment Performance.” *The Journal of Finance* 62 (1): 251–301. https://doi.org/10.1111/j.1540-6261.2007.01207.x.

Huang, Bai, Tae-Hwy Lee, and Aman Ullah. 2020. “Combined Estimation of Semiparametric Panel Data Models.” *Econometrics and Statistics* 15 (July): 30–45. https://doi.org/10.1016/j.ecosta.2019.05.001.

Ivashina, Victoria. 2009. “Asymmetric Information Effects on Loan Spreads.” *Journal of Financial Economics*.

Ivashina, Victoria, and David Scharfstein. 2010. “Loan Syndication and Credit Cycles.” *American Economic Review* 100 (2): 57–61. https://doi.org/10.1257/aer.100.2.57.

Jung, Hyeyoon, Robert F. Engle, and Richard Berner. 2025. “CRISK: Measuring the Climate Risk Exposure of the Financial System.” *Journal of Financial Economics* 171 (September): 104076. https://doi.org/10.1016/j.jfineco.2025.104076.

Karolyi, Stephen Adam. 2018. “Personal Lending Relationships.” *The Journal of Finance* 73 (1): 5–49. https://doi.org/10.1111/jofi.12589.

Kempa, Karol, Ulf Moslener, and Oliver Schenker. 2021. “The Cost of Debt of Renewable and Non-Renewable Energy Firms.” *Nature Energy* 6 (2): 135–42. https://doi.org/10.1038/s41560-020-00745-x.

Kim, Soohun, and Aaron Yoon. 2023. “Analyzing Active Fund Managers’ Commitment to ESG: Evidence from the United Nations Principles for Responsible Investment.” *Management Science* 69 (2): 741–58. https://doi.org/10.1287/mnsc.2022.4394.

Kobayashi, Teruyoshi, and Taro Takaguchi. 2018. “Identifying Relationship Lending in the Interbank Market: A Network Approach.” *Journal of Banking & Finance* 97 (December): 20–36. https://doi.org/10.1016/j.jbankfin.2018.09.018.

Laeven, Luc, and Ross Levine. 2007. “Is There a Diversification Discount in FInancial Conglomerates?$.” *Journal of Financial Economics*.

Markard, Jochen. 2020. “The Life Cycle of Technological Innovation Systems.” *Technological Forecasting and Social Change* 153 (April): 119407. https://doi.org/10.1016/j.techfore.2018.07.045.

Marquis, Christopher, Michael W. Toffel, and Yanhua Zhou. 2016. *Scrutiny, Norms, and Selective Disclosure: A Global Study of Greenwashing*. January 14.

Mountain, Travis P. 2018. *Economic Growth, Regulatory Relief, and Consumer Protection Act*.

Onali, Enrico, Gianluca Ginesti, and Chrysovalantis Vasilakis. 2017. “How Should We Estimate Value-Relevance Models? Insights from European Data.” *The British Accounting Review* 49 (5): 460–73. https://doi.org/10.1016/j.bar.2017.05.006.

Papari, Cătălina-Alexandra, Friedemann Polzin, Florian Egli, Bjarne Steffen, and Tobias S. Schmidt. 2026. “How Does the Financial Sector Learn in Socio-Technical Transitions?” *Technovation* 151 (March): 103467. https://doi.org/10.1016/j.technovation.2026.103467.

Reghezza, Alessio, Yener Altunbas, David Marques-Ibanez, Costanza Rodriguez d’Acri, and Martina Spaggiari. 2022. “Do Banks Fuel Climate Change?” *Journal of Financial Stability* 62 (October): 101049. https://doi.org/10.1016/j.jfs.2022.101049.

Rickman, J., M. Falkenberg, S. Kothari, F. Larosa, M. Grubb, and N. Ameli. 2024. “The Challenge of Phasing-out Fossil Fuel Finance in the Banking Sector.” *Nature Communications* 15 (1): 7881. https://doi.org/10.1038/s41467-024-51662-6.

Ross, David Gaddis. 2010. “The ‘Dominant Bank Effect:’ How High Lender Reputation Affects the Information Content and Terms of Bank Loans.” *Review of Financial Studies* 23 (7): 2730–56. https://doi.org/10.1093/rfs/hhp117.

Sastry, Parinitha R., Emil Verner, and David Marques Ibanez. 2024. *BUSINESS AS USUAL: BANK NET ZERO COMMITMENTS, LENDING, AND ENGAGEMENT*.

Scheffer, Marten, Jordi Bascompte, William A. Brock, et al. 2009. “Early-Warning Signals for Critical Transitions.” *Nature* 461 (7260): 53–59. https://doi.org/10.1038/nature08227.

Schmidt, Tobias S. 2014. “Low-Carbon Investment Risks and de-Risking.” *Nature Climate Change* 4 (4): 237–39. https://doi.org/10.1038/nclimate2112.

Shears, Esther, Jonas Meckling, and Jared J. Finnegan. 2025. “How Central Banks Manage Climate and Energy Transition Risks.” *Nature Energy* 10 (4): 470–78. https://doi.org/10.1038/s41560-025-01724-w.

Slager, Rieneke, Kevin Chuah, Jean-Pascal Gond, Santi Furnari, and Mikael Homanen. 2023. “Tailor-to-Target: Configuring Collaborative Shareholder Engagements on Climate Change.” *Management Science* 69 (12): 7693–718. https://doi.org/10.1287/mnsc.2023.4806.

Steffen, Bjarne. 2018. “The Importance of Project Finance for Renewable Energy Projects.” *Energy Economics* 69 (January): 280–94. https://doi.org/10.1016/j.eneco.2017.11.006.

Steffen, Bjarne. 2020. “Estimating the Cost of Capital for Renewable Energy Projects.” *Energy Economics* 88 (May): 104783. https://doi.org/10.1016/j.eneco.2020.104783.

Steffen, Bjarne, Tyeler Matsuo, Davita Steinemann, and Tobias S. Schmidt. 2018. “Opening New Markets for Clean Energy: The Role of Project Developers in the Global Diffusion of Renewable Energy Technologies.” *Business and Politics* 20 (4): 553–87. https://doi.org/10.1017/bap.2018.17.

Sufi, Amir. 2007. “Information Asymmetry and Financing Arrangements: Evidence from Syndicated Loans.” *The Journal of Finance* 62 (2): 629–68. https://doi.org/10.1111/j.1540-6261.2007.01219.x.

Svetek, Mojca. 2022. “Signaling in the Context of Early-Stage Equity Financing: Review and Directions.” *Venture Capital* 24 (1): 71–104. https://doi.org/10.1080/13691066.2022.2063092.

Ullah, Barkat. n.d. *Signaling Value of Quality Certification: Financing under Asymmetric Information*.

Waidelich, Paul, Joscha Krug, and Bjarne Steffen. 2025. “Mobilizing Credit for Clean Energy: De-Risking and Public Loan Provision under Learning Spillovers.” *Journal of Environmental Economics and Management* 133 (September): 103222. https://doi.org/10.1016/j.jeem.2025.103222.

Waidelich, Paul, and Bjarne Steffen. 2024. “Renewable Energy Financing by State Investment Banks: Evidence from OECD Countries.” *Energy Economics* 132 (April): 107455. https://doi.org/10.1016/j.eneco.2024.107455.

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Appendix A

Table A1. NZBA Member list (sample)

MEMBER NAME	COUNTRY	MONTH OF JOINING
Abanca Corporación Bancaria	Spain	May-21
Abn Amro Bank N.V.	Netherlands	Dec-22
Abu Dhabi Commercial Bank Pjsc	United Arab Emirates	Nov-23
Aib Group	Ireland	Apr-21
Akbank Turkish Corporation	Türkiye	Dec-23
Bank Of Aland	Finland	Apr-21
Alpha Bank	Greece	May-23
Amalgamated Bank	USA	Apr-21
Australia And New Zealand Banking Group	Australia	Oct-21
Areti Bank	USA	Jun-23
Arion Bank	Iceland	Dec-23
Bac Credomatic	Costa Rica	Oct-21
Banca Ifis	Italy	Oct-21
BANCA MONTE DEI PASCHI DI SIENA	Italy	Jan-22
BANCA POPOLARE DI SONDRIO S.P.A.	Italy	Dec-23
…	…	…

Table A2. Renewable Energy Deals Summary

Loan Purpose Description	Number of Loans
Project Finance	3,590
Refinance	713
General Corporate Purposes	369
Working Capital	146
Capital Expenditures	108
Sustainable Purpose	89
Acquisition Financing	60
Real Estate	22
LBO Financing	21
Trade Finance	19
General Sovereign Financing	16
Ship Financing	13
Bankruptcy Exit Financing	5
Dividend Payment	2
Recapitalization	1
Stock Buyback	1

Table A3. Fossil Fuel Deals Summary

Loan Purpose Description	Number of Loans
Refinance	1,837
General Corporate Purposes	1,748
Project Finance	1,178
Acquisition Financing	390
Working Capital	375
Capital Expenditures	169
Ship Financing	161
Trade Finance	83
Bankruptcy Exit Financing	62
LBO Financing	61
Dividend Payment	18
Real Estate	16
Stock Buyback	6
General Sovereign Financing	4
Recapitalization	3
Aircraft Financing	2
Intermediary Loan	1
CP Backup	1

Appendix B Summary Statistics

Table B1. Fossil fuel corporate-level lending summary statistics

	mean	sd	p25	p75	count
Lending (billion USD)	1.439	1.882	0.054	2.031	1261
ROA	0.006	0.004	0.003	0.009	1261
Loan Loss Reserves Ratio	0.018	0.018	0.007	0.024	1261
Non_interest_NetIncome	2.938	17.428	0.765	2.727	1252
Leverage	0.931	0.022	0.919	0.945	1261
Observations	1261				

Table B2. Renewable Energy Project Finance Lending Summary Statistics

	mean	sd	p25	p75	count
Lending (billion USD)	0.222	0.387	0.000	0.240	1073
ROA	0.006	0.005	0.003	0.009	1073
Loan Loss Reserves Ratio	0.019	0.018	0.008	0.024	1073
Non_interest_NetIncome	3.194	18.850	0.782	2.813	1064
Leverage	0.931	0.022	0.918	0.945	1073
Observations	1073				

Table B3. Fossil Fuel Bank-level Data Correlations

	ROA	Loan Loss Reserves / Total Loans	Non Interest Income / Net Income	Leverage
ROA	1			
Loan Loss Reserves / Total Loans	0.0956	1		
Non Interest Income / Net Income	-0.0877	0.0762	1	
Leverage	-0.508	-0.128	0.0290	1

Table B4. Renewable Energy Bank-level Data Correlations

	ROA	Loan Loss Reserves / Total Loans	Non Interest Income / Net Income	Leverage
ROA	1			
Loan Loss Reserves / Total Loans	0.0351	1		
Non Interest Income / Net Income	-0.0938	0.0798	1	
Leverage	-0.499	-0.0786	0.0376	1

Appendix C

To strengthen the identification of the causal impact of the Net-Zero Banking Alliance (NZBA) on fossil fuel (FF) corporate lending and renewable energy (RE) project finance, we implement a coarsened exact matching (CEM) procedure prior to difference-in-differences estimation. A key concern in our baseline identification strategy is potential selection bias, as NZBA member banks may systematically differ from non-member banks in observable characteristics, particularly bank size and pre-existing lending exposure. Therefore, we first restrict the sample to banks with total assets above USD 200 billion, thereby focusing on globally active institutions with broadly comparable scale and regulatory environments. Building on this restricted sample, we apply CEM to construct a matched sample of treated and control banks that are comparable along key pre-treatment dimensions.

The matching variables are defined as pre-treatment averages over the period 2011–2020 and include: (i) average total assets, capturing bank size, and (ii) average fossil fuel corporate lending or renewable energy project finance lending, capturing baseline exposure to fossil fuel activities and renewable energy activities. Both variables are coarsened into quartiles prior to matching to balance matching quality and sample retention.

In terms of fossil fuel corporate lending, the CEM procedure yields 15 strata, of which 11 are matched strata containing both NZBA and non-NZBA banks, with 10 observations dropped from the sample (see Table C1). The resulting multivariate L1 distance is 3.331×10^{-16}, indicating near-perfect balance between the treated and control groups. In the subsequent analysis, all regressions are weighted using CEM weights, and standard errors are clustered at the bank level.

The CEM-weighted DiD results for fossil fuel corporate lending remain robust. The coefficient on the interaction term $\mathrm{NZBA} \times \mathrm{Post}$ is negative and statistically significant at the 1% level (see Table C3). The magnitude of the estimate suggests that NZBA member banks reduce their annual fossil fuel corporate lending by approximately 0.674 billion USD relative to non-member banks, after controlling for bank fixed effects and country-by-year fixed effects.

Turning to renewable energy project finance, the CEM procedure also produces 15 strata, of which 11 are matched strata, with 17 observations dropped from the sample (see Table C2). The multivariate L1 distance is 9.194×10^{-17}, again indicating near-perfect balance between treated and control banks. As in the fossil fuel specification, all regressions are weighted using CEM weights, with standard errors clustered at the bank level.

The corresponding DiD estimate for renewable energy project finance lending is positive and statistically significant at the 5% level (see Table C3). The results indicate that NZBA participation is associated with an increase of approximately 0.131 billion USD in renewable energy lending relative to non-member banks, conditional on bank fixed effects and country-by-year fixed effects.

Table C1. CEM results for fossil fuel corporate-level lending

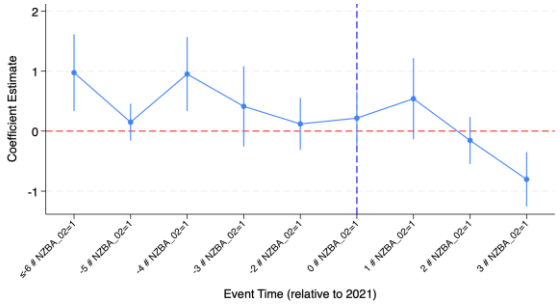
CEM Results	NZBA		
	0	1	Total
0	10	0	10
1	47	54	101
Total	57	54	111

Table C2. CEM results for renewable energy project finance lending

CEM Results	NZBA		
	0	1	Total
0	6	11	17
1	36	40	76
Total	42	51	93

Figure C1. Event Study for CEM-DiD Parallel Assumption Test

(a) Fossil fuel corporate-level lending (Bank FE and Country-by-year FE)



(b) Renewable energy project finance lending (Bank FE and Country-by-year FE)

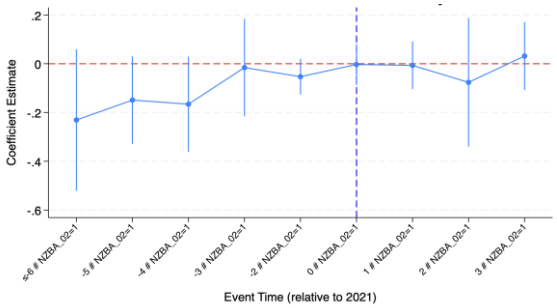


Table C3. CEM-DiD results for fossil fuel corporate-level lending and renewable energy project finance lending

Variable	***FF Corporate level***	***RE Project Finance***
$NZBA \times Post$	-0.674***	0.131**
Return on Asset	-20.765	-4.296
Loan Loss Reserves / Loans	3.579	-0.955
Leverage	-0.169	2.263
Constant	2.128	-1.781
N	1176	882
Controls	Y	Y
Bank FE	Y	Y
County by year FE	Y	Y
Adj R2	0.803	0.631

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix D

D.1. NZBA Degree Centrality

Degree centrality measures the number of ties an actor has with other members of the network and reflects the breadth of a bank's direct syndication relationships. Banks with higher degree centrality participate in a larger number of co-lending arrangements, indicating greater lending experience, more frequent market engagement, and a more active role in the global energy syndicated market (Ivashina 2009; Ivashina and Scharfstein 2010; Godlewski et al. 2012; Alperovych et al. 2022). $A_t = [x_{ij,t}] \in R^{N \times N}$ denotes the undirected adjacency matrix by using a five-year rolling window from year t-5 to year t-1, where x_{ij} records the counts of the co-lending tie between banks i and j. The degree centrality of bank i in year t is defined as the row or column sum of A_t:

$$\mathrm{Degree_{i,t}} = \sum_{\mathrm{j,i \neq j}} \mathrm{x_{ij,t}}$$

Equation B1

We further define NZBA degree centrality as the subset of bank i's co-syndication ties that involve NZBA member banks, aiming to isolate the alliance-related component of a bank's direct network exposure. This measure captures the counts of a bank's repeated direct interactions with NZBA institutions and, consequently, its potential exposure to NZBA-related norms, information, and strategic priorities transmitted through co-lending relationships. Therefore, we first define an $N \times 1$ NZBA indicator vector $m_t \in \{0,1\}^N$, whose j-th element equals one if bank j is an NZBA member in year t, and zero otherwise (see Equation 4).

$$m_{i,j} = \begin{cases} 1, if\ bank\ j\ is\ an\ NZBA\ member\ in\ year\ t, \\ 0, otherwise. \end{cases}$$

Equation B2

Then NZBA degree centrality is:

$$\mathrm{NZBA\ Degree_{i,t}} = \sum_{\mathrm{j,i \neq j}} \mathrm{x_{ij,t}\, m_{j,t}} = \mathrm{A}_t m_t$$

Equation B3

D.2. Eigenvector Centrality Contributed from NZBA

Eigenvector centrality assigns greater weight to connections with banks that are themselves more central in the network, thereby reflecting a bank's embeddedness in the core of the lending system. It helps capture differences in the quality and strategic importance of lending connections among different bank nodes.

Formally, eigenvector centrality is defined as the principal eigenvector of the adjacency matrix A_t. Let $x_t \in R^N$ denote the vector of eigenvector centralities in year t. Eigenvector centrality satisfies the eigenvalue equation

$$A_t \mathrm{x_t} = \lambda_{\max} \mathrm{x_t} \,,$$

$$Eigenvector_{i,t} = \frac{1}{\lambda_{max}} \sum_{j \neq i} a_{ij,t} \; x_{j,t} \,,$$

Equation B4

where λ_{max} is the largest eigenvalue of A_t.

This expression shows that a bank attains a high eigenvector centrality not only by maintaining many syndication ties, but also by being connected to other highly connected and influential banks. Eigenvector centrality therefore captures a bank's position and reputation within the core of the global lending network (Ivashina and Scharfstein 2010; Rickman et al. 2024); However, eigenvector centrality cannot capture the relationship of bank i with NZBA members in the syndicated network. Therefore, we further isolate the component of a bank's eigenvector centrality that is attributable to its connections with NZBA member banks. We decompose the summation in Equation 6 according to whether a counterparty belongs to the NZBA. Let N_t^{NZBA} denote the set of NZBA member banks in year t, and N_t^{Non} the set of non-NZBA banks. Then eigenvector centrality can be decomposed as

$$Eigenvector_{i,t} = \frac{1}{\lambda_{\max}} \left(\sum_{t \in N^{NZBA}} a_{\mathrm{ij},t} x_t \; + \sum_{t \in N^{non}} a_{\mathrm{ij},t} x_t \right)$$

Equation B5

We define *Eigenvector Centrality Contributed from NZBA* as the component arising from connections to NZBA members:

$$\mathrm{Eigenvector}_{i,t}^{NZBA} = \frac{1}{\lambda_{\max}} \sum_{t \in N^{NZBA}} a_{\mathrm{ij},t} x_t$$

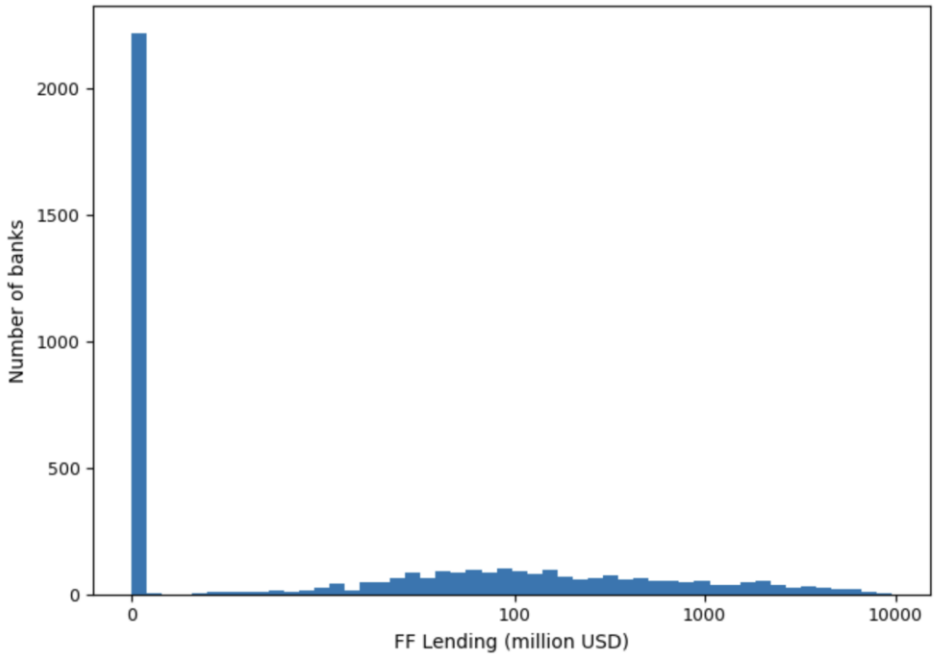
Equation B6

$\text{Eigenvector}_{i,t}^{NZBA}$ captures the extent to which bank i's position in the lending network is shaped by its direct connections to structurally influential NZBA members. Eigenvector contributed from NZBA emphasizes exposure to NZBA banks, highlighting the potential transmission of NZBA-related norms, information, and strategic orientations through first order but highly influential network channels. However, this indicator has an important limitation that captures only the direct, first-order influence of NZBA members through immediate co-syndication ties, while ignoring indirect effects that may arise when NZBA-related norms and information propagate to bank i.e. via non-NZBA intermediary nodes (Banerjee et al. 2013).

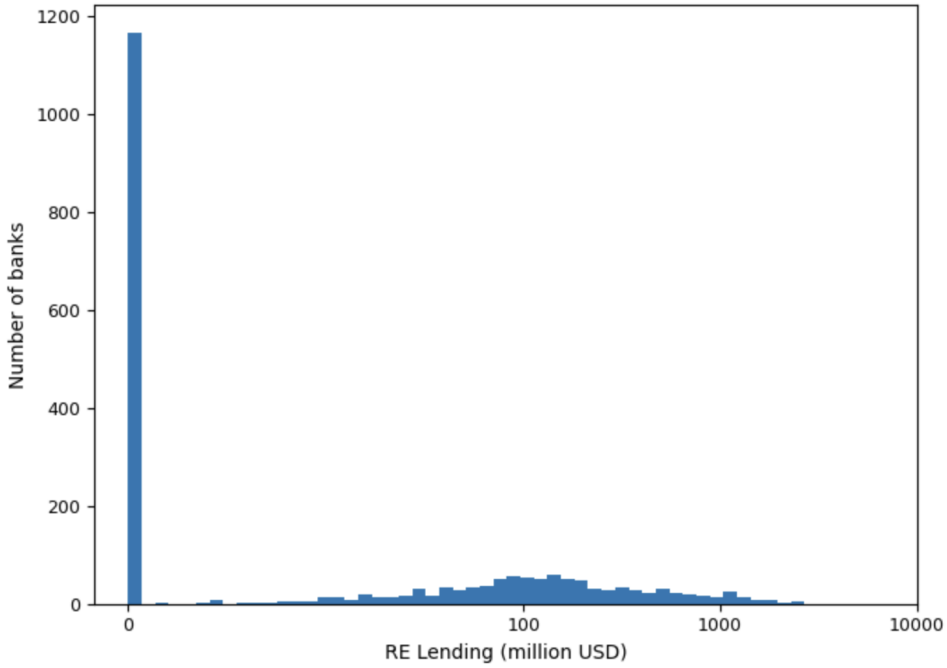
Appendix E

Figure C1. Annual Lending Amount Distribution for Banks

(a) Fossil fuel corporate-level lending for each bank per year



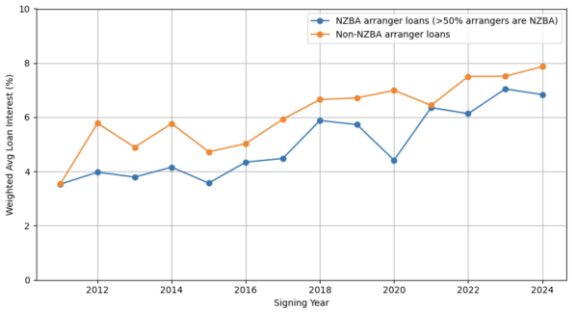
(b) Renewable energy project finance lending for each bank per year



Appendix F

Figure F1. Weighted average loan spreads for NZBA dominated loans and non-NZBA dominated loans

(a) Fossil fuel corporate-level lending (weighted average loan spread, loan level)



(b) Renewable energy project finance lending (weighted average loan spread, loan level)

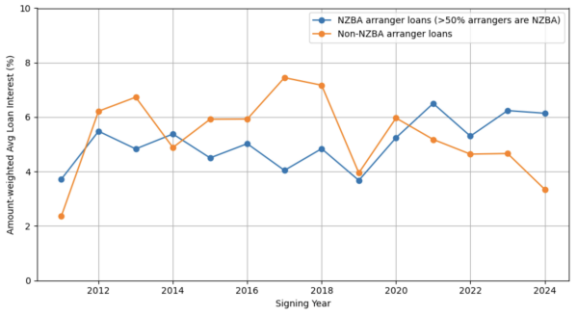
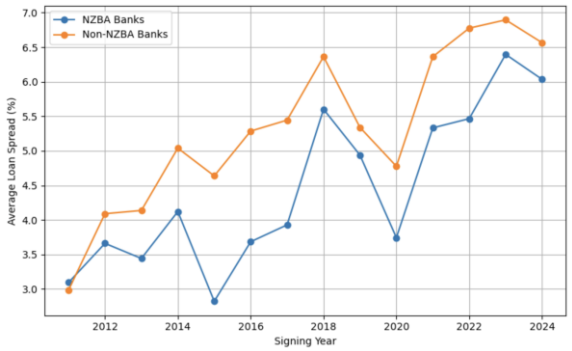


Figure F2. Average loan spreads for NZBA and non-members

(a) Fossil fuel corporate-level lending (loan spread, bank level)



(b) Renewable energy project finance lending (loan spread, bank level)

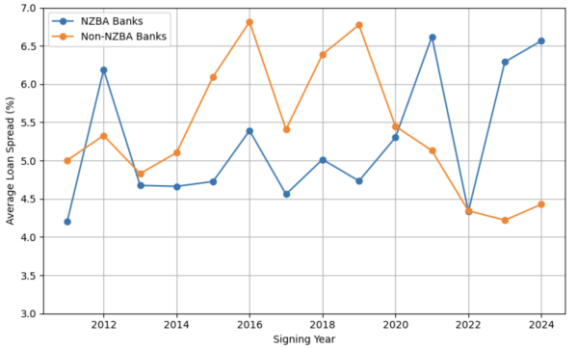


Figure F3. K-core structure of the global energy syndicated lending network (k = 20)

(a) display year 2016, rolling Window 2011–2015; **(b)** display year 2019, rolling Window 2014–2018; **(c)** display year 2022, rolling Window 2017–2021; **(d)** display year 2024, rolling Window 2019–2023.



Appendix G

G.1. Transaction analysis for Europe banks and European Union banks

We conduct an empirical analysis when restricting sample to banks located in Europe or located in EU, respectively. We include bank fixed effect α_i and year fixed effect δ_t rather than country-by-year fixed effects in both Europe and EU empirical analysis which is also consistent with the empirical strategy adopted by Sastry et al. (2024) (see Equation 1 and Equation 2)

$$FF_{ict} = \beta_{\mathrm{E1}(NZBA_i \times Post_t)} + \alpha_i + \delta_t + \epsilon_{ict}$$

Equation E1

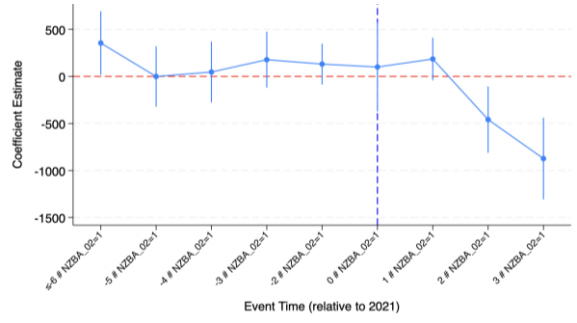
$$RE_{ict} = \beta_{\mathrm{E2}(NZBA_i \times Post_t)} + \alpha_i + \delta_t + \epsilon_{ict}$$

Equation E2

where FF_{ict} denotes the total fossil fuel corporate lending of bank i in country c and year t, measured as the allocated loan amount aggregated across syndicated deals and RE_{ict} denotes the total renewable energy project finance lending of bank i in country c and year t, measured as the allocated loan amount aggregated across syndicated deals. $NZBA_i$ is an indicator equal to one if bank i is a member of the Net-Zero Banking Alliance and zero otherwise. $Post_t$ is a post-treatment indicator equal to one for years after the formation of NZBA and zero for pre-treatment years, with the baseline policy year set to 2021. Standard errors are clustered at the bank level to account for serial correlation in lending behavior over time. The coefficient of interest, β_{E1} and β_{E2} captures the average change in fossil fuel corporate lending and renewable energy project finance by NZBA member banks relative to non-member banks following NZBA formation.

Figure G1. Event Study with bank and year fixed effect for fossil fuel in Europe or European Union (transaction amount)

(a) Fossil fuel corporate-level lending (transaction amount, Europe)



(b) Fossil fuel corporate-level lending (transaction amount, European Union)

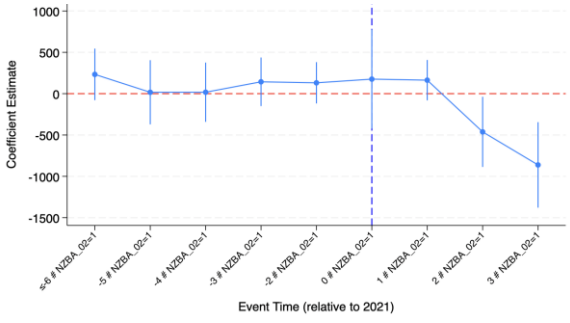
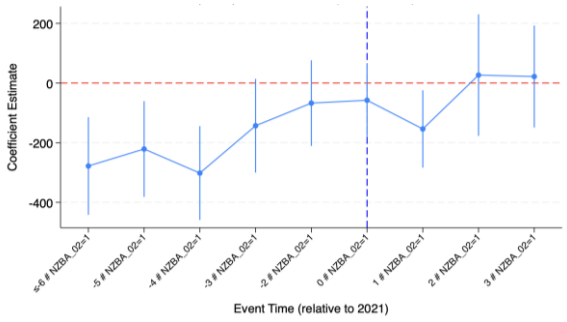


Figure G2. Event Study with bank and year fixed effect for renewable energy in Europe or European Union (transaction amount)

(a) Renewable energy project finance lending (transaction amount, Europe)



(b) Renewable energy project finance lending (transaction amount, European Union)

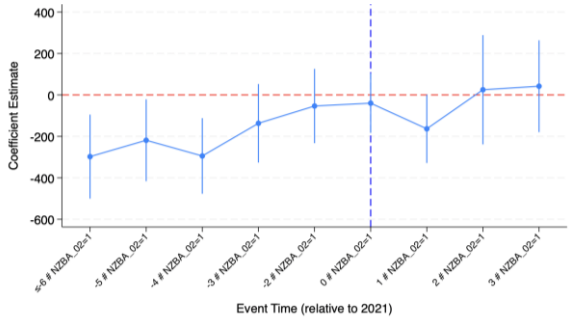


Table G1. Standard DiD Economic results (FF corporate level, Europe or European Union)

FF corporate level	**Europe**	**European Union**
$NZBA \times Post$	-474.62***	-393.42***
Constant	506.67***	445.29***
Bank FE	Y	Y
Year FE	Y	Y
Observations	1,722	1,274

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table G2. Standard DiD Economic results (FF corporate level, Europe or European Union, Restricted to year 2022)

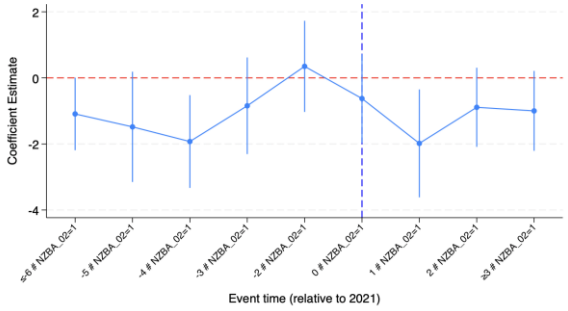
FF corporate level	***Europe***	***European Union***
$NZBA \times Post$	-70.35	22.27
Constant	520.9***	443.2***
Bank FE	Y	Y
Year FE	Y	Y
Observations	1,476	1,092

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

G.2. Loan spread analysis for Europe banks

Figure E3. Event Study with bank and year fixed effect for fossil fuel corporate-level and renewable energy project finance analysis in Europe (loan spread)

(a) Fossil fuel corporate-level lending (loan spread, Europe)



(b) Renewable energy project finance lending (loan spread, Europe)

