Business Strategy and the Environment

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RESEARCH ARTICLE OPEN ACCESS

Climate Transition Challenges: Exploring Credit Portfolio Misalignment in European Banks

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Received: 24 April 2025 | **Revised:** 9 July 2025 | **Accepted:** 21 July 2025

Funding: This study was funded by the European Union - NextGenerationEU, Mission 4, Component 2, in the framework of the GRINS - Growing Resilient, INclusive and Sustainable project (GRINS PE00000018 - CUP E63C22002120006). This study was also funded by DM n. 118, 02-03-2023 - ID: 7131. Open access publishing was facilitated by Universita degli Studi di Catania, as part of the Wiley - CRUI-CARE agreement.

Keywords: banking industry | credit portfolio | environmental policy | sustainable finance

ABSTRACT

This paper examines the underlying factors contributing to the misalignment of banks' credit portfolios with European environmental objectives. Drawing on panel data on green lending from 2015 to 2023, the empirical analysis reveals that such misalignment is primarily influenced by the country and sector in which the financed firms operate. The main findings indicate a positive relationship between green lending and the environmental performance of the country where the firm is based. Moreover, the significant presence of carbon-intensive sectors within national economies shapes banks' credit allocation decisions, reflecting broader structural characteristics rather than bank-specific strategies. Policymakers are therefore encouraged to support the alignment of bank lending with climate goals through public policies and enhanced regulations that promote firms' business model innovation. In addition, the implementation of appropriate macroprudential tools may help address the systemic dimension of climate-related financial risk.

1 | Introduction

The financial sector is a central actor in the global transition toward a low-carbon economy, yet it remains highly exposed to climate-related risks that threaten financial stability. As global commitments—such as the Paris Agreement (United Nations Framework Convention on Climate Change 2015), the European Green Deal (European Commission 2019) and the latest United Nations Climate Change Conference (COP28[1])—underscore the urgency of decarbonization, banks and financial institutions face mounting pressures to align their portfolios with sustainability objectives (Antimiani et al. 2023; Arzaghi and Squalli 2023).

The transition to a low-carbon economy represents for the banking industry a critical issue, with both physical and transition risks threatening substantial financial losses. To address these challenges, the United Nations Environment Programme Finance Initiative (2019) introduces the Principles for Responsible Banking (PRB), comprising six targets that require signatory banks to align their strategies, decision-making, and investment practices with the UN Sustainable Development Goals and global agreements. Industries highly reliant on carbon emissions are predominantly debt-financed, exposing banks to significant risks due to the obsolescence of fossil fuel assets (Delis et al. 2024). Against this background, the European Central Bank (2020) and the European Banking Authority (2021) provide both definitions of climate-related physical and transition risks and insights into their impact on credit, market, and operational risks. These may affect stakeholders and might expose the bank to reputation and liability risks because of the funding of ecologically or socially questionable operations (European Central Bank 2020). While physical climate risk is commonly assessed at the regional or city level

(Basel Committee on Banking Supervision 2021a; European Central Bank 2023), transition risk primarily arises from policies designed to regulate carbon emissions (Dunz et al. 2021; Roncoroni et al. 2021). Banks with portfolios with high levels of carbon are more likely to experience increased transition risk. Consequently, authorities and other stakeholders have been closely monitoring banks' efforts to incorporate environmental, social, and governance (ESG) factors into their risk management strategies and financing decisions (European Central Bank 2022).

Notwithstanding the regulatory pressures and the growing interest from stakeholders, the path towards sustainability is not straightforward. Recent investigations (European Central Bank 2024) have identified a misalignment within banks' credit portfolios, highlighting the challenges encountered by financial institutions to align with decarbonization objectives. Among the 95 significant institutions analyzed by the ECB, 90% were found misaligned, exhibiting varying degrees of exposure and misalignment. In European Central Bank (2024), "misalignment" is defined as a situation in which a corporation is adjusting its production more slowly than necessary to comply with decarbonization goals.

The misalignment of banks' credit portfolios raises important questions regarding its underlying causes. Specifically, what are the main drivers of the misalignment of banks' credit portfolios? To what extent is it grounded in banks' endogenous choices, or driven by exogenous forces beyond banks' control? This paper sets out to explore the role of country and industry effects on green lending and, consequently, their impact on credit portfolio misalignment. First, the industry to which financed companies belong may affect the allocation of green loans. Corporate counterparties tend to exhibit risk exposure commonalities along sectoral classification, typically for transition risk but also for physical risk (Basel Committee on Banking Supervision 2021b). Second, the country in which banks operate may exert an influence on their business strategy on climate change risks. In less sustainable countries, banks may struggle to engage with suitably sustainable counterparties. Conversely, when operating in more sustainable countries, banks may benefit from broader awareness and proactive engagement of their stakeholders and society at large. Previous studies have also shown that banks adjust their behavior to react to cross-country heterogeneity in climate policies (Benincasa 2021; Bruno and Lombini 2023; Erten and Ongena 2024).

Despite the importance of sustainable lending practices, there has been little discussion about the drivers of banks' portfolio misalignment. The rationale for investigating these drivers is grounded in the need to achieve ambitious climate objectives. Identifying and measuring the environmental misalignment of banks' portfolios represent a crucial first step in critically recognizing the challenges involved in meeting these goals. Analyzing the underlying causes of this phenomenon is a natural progression of this process and is essential for policymakers and authorities to design effective and targeted measures to mitigate the issue. The effectiveness of any institutional intervention—from public support schemes to enhanced regulations—depends on a careful consideration of the specific characteristics and needs of the contexts in which they are implemented, to ensure flexible adaptation.

To fill this gap, we employ data on green syndicated loans from 2015 to 2023. The use of syndicated loans data is particularly suited to this analysis for several reasons. The syndicated loan market serves as an exemplary setting for examining banking conduct, as highlighted by a growing body of research (Ivashina 2009; Cerutti et al. 2015; Kleimeier and Viehs 2018; Degryse et al. 2023). Syndicated loans accurately record bank-borrower interactions, differentiating between factors of credit demand and supply. Moreover, the syndicated loans data provide significant information on loan characteristics, including the sustainability of the funding itself. This detail is fundamental to this study, given that the misalignment of credit portfolios inherently depends on the sustainability profile of the loans in which banks have participated. Lastly, syndicated loans generally feature medium-term maturities and are often used to finance capital-intensive sectors (De Haas and Popov 2019; Delis et al. 2024), which makes them suitable for the analysis of the green transition as it tends to be highly capital-intensive and innovation-driven.

By using different econometric specifications, we find that banks' drivers of credit portfolio misalignment with EU climate objectives stem from the inherent characteristics of the country in which financed firms operate and the sectors with which they engage.

The remainder of the paper proceeds as follows. Section 2 reviews the related literature and outlines our hypotheses. Section 3 describes the research design, including data and methodology. Section 4 is dedicated to robustness checks. Section 5 discusses the results. Section 6 concludes.

2 | Theoretical Background and Hypotheses

The growing relevance of the environmental issue compels the banking industry to reassess the financial risks related to continuing to invest in carbon-intensive technologies. Earlier research calls (Gallego-Álvarez and Pucheta-Martínez 2020; Di Tommaso and Thornton 2020; Khattak and Saiti 2021) have emphasized the need for a deeper investigation into the effects of the banks' strategy on climate change, with respect to their true environmental impact. Previous research has established that banks are increasingly aware of environmental risks and are beginning to incorporate green criteria into their evaluation of borrowers' creditworthiness (Weber et al. 2008; European Central Bank 2020; Basel Committee on Banking Supervision 2023; Song and Rimmel 2025). Additionally, banks are being urged to enhance transparency regarding the financial and material risks stemming from climate change, as well as their strategies to address climate-related challenges (Friedrich et al. 2023; Cregan et al. 2024). This trend is fostering the promotion of green lending to businesses in countries with stronger sustainability frameworks (Fard et al. 2020). The environmental sustainability of a borrower has increasingly become a pivotal factor that can influence the financial valuation of credit, positively affecting the quality of bank loans and reducing credit risk (Birindelli et al. 2022). By

contrast, banks engaged in lending to high-polluting companies, such as those in the oil and gas sector, are experiencing heightened operational, credit, and reputation risks to such an extent that they are now required to disclose the environmental impacts of their lending practices (Nandy and Lodh 2012; Erragragui 2018).

Conversely, other studies have reported that banks continue to extend larger loan amounts to corporations that do not align with their stated sustainability objectives, resulting in average exposures more than double those toward aligned firms (Benincasa 2021; Bruno and Lombini 2023; European Central Bank 2024). It follows that the increasing transition risk within credit portfolios originates from financing counterparties who demonstrate resistance to swift actions in addressing transition challenges, such as a lack of expediency in either discontinuing their high-carbon production capacities or expanding their renewable energy production capabilities (European Central Bank 2024).

The literature on the assessment of climate-related risks in banking loan markets remains quite limited. The lack of emission data for unlisted entities significantly hinders accurate greenhouse gas accounting for bank loan portfolios. Considering these limitations, some authors have focused on techniques for determining financed emissions held by investors, rather than exploring banks' lending practices (Bolton and Kacperczyk 2021; Ilhan et al. 2021).

In contrast, other studies have relied on syndicated loans data as a valuable context for examining banking lending practices. Delis et al. (2024) analyze syndicated loan data for fossil fuel firms to evaluate whether banks are pricing the risk of stranded assets. They find that after the Paris Agreement in 2015, banks have begun to incorporate the risk of stranded fossil fuel reserves into their pricing strategies. Degryse et al. (2023) highlight that green banks have rewarded environmentally responsible firms through cheaper loans. Kleimeier and Viehs (2018) examine whether companies that choose to disclose their carbon emissions to the Carbon Disclosure Project (CDP) can reduce their credit costs. By employing syndicated loan data, they show that companies voluntarily disclosing their CO_2 emissions experience decreased credit costs in comparison to those that do not disclose. Likewise, Bruno and Lombini (2023) observe that banks react to heightened climate risks by adjusting the cost and the amount of credit to heavily polluting firms situated in jurisdictions with rigorous climate regulations. Ehlers et al. (2022) show that the pricing of carbon risk in the syndicated loan market has undergone substantial changes following the implementation of the Paris Agreement. Additionally, Benincasa (2021) observes that disparities in climate policies across countries drive banks to intensify their cross-border lending activities. Banks expand such operations when subject to stringent domestic climate regulations, as local lending can become less profitable. Also drawing on syndicated loan data, Del Gaudio et al. (2022) identify a correlation between the propensity for green lending and a reduction in risk-profitability within financial institutions. Their findings suggest that banks typically adopt a cautious credit policy and cooperative strategies in their green lending practices. Consequently, banks that prioritize investments in environmentally sustainable projects tend to experience lower default and credit risk compared to those that do not prioritize green initiatives.

Differently from previous research that explores banks' environmental practices and their relationship with performance or risk metrics, our study investigates which factors have the greatest impact on increasing portfolio misalignment, thereby heightening banks' exposure to transition risk. Therefore, we propose the following hypotheses.

Hypothesis 1. Industry-specific characteristics foster (hinder) banks' green lending practices.

Hypothesis 1 explores the existence of an industry-specific influence on the allocation of green loans, proxied by syndicated green loans. Different industries encompass activities with varying degrees of sustainability and risk exposure and have received different levels of attention from environmental initiatives (Intergovernmental Panel on Climate Change 2014; Basel Committee on Banking Supervision 2021b). The energy sector has been at the forefront of environmental efforts, thereby facilitating a smoother transition to environmental sustainability (Green and Reyes 2023; Joshipura et al. 2025). Furthermore, commonalities along sectoral classification that affect green lending may be the result of isomorphic processes, as outlined by DiMaggio and Powell (1983). Isomorphism is a constraining force that drives the homogenization of organizational behavior. In the case of environmental transition, isomorphism can manifest through its three fundamental mechanisms: coercive isomorphism, arising from direct or subtle pressures, persuasion or invitations; mimetic isomorphism, whereby organizations emulate standard responses to uncertainty, when facing problems with ambiguous causes or unclear solutions; normative isomorphism, associated with professionalization and the emergence of individuals who occupy similar positions across organizations and share common orientations and dispositions.

Hypothesis 2. Countries' sustainability fosters (hinders) banks' green lending practices.

Hypothesis 2 investigates country-level differences in green loans driven by countries' environmental performance. Some CSR and environmental studies employ both the institutional and legitimacy theory to conclude that corporate behavior is shaped by the context in which they operate, respectively through social pressure, public and private rules as well as the seek for social acceptance and legitimacy (Delmas and Toffel 2004; Ioannou and Serafeim 2012; Baldini et al. 2018). In a careful synthesis of the literature on organizational legitimacy, Suchman (1995) defines legitimacy as a generalised perception that an entity's actions are desirable or appropriate within some socially constructed system of norms, values and beliefs. Organizations seek legitimacy as it enhances their stability and comprehensibility and audiences tend to perceive legitimate organizations as more worthy, meaningful, predictable and trustworthy. In this perspective, countries' environmental commitment may provide firms with guidance on what is considered the "right thing to do" (moral legitimacy), highlight their broader interests that trigger firms' responsiveness

in exchange for support (pragmatic legitimacy) or furnish cultural models that make corporate actions meaningful and comprehensible (cognitive legitimacy).

3 | Research Design

3.1 | Data

To investigate the key determinants of loan environmental sustainability, we use a dataset on syndicated loans over the 2015–2023 period. The initial dataset comprises 17,035 syndicated loans closed between January 1, 2015, and December 31, 2023, in which at least one European bank—from countries within the European System of Central Banks—participates. Each observation includes information about the loan and the bookrunner banks[2] involved, as well as the country and industry of the financed company and the sustainability of the financing itself. This last feature consists of a dummy variable which is equal to 1 if the loan meets at least one of the following conditions: the proceeds are used for green purposes; its pricing is tied to the borrower's sustainability performance; or the borrower is classified under a list of sustainable business activities[3]; otherwise, it is 0. Additionally, we include various control variables that may affect our results to alleviate concerns about omitted variables, such as controls for banks' financial metrics and the environmental performance of the financed country. The final sample—reduced to 16,428 observations due to missing data in those covariates—consists of data collected matching three different sources: Refinitiv Eikon, International Monetary Fund (IMF), and BankFocus. Detailed information on their respective definitions is provided in Table 1. For the descriptive analysis of our sample, we complement the main dataset with data from the Organisation for Economic Co-operation and Development (OECD) on industry-level production covering the EU countries of the borrowers' firms in our sample. Prior to conducting the regression analysis, we first explore the dataset's structure. The variable INDUSTRY refers to the Refinitiv Business Classification (TRBC) developed by Thomson Reuters for the borrower firms. The variables SIZE, LIQRATIO, and ROA represent bank-level economic and financial metrics to control for the characteristics of the loan's bookrunners. For each observation, the value of these variables corresponds to the average of the individual values reported by each European bookrunner bank participating in that specific loan.

Table 2 provides the summary statistics of the continuous variables employed in the analysis, while Table 3 and Table 4 exhibit the sample distribution by COUNTRY and INDUSTRY.

All the continuous independent variables have been winsorized at 1% and 99% levels to reduce the effect of potential outliers and are lagged by 1 year.

In addition to the overall sample distribution by industry and country, Table 5 reports the sectoral breakdown of the domestic economy for each of the EU countries in our sample, as measured by the share of production attributable to each industry. The data are derived from industry-level production values sourced from a repository of structural business statistics provided by the OECD. Across most countries, we observe that Auto, Machinery & Vehicles, Construction, Food & Accommodation, Oil, Gas & Metals, and Technology are among the industries with the highest production shares.

TABLE 1 | Variables description.

Variable	Description	Source
Dependent variable		
GREENSYND	Dummy variable equal to 1 if the syndicated loan is classified as green, and 0 otherwise	Refinitiv Eikon (2024)
Variables of interest		
INDUSTRY	Classification of the industry in which the borrower primarily operates	Refinitiv Eikon (2024)
COUNTRY	The country in which the borrower firm is established	Refinitiv Eikon (2024)
YEAR	The year in which the loan syndication was signed and completed	Refinitiv Eikon (2024)
GHG	Total Greenhouse Gas emissions of the borrower's country relative to its GDP	Authors' calculations based on the IMF
Control variables: Loan characteristics		
LOANSIZE	The total monetary value of the syndicated loan package	Refinitiv Eikon (2024)
TRANCHENUM	Total number of tranches within the loan package	Refinitiv Eikon (2024)
BOOKNUM	Number of Bookrunner banks involved in the syndication of the loan	Refinitiv Eikon (2024)
Control variables: Bank characteristics		
SIZE	Bookrunner banks' total assets	BankFocus (2024)
ROA	Bookrunner banks' return on assets	BankFocus (2024)
LIQRATIO	The ratio between liquid assets and short-term funding and deposits	Authors' calculations based on BankFocus

Note: Definition of variables.

TABLE 2 | Main descriptive statistics.

Variable	Obs	Mean	Median	SD	Min	Max
GREENSYND	16,428	0.142	0	0.350	0	1
LOANSIZE	16,428	715.737	276.804	1166.566	5.061	7114.155
TRANCHENUM	16,428	1.798	1	1.084	1	6
BOOKNUM	16,428	3.974	3	3.569	1	17
SIZE	16,428	1073.967	967.929	579.864	26.311	2634.444
ROA	16,428	0.299	0.319	0.274	−0.590	0.924
LIQRATIO	16,428	0.652	0.621	0.308	0.109	2.330
GHG	16,371	0.315	0.277	0.207	0.062	1.476

Note: This table presents the summary statistics of the variables used in the analysis.

TABLE 3 | Sample distribution by COUNTRY.

COUNTRY	Obs
Austria	112
Belgium	159
Bulgaria	16
Croatia	17
Cyprus	5
Czech Republic	41
Denmark	89
Estonia	11
Finland	150
France	1712
Germany	1484
Greece	40
Hungary	25
Ireland	104
Italy	695
Lithuania	19
Luxembourg	129
Netherlands	403
Poland	71
Portugal	50
Romania	21
Slovakia	10
Spain	1453
Sweden	192
Non-EU	9420
Total	16,428

Note: This table presents the number of syndicated loans in our sample by country.

TABLE 4 | Sample distribution by INDUSTRY.

INDUSTRY	Obs
Auto, Machinery & Vehicles	1119
Chemicals & Plastics	778
Construction	1049
Consumer Goods	626
Education & Entertainment	625
Food & Accommodation	1325
Healthcare	917
Oil, Gas & Metals	1874
Paper & Woods	193
Professional & Business Services	1103
Real Estate	1155
Technology	1640
Trade	690
Transportation & Logistics	968
Utilities	2366
Total	16,428

Note: This table presents the number of syndicate loans in our sample by industry.

We finally examine the pairwise correlations among the variables to check for any potential multicollinearity. The resulting correlation matrix is presented in Table 6. Statistically significant coefficients are predominantly below|0.5|, suggesting the presence of weak to moderate correlations. Consequently, we find no evidence of a severe multicollinearity problem within the dataset.

3.2 | Model and Methodology

To analyze the relationship between the independent variables and the sustainability of syndicated loans, we begin by setting a

TABLE 5 | Sectoral composition of domestic production (%).

	AMV	CHP	CST	CGO	EDE	FOA	HLT	OGM	PAW	PBS	RES	TEC	TRD	TRL	UTL
AT	11.2	4.0	11.9	4.1	2.4	9.8	4.5	14.9	3.1	6.6	3.3	7.2	5.4	4.9	6.7
BE	6.3	5.3	11.0	6.3	2.9	9.8	10.2	10.6	1.0	11.2	1.8	6.4	4.7	6.5	6.1
BG	5.9	3.9	10.8	6.3	3.4	11.9	2.4	14.4	1.4	5.7	2.0	9.8	5.9	9.2	6.9
HR	5.0	0.7	5.8	6.2	3.4	14.5	1.1	4.0	0.7	12.5	3.1	11.5	15.6	13.2	2.6
CY	2.3	0.6	13.9	2.8	4.9	15.1	4.5	3.8	0.7	10.4	0.7	17.9	6.3	11.7	4.4
CZ	19.0	5.3	9.9	4.0	2.5	2.5	2.5	11.8	1.9	6.7	2.2	11.8	4.5	5.9	9.5
DK	6.8	2.0	10.7	4.2	4.0	8.3	7.0	4.6	0.7	8.5	12.1	7.9	3.9	15.0	4.5
EE	4.9	2.3	11.2	5.1	3.1	8.1	2.4	7.5	7.0	7.8	4.2	13.1	5.6	12.2	5.4
FI	9.0	3.3	15.0	2.8	3.2	6.5	4.3	7.7	6.8	7.4	4.2	12.5	5.4	7.4	4.4
FR	10.4	3.6	12.2	3.8	3.9	11.0	5.7	6.9	1.0	10.1	2.9	8.9	6.5	7.8	5.1
DE	15.6	4.4	7.5	3.2	2.7	6.4	8.5	10.2	1.3	6.9	2.1	8.2	4.5	4.5	13.9
GR	2.3	2.4	6.8	5.8	7.0	18.1	4.2	14.6	1.0	6.4	1.2	7.0	6.2	7.9	9.0
HU	18.6	5.3	8.1	3.3	3.7	9.7	3.2	9.6	1.4	6.4	2.1	13.6	5.6	5.7	3.7
IE	2.3	6.6	9.2	3.3	3.2	13.9	2.9	3.3	0.5	17.8	0.9	23.1	5.1	4.6	3.3
IT	11.4	4.5	9.2	8.0	3.2	10.5	4.4	11.5	1.6	8.0	1.8	7.3	5.5	7.2	6.0
LT	5.6	7.0	13.9	8.5	3.2	4.3	2.5	4.5	3.7	7.6	3.2	7.7	6.3	16.7	5.3
LU	5.0	0.8	15.9	1.7	1.3	13.1	5.7	8.3	0.4	9.9	3.7	14.2	7.6	11.7	0.6
NL	6.9	5.4	9.3	4.2	3.9	11.1	11.1	7.4	1.0	13.0	2.6	9.7	4.4	7.3	2.6
PL	9.0	5.1	10.8	4.6	3.7	11.6	3.4	13.0	2.6	6.3	2.9	8.0	6.9	7.5	4.6
PT	7.3	3.7	9.2	7.9	3.2	13.0	4.4	9.7	2.9	8.4	2.5	7.5	6.3	8.0	5.9
RO	12.8	3.8	11.7	5.2	2.9	8.7	2.6	9.1	2.0	6.4	2.0	9.6	8.0	8.8	6.4
SK	23.9	4.0	7.8	3.0	3.1	5.3	2.2	10.3	1.7	8.2	2.0	9.9	6.3	6.1	6.3
ES	9.5	4.4	11.5	4.7	4.8	15.8	4.2	9.6	1.5	8.1	1.8	6.7	5.7	6.1	5.6
SE	11.0	2.1	14.0	4.3	4.3	6.3	4.8	7.8	3.8	9.6	5.4	10.8	4.4	7.3	4.0

Note: This table presents the shares of total domestic production across industries for each of the EU countries in our sample. Country names are indicated by their two-letter ISO codes along the rows, while each numbered column corresponds to a specific industry, as follows: Auto, Machinery & Vehicles (AMV); Chemicals & Plastics (CHP); Construction (CST); Consumer Goods (CGO); Education & Entertainment (EDE); Food & Accommodation (FOA); Healthcare (HLT); Oil, Gas & Metals (OGM); Paper & Woods (PAW); Professional & Business Services (PBS); Real Estate (RES); Technology (TEC); Trade (TRD); Transportation & Logistics (TRL); Utilities (UTL). To enhance readability, a color gradient is applied to the table, with more intense tones corresponding to higher percentages. Columns outlined in black correspond to sectors that most frequently feature among the main contributors to domestic production across countries.

TABLE 6 | Correlation matrix.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GREENSYND	1.000							
(2) LOANSIZE	−0.055*	1.000						
(3) TRANCHENUM	0.016*	0.109*	1.000					
(4) BOOKNUM	−0.079*	0.567*	0.009	1.000				
(5) SIZE	−0.114*	0.204*	−0.047*	0.220*	1.000			
(6) ROA	0.075*	−0.084*	−0.027*	−0.097*	−0.124*	1.000		
(7) LIQRATIO	−0.031*	0.062*	−0.022*	0.076*	0.042*	−0.184*	1.000	
(8) GHG	−0.060*	−0.002	−0.048*	0.015*	0.058*	0.014*	0.005	1.000

Note: This table presents the pairwise correlations of the variables used in our analyses. Asterisk (*) indicates significance at the 10% level.

multiple logistic regression model that incorporates the categorical variables for the financed country, financed industry, and closing year as regressors. The baseline model is:

$$\begin{aligned} GREENSYND_{it} = \beta_c LOAN_{it-1} + \beta_b BANK_{it-1} + \beta_j COUNTRY_i \\ + \beta_k INDUSTRY_i + \beta_h YEAR_i, \end{aligned} \quad (1)$$

where $GREENSYND_{it}$ is the dummy response variable, $LOAN_{it-1}$ is the vector of control variables accounting for loan characteristics, $BANK_{it-1}$ is the vector of control variables for bank characteristics, while COUNTRY, INDUSTRY, and YEAR represent the fixed effects at the levels of, respectively, financed companies' country, financed companies' industry, and time.

Table 7 shows the results of the logistic regression, expressed in terms of odds ratios. It can be observed that most of the coefficients are statistically significant, providing evidence that differences exist with respect to the base level chosen for each categorical regressor (Column 1, Table 7). First, concerning the temporal dimension, the odds of syndicated loans being green have increased compared to 2015—the reference year—reaching a peak in 2022, when the odds ratio with respect to 2015 is 14.426. Second, at the industry level, the highest odds are associated with Utilities[4]—chosen as the reference category—since every odds ratio is lower than one. This result shows the existence of an industry-specific influence, as stated in Hypothesis 1. Environmental efforts have predominantly targeted the energy sector, to ensure a reliable, sustainable, and efficient energy system. Some initiatives (European Parliament and Council 2012) precede the Paris Agreement and have progressively consolidated over time. As a result, the path to environmental transition has been better defined for those firms (Green and Reyes 2023), which, in turn, facilitates the origination of syndicated green loans. Third, for most EU countries in the sample, the odds are higher than those of non-EU countries, used as the reference level for the variable concerning the borrower's country.

We then compute the predicted probabilities associated with the two dimensions of interest in our research question, countries and industries (Column 2, Table 7). With a focus on syndicated loans to firms in EU countries, the aim is to identify which category is lagging the most, thereby impacting green lending. Probabilities are rather low across both dimensions, which corroborates the existence of a limited sustainability challenge and the consequent misalignment issue in the loan market. The lowest probabilities tend to be recorded at the industry level, except for Utilities, which show a significantly different profile relative to the others.

These results suggest that almost every industry struggles to generate syndicated green loans, regardless of both the bank and the country involved. Not even the combinations of industries at the country level result in remarkably higher probabilities, as most remain below 30%. No country outperforms the others and stands out as markedly better associated with green loans, thus representing a clear benchmark for best practices. Instead, an opposite situation is observed with Utilities at an industry level, highlighting how certain sectors may be more responsive to align with environmental goals.

TABLE 7 | Syndicated green loans and COUNTRY, INDUSTRY, and YEAR.

	(1)	(2)
Variables	**GREENSYND**	**GREENSYND**
Austria	2.658 (0.676)***	0.220 (0.031)***
Belgium	3.303 (0.741)***	0.248 (0.029)***
Bulgaria	1.973 (1.686)	0.185 (0.094)***
Croatia	0.527 (0.397)	0.077 (0.043)*
Cyprus	4.439 (4.374)	0.290 (0.144)**
Czech Republic	0.494 (0.224)	0.074 (0.025)***
Denmark	2.919 (0.759)***	0.232 (0.033)***
Estonia	1.134 (1.019)	0.131 (0.077)*
Finland	2.355 (0.575)***	0.206 (0.028)***
France	2.000 (0.201)***	0.188 (0.010)***
Germany	1.241 (0.139)*	0.139 (0.009)***
Greece	1.712 (0.834)	0.170 (0.050)***
Hungary	0.693 (0.329)	0.094 (0.031)***
Ireland	2.324 (0.552)***	0.204 (0.028)***
Italy	3.030 (0.335)***	0.237 (0.013)***
Lithuania	0.187 (0.160)**	0.034 (0.025)
Luxembourg	0.909 (0.337)	0.113 (0.028)***
Netherlands	2.295 (0.370)***	0.203 (0.018)***
Poland	1.252 (0.446)	0.140 (0.032)***
Portugal	8.030 (2.797)***	0.383 (0.057)***
Romania	0.298 (0.256)	0.050 (0.034)
Slovakia	2.782 (2.598)	0.226 (0.118)*
Spain	3.200 (0.286)***	0.244 (0.010)***
Sweden	2.201 (0.463)***	0.198 (0.024)***
Auto, Machinery & Vehicles	0.123 (0.015)***	0.163 (0.012)***
Chemicals & Plastics	0.109 (0.015)***	0.148 (0.014)***
Construction	0.119 (0.014)***	0.159 (0.012)***
Consumer Goods	0.074 (0.012)***	0.110 (0.014)***
Education & Entertainment	0.031 (0.008)***	0.052 (0.012)***
Food & Accommodation	0.124 (0.013)***	0.163 (0.011)***
Healthcare	0.049 (0.008)***	0.079 (0.011)***
Oil, Gas & Metals	0.092 (0.010)***	0.131 (0.010)***
Paper & Woods	0.155 (0.032)***	0.191 (0.026)***
Professional & Business Services	0.080 (0.010)***	0.117 (0.011)***
Real Estate	0.144 (0.015)***	0.181 (0.012)***

(Continues)

TABLE 7 | (Continued)

Variables	(1) GREENSYND	(2) GREENSYND
Technology	0.077 (0.009)***	0.113 (0.009)***
Trade	0.105 (0.014)***	0.144 (0.013)***
Transportation & Logistics	0.102 (0.013)***	0.141 (0.012)***
Utilities		0.508 (0.012)***
2016	0.699 (0.132)*	
2017	1.357 (0.223)*	
2018	2.005 (0.308)***	
2019	3.846 (0.565)***	
2020	4.586 (0.680)***	
2021	10.240 (1.442)***	
2022	14.426 (2.047)***	
2023	11.510 (1.654)***	
Loan controls	Yes	
Bank controls	Yes	
Pseudo R^2	0.275	
Observations	16,428	

Note: This table presents the estimation results for the logistic regression of GREENSYND on COUNTRY, INDUSTRY, and YEAR variables, controlling for loan and bank characteristics. In Column 1, coefficients are reported as odds ratios with respect to their corresponding reference category, respectively, non-EU, Utilities, 2015. Column 2 presents the corresponding predicted probabilities. *, **, and *** represent *p*-values smaller than 10%, 5%, and 1%, respectively. Robust standard error in parentheses in Column 1. Delta-method standard error in parentheses in Column 2.

3.3 | Further Analysis

To deepen the understanding of the underlying impact at the country level on syndicated green loans, we propose a revised specification of Model (1), incorporating the GHG variable as a proxy for the sustainability level of the country where the borrower firms are established.

To distinguish this effect between EU countries and not, and to prevalently examine this relationship in EU countries, we adopt a logistic model including an interaction between the GHG variable and the dummy EU, which is equal to 1 if the country is among those belonging to the EU and 0 otherwise.

Model (2), whose output is displayed in Table 8, has the following framework:

$$\text{GREENSYND}_{it} = \beta_e \text{GHG}_{it-1} + \beta_j \text{EU}_i + \beta_w \left(\text{GHG}_{it-1} \times \text{EU}_i\right) + \beta_c \text{LOAN}_{it-1} + \beta_b \text{BANK}_{it-1} + \beta_k \text{INDUSTRY}_i + \beta_h \text{YEAR}_i, \quad (2)$$

where GHG_{it-1} is the variable concerning environmental sustainability in terms of emissions over GDP, EU_i is the dummy variable separating EU countries from non-EU countries, LOAN_{it-1} is the vector of controls accounting for loan characteristics, BANK_{it-1} is the vector of controls for bank characteristics, while INDUSTRY and YEAR are the fixed effects at the industry and time level, as already specified in Model 1.

TABLE 8 | Syndicated green loans and country's sustainability.

Variables	GREENSYND
GHG_{t-1}	0.843 (0.167)
1.EU	2.830 (0.396)***
$\text{GHG}_{t-1} \times 1.\text{EU}$	0.296 (0.149)**
Loan Controls	Yes
Bank Controls	Yes
Industry FE	Yes
Year FE	Yes
Pseudo R^2	0.265
Observations	16,371

Note: This table presents the estimation results for a logistic regression of GREENSYND on GHG interacting with the dummy variable EU, controlling for loan characteristics, industry, and year fixed effects. Coefficients are reported as odds ratios. *, **, and *** represent *p*-values smaller than 10%, 5%, and 1%, respectively. Robust standard error in parentheses.

Table 8 displays a statistically significant coefficient associated with the aforementioned interaction term, suggesting that the relationship between country-level sustainability and the issuance of syndicated green loans varies between EU and non-EU countries. The coefficients in Table 9 present the average marginal effects of GHG on the likelihood of sustainable loans for the two groups of EU countries (EU = 1) and non-EU countries (EU = 0). Notably, for borrowers located in EU countries, a negative relationship emerges between the level of GHG emissions per GDP and the probability of green lending. In other words, in more sustainable countries the probability of a loan being green is higher and increases with its level. With regard to Hypothesis 2, this result supports the existence of a positive relationship between countries' environmental sustainability and banks' green lending practices. However, this relationship does not hold for loans to companies in non-EU countries, as evidenced by the corresponding coefficient in Table 9, which remains negative but is substantially smaller and statistically insignificant. This suggests that institutional forces, pressures, and the pursuit of legitimacy are stronger and more evident in EU countries.

4 | Robustness Checks

To support the previous findings, in this section we conduct a robustness check, which involves the adoption of an alternative dependent variable and a different model specification. The observations of the original dataset on syndicated loans are now disaggregated to capture the participation of each bookrunner involved in every loan tranche, along with the corresponding amount credited to it (Refinitiv). All other key information is maintained, such as the environmental flag, as well as the borrowers' country and industry. The data on banks' participation in syndicated loans is then aggregated by bank and year, distinguishing between green syndicated loans and not. The ratio between the amount of syndicated green loans and the total amount of syndicated loans for each bank each year represents our new outcome variable (GREENSHARE),

TABLE 9 | Average marginal effects of GHG on syndicated green loans.

VARIABLES	GREENSYND
At EU = 0	−0.012 (0.014)
At EU = 1	−0.159 (0.053)***

Note: This table presents the average marginal effects of GHG on the probability of syndicated green loans for the two groups of EU countries (*EU = 1*) and non-EU countries (*EU = 0*). *, **, and *** represent *p*-values smaller than 10%, 5%, and 1%, respectively. Delta-method standard errors are in parentheses.

taken as a proxy for banks' portfolio misalignment. A similar aggregation at the bank-year level is then performed to identify the industry with which each bookrunner is most involved.

We also consider CO_2 emissions over GDP as a different proxy for the environmental sustainability level of the country where the bookrunner is involved in the loan operations. Therefore, the resulting dataset consists of a bank-level panel, where each observation reflects the yearly aggregated characteristics of the syndicated loan participations attributed to a given bookrunner bank.

We estimate a fixed-effect linear regression model on GREENSHARE, with the following equation:

$$\text{GREENSHARE}_{it} = \beta_k \text{INDUSTRY}_i + \beta_w \text{CO2}_{it-1} + \beta_h \text{YEAR}_i + \beta_b \text{BANK}_{it-1}, \quad (3)$$

where GREENSHARE_{it} is the dependent variable accounting for the ratio between syndicated green loans and total syndicated loans credited to the bookrunners, BANK_{it-1} is the vector of controls for bank characteristics, INDUSTRY_i captures the fixed effects of the primary sectoral engagement for each bank, CO2_{it-1} is the lagged variable concerning the country's environmental sustainability in terms of CO_2 emissions over GDP, and YEAR represents the time fixed effects.

Table 10 shows the model results in Column 1 and the corresponding predicted margins for each industry in Column 2, respectively. These findings corroborate those of the previous Model (1) (Table 7). At the industry level, the highest proportion of syndicated green loans is recorded among banks primarily involved in the Utilities sector, chosen as the reference category (Column 2, Table 10). All the other industries are associated with lower shares. At the country level, the positive relationship between the country's environmental sustainability and the issuance of syndicated green loans is confirmed by a negative coefficient associated with the logarithm of CO_2.

Finally, we propose a further specification of Model (3) in which we add the 1-year lagged dependent variable (GREENSHARE_{it-1}) as a new regressor to capture the potential persistence effects of the dependent variable over time:

$$\begin{aligned}\text{GREENSHARE}_{it} = {} & \beta_d \text{GREENSHARE}_{it-1} + \beta_k \text{INDUSTRY}_i \\ & + \beta_w \text{CO2}_{it-1} + \beta_h \text{YEAR}_i + \beta_b \text{BANK}_{it-1}, \end{aligned} \quad (4)$$

where GREENSHARE_{it-1} is the lagged dependent variable introduced as a new regressor, BANK_{it-1} is the vector of controls for bank characteristics, INDUSTRY_i captures the fixed effects of the primary sectoral engagement for each bank, CO2_{it-1} is the lagged variable concerning the country's environmental sustainability in terms of CO_2 emissions over GDP, and YEAR represents the time fixed effects. Column 3 of Table 10 contains the output of a dynamic OLS regression model. The results align with the previous findings on the industry-level and country's sustainability effects on the shares of syndicated green loans. Another important result that also serves as a check of the dynamic estimation is the coefficient associated with the lagged dependent variable. Persistence in GREENSHARE is present, as indicated by a statistically significant coefficient (0.378) on its lagged value.

5 | Discussion

This paper sets out to investigate the main determinants of the misalignment in banks' credit portfolios, through data of the syndicated loans market. The aim is to determine whether exogenous factors such as the characteristics of the countries in which banks operate—and notably their sustainability—as well as the financed industries may be considered the primary obstacles for banks in aligning with climate objectives. Our results reflect an important shift in perspective that complements much of the previous literature primarily focused on the proactive role of the financial system in driving the environmental transition (Kleimeier and Viehs 2018; Degryse et al. 2023; Delis et al. 2024; Erten and Ongena 2024; Song and Rimmel 2025). Instead, building on recent acknowledgments of the difficulties encountered by financial institutions in the path towards decarbonization (European Central Bank 2024), we highlight the major role played by structural elements, such as country- and sector-specific characteristics, in explaining portfolio misalignment. In this sense, these factors may represent constraints that undermine the environmental efforts of financial institutions previously documented in the literature.

The main findings indicate that there are statistically significant differences in green syndicated loan issuance among different countries and sectors. With respect to the industry receiving the financing, Utilities are found to be more associated with green loans, while the other industries show lower probabilities of their issuance. Additionally, when comparing industry- and country-specific effects, it can be observed that the major impediment to green lending lies at the industry level. The exception represented by Utilities suggests that higher levels of sustainable financing are attainable, whereas all other industries consistently lag behind. However, it is worth noting that Utilities is still a rather marginal industry across EU countries' economies (as reported in Table 5), while those with larger production shares—such as Auto, Machinery & Vehicles, Construction, Food & Accommodation, Oil, Gas & Metals, and Technology—tend to be relatively less likely to secure syndicated green loans. This reinforces the notion that the major barrier in transitioning toward decarbonization comes from industries with a more entrenched role in national economies. Consequently, these structural constraints are reflected in banks' portfolios, as they are not fully independent in the allocation of financial resources.

Furthermore, as far as the differences among countries are concerned, it has also been shown that countries' sustainability facilitates the origination of syndicated green loans. In this context, countries' GHG emissions over GDP serve as a proxy for

TABLE 10 | Share of syndicated green loans on INDUSTRY and CO_2.

	(1)	(2)	(3)
Variables	**GREENSHARE**	**GREENSHARE**	**GREENSHARE**
$GREENSHARE_{t-1}$			0.378 (0.060)***
$CO2_{t-1}$	−4.463 (2.080)**		−4.329 (2.485)*
Auto, Machinery & Vehicles	−15.256 (4.433)***	20.961 (3.379)***	−7.411 (4.789)
Chemicals & Plastics	−17.330 (4.872)***	18.887 (3.972)***	−14.198 (4.718)***
Construction	−17.610 (3.891)***	18.607 (2.615)***	−10.234 (4.474)**
Consumer Goods	−23.278 (3.898)***	12.939 (2.644)***	−16.676 (4.288)***
Education & Entertainment	−24.309 (4.003)***	11.908 (2.783)***	−14.687 (4.544)***
Food & Accommodation	−20.109 (3.802)***	16.108 (2.494)***	−11.556 (4.202)***
Healthcare	−22.008 (4.135)***	14.210 (3.047)***	−17.186 (3.776)***
Oil, Gas & Metals	−27.421 (3.432)***	8.797 (1.854)***	−18.382 (3.970)***
Paper & Woods	−12.916 (7.700)*	23.302 (7.111)***	−14.542 (5.457)***
Professional & Business Services	−17.329 (4.468)***	18.889 (3.450)***	−14.284 (4.444)***
Real Estate	−20.253 (4.534)***	15.964 (3.457)***	−9.245 (5.304)*
Technology	−25.053 (3.499)***	11.164 (2.042)***	−21.742 (3.954)***
Trade	−21.596 (3.997)***	14.621 (2.780)***	−11.546 (4.716)**
Transportation & Logistics	−22.749 (3.989)***	13.468 (2.708)***	−16.457 (4.721)***
Utilities		36.217 (2.845)***	
Bank Controls	Yes		Yes
Year FE	Yes		Yes
Observations	1099		696
Adj R^2	0.277		0.365

Note: This table presents the estimation results for the linear regression of GREENSHARE on CO_2, INDUSTRY, and YEAR variables, controlling for bank characteristics. INDUSTRY identifies the industry with which each bookrunner is most involved. *, **, and *** represent *p*-values smaller than 10%, 5%, and 1%, respectively. Robust standard errors in parentheses in Columns 1 and 3. Delta-method standard error in parentheses in Column 2.

their environmental performance, reflecting the broader societal commitment to climate issues signaled to firms. In response to this—as explained by institutional and legitimacy theories—companies may experience direct pressures or more subtle persuasion to align with certain societal expectations on the environmental dimension (DiMaggio and Powell 1983), while also becoming aware of the dedicated efforts needed to achieve legitimacy (Suchman 1995). Therefore, the higher a country's environmental commitment, the stronger the pressure local firms will face—for example, stronger environmental requirements—and the higher the threshold they must meet to gain legitimacy. Consequently, as firms become more environmentally responsive, banks will find it easier to engage with green counterparties, which results in a greater allocation of syndicated green loans, thereby reducing their portfolio misalignment.

6 | Conclusion

Overall, this study provides evidence that banks' portfolio misalignment is not primarily attributable to their allocation choices, but rather to exogenous factors related to the industrial structure of the countries in which they operate. Our results set some implications for banks and policymakers. The issue of portfolio misalignment must be contextualized with the business characteristics of the bank's operating area. From this perspective, although banks can take a proactive role in urging firms toward the green transition by applying higher credit costs or fewer financing opportunities to polluting firms, their financing decisions are influenced by exogenous factors that are difficult to control. Furthermore, such choices could generate a compression of bank profitability margins in the short run, particularly due to the constraints imposed by the environmental characteristics inherent to the industries in which these banks operate. Despite the role they may play in incentivizing the pathway to decarbonization, banks remain constrained—by the need to preserve revenue streams—to continue financing firms not yet fully aligned with the low-carbon economy objective.

From the perspective of policymakers, the pursuit of a greater environmental transition of firms must be based on public policies aimed at the green innovation of companies' business models. Indeed, the role banks can play in promoting the ecological transition can be undermined by political decisions at

other levels that are not equally responsive and sensitive to environmental issues. Advancing the green transition of the EU economy requires substantial investments, and despite recent progress, further efforts are needed to keep decarbonization on track toward carbon neutrality by 2050. The existence of an environmental misalignment problem underscores the complexity of the green finance landscape, and the public sector needs to support the process, acting as a catalyst through the crowding-in of green private investment (European Central Bank 2025). On the regulatory side, strengthening the EU taxonomy and increasing the transparency and consistency of sustainability-related disclosures could lay the groundwork for gradually introducing regulatory requirements for businesses. However, the scope and effectiveness of this normative intervention cannot overlook structural factors and should tailor those macro contexts facing greater challenges in private green financing.

Beyond this, the widespread misalignment in banks' portfolios signals a significant transition risk for the entire financial system (European Central Bank 2024), thus requiring a supervisory and regulatory approach to the issue. Applying standard and uniform measures, such as higher capital requirements for exposures to carbon-intensive firms, may reduce the availability and affordability of financing for these firms, thereby undermining their capacity to adjust their business models (Financial Stability Institute 2023). Macroprudential instruments should therefore be defined not to hinder the provision of transition finance. The European Central Bank and European Systemic Risk Board (2022) have proposed several candidate tools for addressing climate-related systemic risks in the banking sector. Many of these instruments—such as the sectoral systemic risk buffer, concentration thresholds, concentration charges, and the sectoral leverage ratio—could be deployed with greater flexibility and allow for tailored application across different sectors and geographical areas.

Finally, there are certain limitations to this study that should be addressed in future research. First, industry-level categories are obtained by aggregating TRBC sub-industries to reduce fragmentation and ensure better comparability with the OECD dataset's ISIC Rev.4 classification. Second, future studies could extend our findings on the drivers of banks' portfolio misalignment, exploring whether and how bank business models are differently affected by such external drivers. Third, the analysis could also be extended from a geographical perspective, investigating whether non-European banks face the same challenges in aligning with climate objectives, influenced by the context in which they operate.

Acknowledgements

Galletta acknowledges the GRINS project for support related to issues included in the GRINS Project, such as "Resilience, recovery and sustainability: Sustainable Finance." This study was funded by the European Union – NextGenerationEU, Mission 4, Component 2, in the framework of the GRINS – Growing Resilient, INclusive and Sustainable project (GRINS PE00000018 – CUP E63C22002120006). The views and opinions expressed are solely those of the authors and do not necessarily reflect those of the European Union, nor can the European Union be held responsible for them. Lorenzo Fichera acknowledges the fund funded by DM n. 118, 02-03-2023 – ID: 7131. Open access publishing facilitated by Universita degli Studi di Catania, as part of the Wiley – CRUI–CARE agreement. [Correction added on 20 October 2025, after first online publication: Acknowledgements section has been updated in this version.]

Conflicts of Interest

The authors declare no conflicts of interest.

Endnotes

[1] United Nations Climate Change Conference - United Arab Emirates 30 November - 12 December 2023 https://unfccc.int/cop28.

[2] The bookrunner leads, originates, structures, and runs the books on the deal, maintains a record of activity for the syndicate and underwrites the largest portion of the securities (Refinitiv Eikon).

[3] Renewable Energy Equipment & Services (5020101010), Wind Systems & Equipment (5020101011), Stationary Fuel Cells (5020101012), Photovoltaic Solar Systems & Equipment (5020101013), Thermal Solar Systems & Equipment (5020101014), Biomass Power Energy Equipment (5020101015), Waste to Energy Systems & Equipment (5020101016), Hydropower Equipment (5020101017), Wave Power Energy Equipment (5020101018), Renewable Energy Services (5020101019), Geothermal Equipment (5020101020), Renewable Fuels (5020102010), Biodiesel (5020102011), Ethanol Fuels (5020102012), Pyrolytic & Synthetic Fuels (5020102013), Biomass & Biogas Fuels (5020102014), Hydrogen Fuel (5020102015), Carbon Capture & Storage (5220301015), Electrical (Alternative) Vehicles (5310101014), Sustainable & Energy Efficient Home Builders (5320301014), Organic Farming (5410201023), Power Charging Stations (5910101014), Alternative Electric Utilities (5910101020), Hydroelectric & Tidal Utilities (5910101021), Solar Electric Utilities (5910101022), Wind Electric Utilities (5910101023), Biomass & Waste to Energy Electric Utilities (5910101024), Geothermal Electric Utilities (5910101025), Independent Power Producers (5910102010), Renewable IPPs (5910102012).

[4] According to the TRBC scheme, the "Utilities" economic sector comprises both renewable and fossil-fuels-based firms within its subsectors of "Electric utilities" and "Independent power producers."

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