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## Greening the economy: how public-guaranteed loans influence firm-level resource allocation

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**Abstract**

This study investigates the underlying reasons for banks' continued support of fossil fuel-based firms and examines the role of public guaranteed loans (PGLs) in redirecting resources towards greener economic activities, thereby facilitating the climate transition process. Using a unique pan-European credit register dataset, we combine supervisory bank data with firm-level greenhouse gas emission data and financial information. Our analysis yields three main findings. Firstly, European banks perceive lending to green companies as riskier compared to their brown counterparts, a phenomenon we term as the "green-transition risk." Secondly, we provide evidence that during the COVID-19 pandemic, European banks have strategically leveraged PGLs to channel resources towards environmentally sustainable activities, thereby augmenting the proportion of green loans in their portfolios and partially shifting the inherent "green-transition risk" to European governments and citizens. Lastly, our investigation reveals a banking preference for awarding PGLs to financially robust green firms over less profitable, highly indebted green firms, which could pose significant challenges for green businesses requiring financial support during the COVID-19 crisis.

**Keywords:** Climate Change, Green Lending, Public Guaranteed Loans, Credit Risk.

**JEL classification:** G20, G21, G28

## Non-Technical Summary

In recent years, there has been growing attention from policymakers, governments, and supranational institutions towards addressing environmental concerns.

These efforts aim to combat climate change and safeguard human well-being by transitioning to a carbon-neutral economy. This transition requires significant changes in economic structures, such as adopting renewable energy systems, upgrading infrastructure, and implementing energy-efficient policies. Banks could play a crucial role in this process by allocating resources and imposing costs on companies that fail to meet environmental standards, especially in Europe, where bank lending is the main source of corporate funding

Despite these initiatives, banks still support a considerable portion of fossil fuel-based corporations.

In this paper, we explore a tradeoff faced by financial institutions. On the one hand, they have incentives to engage in green lending to meet regulatory expectations and sustainability goals. On the other hand, they also encounter a challenge in green lending, which involves unfamiliarity and uncertainty of climate policies and hidden costs intrinsic to greener technologies and projects which can make it hard to reallocate funds, measure risks, and efficiently allocate capital.

This study presents an explanation for banks' preference for lending to "browner" firms. We propose that banks may hesitate to green their portfolios due to perceived higher risks associated with green loans, resulting in increased capital allocation and monitoring costs. We term this phenomenon "green-transition-risk" where banks perceive exposures to green firms as riskier than to brown firms. To investigate this effect, we analyze the probability of defaults (PDs) for firms within the same industry-location-size (ILS) cluster based on their greenhouse gas emission (GHG) intensity. We also explore a potential solution to mitigate the green-transition-risk and promote lending to green companies. We suggest that public guaranteed Loans (PGLs) can help banks shift their portfolios towards greener firms by providing implicit protection against higher default probabilities. By introducing the PGL framework, banks no longer bear the downside risk of lending to greener companies as the government assumes the implicit higher bankruptcy risk. This change in incentive structure

encourages banks to provide more credit to greener companies while transferring default risk to the government. This allows banks to decarbonize their lending portfolios and meet supervisors' and policymakers' expectations regarding climate-related and environmental risks. We investigate whether PGLs have been directed primarily towards greener firms during the COVID-19 pandemic.

Our findings reveal two main results. First, within-ILS estimations demonstrate that PDs are higher for less polluting firms compared to more polluting firms, confirming the existence of green-transition-risk. Second, we observe that at the beginning of the pandemic, banks granted a higher share of PGLs to less polluting firms, supporting our hypothesis. Additionally, we find that lending to greener firms receiving PGLs improves compared to brown firms, and the likelihood of establishing new bank-firm relationships is higher through PGLs, particularly for less polluting firms.

Our research highlights the dilemma faced by financial institutions. While they have reasons to engage in green lending to align with sustainability goals and meet regulatory expectations, they encounter challenges in this new lending area. The perceived riskiness of green lending arises from uncertainties and potential hidden costs associated with green technologies and projects, as well as the changing landscape of climate policies lacking long-term predictability. This uncertainty affects banks' ability to assess and manage climate-related risks, impacting investment evaluations and increasing the cost of capital, thereby limiting the capacity to fund low-carbon activities. In summary, banks face a tradeoff between the incentives to engage in green lending and the perceived risks associated with it, driven by uncertainties in future developments and costs related to environmentally-friendly technologies and projects. The paper articulates that green public guarantee lending structures can alleviate the shown constraints and change the market conditions towards a new equilibrium, where green lending is more competitive and it has greater outcomes.

***"The misalignment with the EU climate transition pathway can lead to material financial, legal and reputational risks for banks. It is therefore crucial for banks to identify, measure and most importantly manage transition risks, just as they do for any other material risk.***

***[...] it is not for us supervisors to tell banks who they should or should not lend to. However, we will continue insisting that banks actively manage the risks as the economy decarbonises. And banks cannot do this without being able to accurately identify transition risks and how they evolve over time."***

(Frank Elderson, member of the ECB Executive Board and Vice-Chair of the Supervisory Board, "Failing to plan is planning to fail" why transition planning is essential for banks. 23 January 2024)

# 1 Introduction

Over the last few years, policymakers, governments, and supranational institutions have devoted increasing attention to environmental factors, introducing *ad-hoc* regulations and initiatives aimed at reducing CO2 emissions (Bolton and Kacperczyk, 2021).[1] All of these initiatives share the overarching goal of combating climate change and protecting human well-being. Achieving a carbon-neutral economy necessitates fundamental shifts in our existing economic structures. Transitioning to renewable energy systems requires comprehensive changes across various sectors. It involves the development and deployment of new technologies, infrastructure upgrades, changes in energy production, distribution and consumption patterns. It also entails promoting energy efficiency and implementing policies that incentivize the adoption of renewable energy solutions. This process needs to be facilitated through channelling investment through tilting investment decisions and incentives at the equilibrium.

[1] Among the most important initiatives: At the worldwide level, the Paris Agreement signed in December 2015 by 195 nations to keep the rise in mean global temperature well below 2°C above pre-industrial levels and ratified during the 26th Conference of the Parties (https://ukcop26.org/uk-presidency/what-is-a-cop/). At the European level, the European Central Bank (ECB) published its "Guide on climate-related and environmental risks" in 2020. It sets out the ECB supervisory expectations for banks' risk management and disclosure in this domain. This guide establishes a clear framework for European banks to accurately measure, mitigate and disclose climate-related and environmental risks. (https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202011finalguideonclimate-relatedandenvironmentalrisks~58213f6564.en.pdf). In addition, the ECB has adopted a climate agenda and started to carry out climate-stress tests in 2022, designed to prepare banks for both upcoming regulatory changes and climate related-risks, most notably transition and physical risks (https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202212_ECBreport_on_good_practices_for_CST~539227e0c1.en.pdf). In Appendix A.1 we provide with a detailed overview of all the climate-related initiatives and the role played by banks in the transition for a low-carbon economy.

Banks play a significant part in these efforts. They are key in allocating resources to non-financial corporations (NFCs) and have the power to impose costs on companies that do not comply with environmental standards through adjustments in loan quantities and/or prices. However, banks continue to support a substantial share of fossil fuel-based corporations. According to Kacperczyk and Peydró (2021), since 2015, 60 major banks have allocated $4.6 trillion to the fossil fuel industry, including $742 billion to oil, gas, and coal in 2021 alone.

This persistent support for fossil-related firms is further underscored by Laeven and Popov (2023), revealing that banks persist in extending loans to such entities even after the implementation of carbon taxes. Their findings indicate a trend of reallocating a larger share of the fossil loan portfolio to countries with less stringent environmental regulation and bank supervision, highlighting the complexities in financial decision-making amidst evolving environmental policies.

This paper first proposes a potential explanation for banks' preference for lending to "browner" firms. We suggest that banks may lack the incentive to green their portfolios, as green loans are perceived as riskier and thus require higher capital allocation due to increased capital risk-weighted charges and monitoring costs. This phenomenon, which we term "green-transition-risk", suggests that banks perceive exposures to "green" firms as riskier than those to "brown" companies. To identify this effect, we examine how the probability of defaults (PDs) of firms operating within the same industry-location-size (ILS) cluster differs depending on the level of greenhouse gas emission (GHG) intensity.

Second, we identify an unexplored channel through which the "green-transition-risk" can be mitigated to favor increased lending to green companies. In this regard, we posit that public guaranteed loans (PGLs) can play a key role in helping banks tilt their loan portfolios away from more polluting firms, thus facilitating lending to greener companies. In fact, PGLs allow banks to increase lending to green companies, even if they are estimated to have a higher probability of default than brown companies. This outcome results from the government bearing the implicit higher bankruptcy risk, protecting banks from potential negative consequences if a green company fails. Therefore, the introduction of the PGL framework changes the incentive structure of banks around green lending, as they no longer bear the downside risk of lending to greener companies. We find that this implicit protection

may encourage banks to "take on more risks", providing more credit to greener companies at the expense of brown companies. In this way, banks may "kill two birds with one stone": transferring default risk (partially or entirely) to the government while decarbonizing their lending portfolio and fulfilling the expectations of supervisors and policymakers regarding the reduction of climate-related and environmental risks. To test this hypothesis, we exploit the deployment of PGLs during the COVID-19 pandemic and investigate whether these have been directed primarily towards greener firms.

During the pandemic, in addition to other relief measures (e.g., tax deferrals, grants, equity injections, and changes to accounting policies), governments resorted to PGLs to reduce disruption to business operations, prevent corporate failures, and sustain lending (Altavilla et al., 2021; IMF, 2022).[2] These loans can offer valuable support by transferring default risk (partially or entirely) to the government (and thereby public finances), potentially encouraging banks to increase their lending (Figure 1), including to companies most affected by the economic crisis (Andaloussi et al., 2022). This tool may also be a more efficient and effective way to distribute public assistance to companies than direct government funding (e.g., fiscal benefits or cash reimbursement). Banks, through their monitoring, typically employ screening tools and maintain longstanding relationships with clients. As a result, they possess more comprehensive and "soft" information, particularly on small firms (Berger et al., 2005; Diamond, 1984; Petersen and Rajan, 1994, 2002), compared to the government (Altavilla et al., 2021). For instance, this information may pertain to the borrower's quality (e.g., the company's reputation) or other firm-level specific characteristics (e.g., whether the company is 'green' or 'brown'). More in general, during economic crises, by leveraging the knowledge of banks, funding is more likely to reach viable companies than if the government were solely responsible for deciding which companies to liquidate or save (Philippon, 2021). In this context, the central contribution of PGLs could be pivotal in shaping banks' lending strategies to support more environmentally-conscious firms, as they do not face the downside of green lending or "green transition risk". This confirms the importance of public interventions in the global economy towards greening and welfare enhancement.

[2]For a detailed overview of the PGL schemes in Europe refer to Appendix A.2. Please see the online appendix of the paper here.

To disentangle the demand and supply effects of PGLs, we rely on granular credit registry data and comprehensive information on the PGLs provided by government agency underwriters. We match credit registry data with firm-year financial data from Orbis BVD, firm-year GHG emissions from Urgentem and bank balance-sheet supervisory information from the ECB's database. Our analysis includes 91 banks from 12 European countries: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal and Spain, focusing our analysis on quarterly data from 2019 Q1 to 2020 Q4.

We establish two main findings. First, within-ILS estimations show a negative relationship between GHG emissions and firms' PDs, confirming our first hypothesis that banks indeed face a "green-transition-risk", as exposures with less polluting firms are riskier than those with more polluting firms. Specifically, two standard deviations decrease in GHG emissions leads to approximately 48 basis points (bps) increase in PDs. Given that the average PDs for the entire sample is 3.61%, the obtained result is significant and noteworthy.[3] Second, we also find that at the onset of the pandemic, banks granted more PGLs to less polluting firms in relative terms, supporting our second hypothesis. In particular, two standard deviations decrease in GHG emissions results in about 30 bps higher share of guaranteed credit over total credit. Although not large, the effect is economically relevant considering that supporting greener firms during the Covid-19 pandemic was not the main aim of PGLs.

Furthermore, we observe improved lending for greener firms receiving PGLs compared to brown firms. Additionally, the likelihood of establishing a new bank-firm relationship during the pandemic is higher through PGLs; however, this effect is more pronounced for less polluting firms.

We also conduct a large set of robustness checks to rule out alternative explanations for our results. First, we ensure that our findings are not influenced by prior credit relationships between banks and firms. Second, we utilize only disclosed greenhouse gas emissions (Aswani et al., 2024) at the corporate level. Third, we check that our findings are robust when changing the econometric specification. We find that our results remain virtually the same.

Our research reveals a potential dilemma faced by financial institutions. On the one hand, they have compelling reasons to offer green lending, to align with sustainability goals

[3]This results in a PD increase of approximately 11% in comparison to the average PD.

[4] and meet the numerous regulatory expectations and requirements (Demekas and Grippa, 2021). On the other hand, these institutions find themselves confronted with a new channel of lending (i.e., green lending). Since this is an area outside their specialization, it can cause green lending to be perceived as riskier due to the future uncertainty and potential hidden costs intrinsic to greener technologies and projects.[5] In addition, this new lending avenue is governed by a changing set of climate policies and regulations that lack long-term predictability, adding further uncertainties. This uncertainty surrounding climate policies makes it difficult for banks to assess and manage climate-related risks effectively, and affects the assessment of investments, leading to a negative impact on their net present values and increasing the cost of capital impairing the marginal capacity of investors to fund low-carbon activities (Berg et al., 2023). In essence, the belief among banks that companies with a focus on sustainability are more hazardous can be traced back to the unpredictability of the future and concealed costs that are inherent in environmentally friendly technologies and projects.

Our study contributes to the growing body of research investigating the financial sector's impact on decarbonizing the global economy, which in turn addresses the challenge of climate change (De Haas and Popov, 2019; Gambacorta et al., 2022; Mésonnier, 2019; Reghezza et al., 2022), and to the literature on government credit guarantees (Atkeson et al., 2019; Bertrand et al., 2007; Kelly et al., 2016; La Porta et al., 2002), as well as on its implications in terms of bank risk-taking and portfolio reallocation (De Blasio et al., 2018; Fischer et al., 2014; Wilcox and Yasuda, 2019).

The remainder of the paper is organized as follows: Section 2 discusses the relevant literature concerning PGLs. Section 3 describes the data used in the analysis. Section 4 presents the empirical methodology and the findings, and Section 5 shows the main robustness test. Finally, Section 6 offers concluding remarks.

[4] See Appendix A.1. Please see the online appendix of the paper here.

[5] In paragraph 4.1 we identify four sources of uncertainty for banks: green policy dependence and uncertainty; technological uncertainty; market uncertainty; and operational challenges.

# 2 Public Guaranteed Loans and the Financing Landscape: A Comprehensive Literature Review

In this research, we focus on the influence of PGLs on the credit supply to green and brown companies, specifically examining their potential role in incentivizing the green transition. It is well-established that credit constraints pose significant obstacles to realizing a truly green economy. In the literature, financing restrictions are mainly associated with their role in limiting SMEs' growth (Barrot, 2016; Kaplan and Zingales, 1997; Petersen and Rajan, 1994).

Previous studies have examined various aspects of PGLs, primarily focusing on how and to what extent PGLs may affect credit. Altavilla et al. (2021) leverage on the PGLs issued during the COVID-19 pandemic in Europe and find that PGLs partially led to substituting non-guaranteed loans with guaranteed credit. Moreover, the authors discover these PGLs were primarily granted to small yet comparatively creditworthy companies operating in sectors severely impacted by the pandemic. Bachas et al. (2021) conduct a study to assess the efficacy of guarantees offered by the Small Business Agency in the United States, findings that banks increased lending in response to the availability of more favorable public guarantees. Ciani et al. (2020), examining the PGLs eligibility rules in Italy before the COVID-19 pandemic, determine that firms receiving PGLs obtained more loans (7-8% of their overall banking exposure) at a reduced interest rate (50-basis-point reduction). De Blasio et al. (2018), study loan guarantee eligibility criteria in Italy from 2005-12 and observe a favorable effect of the program on total bank loans at the threshold between non-eligible and eligible firms. Bertrand et al. (2007) conduct a study on the impact of the French Banking Act of 1985, which removed PGLs (specifically, subsidized bank loans) to assist SMEs. After the reform, the authors establish that banks were less likely to bail out underperforming firms and extend credit to firms experiencing events that negatively affected performance. Moreover, this deregulation introduced a stronger for-profit motive among banks, reducing subsidies to lenders. Atkeson et al. (2019) examine the valuation of American banks with government guarantees, shedding light on the relationship between PGLs and banks' financial stability and market perceptions of their riskiness. Similarly, Fischer et al. (2014) analyze the risk-

taking incentives of German banks in the context of government guarantees, finding that PGLs are associated with banks providing loans to riskier borrowers. Wilcox and Yasuda (2019) examine the effects of the Emergency Credit Guarantee Program (ECGP) introduced by the Japanese government in 1998. They find evidence that banks increased their lending to SMEs under the ECGP; however, this lending was associated with increased riskiness of loans as banks began taking on riskier borrowers. Supporters of PGLs schemes assert that guarantees enable borrowers who otherwise lack access to funds to obtain credit, reducing credit constraints, particularly for SMEs (Bachas et al., 2021; Ciani et al., 2020; Cordella et al., 2018; De Blasio et al., 2018), and during a financial crisis (Altavilla et al., 2021; IMF, 2020). However, critics of PGLs schemes argue that such programs function merely as subsidies for lenders and unhealthy firms (Atkeson et al., 2019; Bertrand et al., 2007) and incentivize banks' risk-taking (De Blasio et al., 2018; Fischer et al., 2014; Wilcox and Yasuda, 2019).

From the perspective of banks, PGLs serve two primary interests. Firstly, banks can use PGLs to support borrowers with a higher risk of default during a crisis to prevent corporate failures and sustain lending (Altavilla et al., 2021; IMF, 2020). Additionally, guaranteed loans originated at lower interest rates than existing loans, as the guarantee mitigates credit risk. This can also incentivize riskier companies (i.e., those that pay a higher interest rate) to request PGLs. Secondly, banks may benefit from replacing their current loans with guaranteed ones. This reduces their capital absorption as PGLs carry lower credit risk weights, with some being fully guaranteed loans that carry zero credit risk weight (e.g., the PGLs provided in Germany and Italy for SMEs during the pandemic period). In both scenarios, PGLs act as a capital top-up, which allows banks to support lending.

# 3 Data, Sample and Descriptive Statistics

## 3.1 Data

We construct a comprehensive and unique dataset that matches (i) the ECB proprietary loan-level credit register *AnaCredit*, (ii) firm-level GHG emissions data from Urgentem, (iii) firm-level characteristics from Orbis BVD, as well as (iv) ECB bank balance-sheet supervi-

sory information from the ECB's database.

AnaCredit provides granular loan-level or credit instrument information. It is a proprietary and confidential database of the ECB that presents individual transaction-level data together with in-depth information, among others, about the lender, the borrower, the precise provider of the collateral (or guarantees/protection), as well as specific information about the nature of the collateral or guarantees provided in each case.[6] We use at the instrument level the individual annualised interest rate of the credit instrument and the outstanding nominal amount, inception date, and the probability of the debtor's default taking part in the instrument as assigned by the creditor.

The debtor companies are identified at the RIAD level, the ECB's Register of Institutions and Affiliates Database (RIAD). This infrastructure provides information on the financial composition and control structure of financial and non-financial legal entities.[7] From this layer, we obtain key corporate-level variables such as the country location of the legal entity, the territorial unit (*NUTS codes level 3*), the postal code, enterprise size[8], as well as its institutional NACE sector.[9] One of the important features that we exploit is the comprehensive information on the collateral, guarantee or protection securing each of the instruments at hand, as well as on the institution behind this collateral. Through this, we can disentangle the guarantee tranches and the loans provided by the government agency underwriters in the policy context.

We obtain firm-level annual data on greenhouse gas emissions (measured in tonnes of GHG emissions) from Urgentem (Gambacorta et al., 2023; Giannetti et al., 2023; Papoutsi et al., 2021). The Urgentem Carbon Dataset provides the complete range of Scope 1, 2 and

[6]The database takes into consideration the different collateral instruments existing for each transaction, as well as in turn, the multiple collateral providers for each of these guarantees. The data has been collected since September 2018 on a monthly level data, covering a reporting set of financial institutions of around 3400 Euro area banks. There are 3400 financial institutions at the consolidated level and 5800 at the subsidiary level, and approximately 120 million credit instruments for 7 million debtors across all Euro area countries. The database includes details for all loans above 25,000 euros granted in the Euro area to a legal entity.

[7]Monetary and Financial Institutions, Investment Funds, Financial Vehicle Corporations and Insurance Corporations.

[8]Company size classification from 1 to 4 (Large, Medium, Small and Micro) enterprise as following the Annex to Recommendation 2003/361/EC.

[9]Statistical Classification of Economic Activities in the European Community (NACE Rev.2).

3 emissions disclosed at a consolidated level by approximately 6,000 global companies. In our analysis, we use the total GHG emissions (the sum of scope 1,2 and 3) and following Bolton and Kacperczyk (2021) procedure, the relative GHG emissions, which measure a company's carbon intensity, are expressed as tonnes of GHG equivalent divided by the company's revenues in EUR millions.

We complement the dataset by incorporating individual bank and borrower information. We obtain a quarterly bank balance sheet report from the ECB supervisory data and collect bank-level controls commonly employed in the banking literature. Specifically, we include (see Table 1 for the definition of the variables) the logarithm of total assets (*Bank Size*), the ratio of customer deposits to total liabilities (*Deposits*), the non-performing loans ratio (*NPL*), the return on assets (*Bank ROA*), the liquidity ratio (*Liquidity Ratio*), the ratio of fees and commissions to operating income (*Fees and Commissions*), the CET1 ratio (*Bank Capitalization*), the risk-weighted assets density (*RWA*) and the provisions to total assets ratio (*Bank Provision*). Finally, we access firm-level characteristics through Orbis BVD and construct a set of corporate-level control variables. Specifically, we include the logarithm of total assets (*Firm Size*), return on assets (*ROA*), the firm's working capital (*Firm Working Capital*), firm liquidity (*Firm Cash*) and the firm's debt (*Firm Debt*).

**[Place Table 1 about here]**

## 3.2 Sample and Descriptive Statistics

The sample covers quarterly data from 2019Q1 to 2020Q4. After matching the different data sources, we obtain a final sample of 2,130,020 observations. In total, the matched estimation sample covers 91 banks and 307,130 firms. Panel A of Table 2 provides the summary statistics for our dependent variables. The $PD_{f,b,q}$ represents the weighted average probability of a firm defaulting on its loan obligations as assigned by the bank $b$ in a given quarter $q$ to firm $f$. The summary statistics show that PD values range from 0.03% to 47.2%, with a mean of 3.6% and a standard deviation of 7.1%. $PGL$ represents the proportion of loans each bank $b$ grants to a specific firm $f$ that falls under the government guarantees. The average public guarantee is 21.2%.

*New bank-firm Relationship* has a mean of 20.7%, suggesting that about one-fifth of the observations involve new bank-firm relationships. The average loan amount is EUR 468,081, while the median is EUR 132,245. The distribution of loan sizes extends from a minimum value of EUR 25,000 to a maximum of EUR 7,253,081. Moreover, as an additional test, we use lending growth, calculated as the quarterly log differences of the total outstanding nominal amount *(or credit stock)* provided by bank $b$ to firm $f$ in a quarter $q$. This provides insight into the banks' lending behaviour. The lending growth variable provides an average measure of 1.6%.

Panel B of Table 2 focuses on the GHG emission variable, GHGTot, which measures the sum of Scope 1, 2, and 3 GHG emissions relative to a firm's revenues, as obtained from Urgentem. The scope 1-3 GHG relative emission ranges from approximately 126 GHG tonnes per million to 5,395 GHG tonnes per million, with a mean of 734.5. Panel C of Table 2 displays the summary statistics for the firm control variables. The average size of the firm (*Firm size*) is EUR 7.9 million. The firm profitability, proxied by the ratio between earnings before interest and taxes to total assets (*Firm ROA*), averages 2.5%. The *Firm working capital* is between -27.8% to 89%, with an average of 25.3%. The average ratio of cash holdings to current liabilities (*Firm Cash*), an indicator of short-term liquidity, stands at 8.3%. Lastly, the average debt ratio (*Firm Debt*) is 70.9%. Panel D of Table 2 shows the summary statistics for bank-specific variables. On average, banks have a total asset (*Bank Size*) of about EUR 624 billion. The ratio of total deposits to total liabilities (*Deposit*), a proxy for the stability of banks' funding structures, averages 76.9%. The ratio of non-performing loans to gross loans (*NPL*), which measures a bank's asset quality, exhibits an average value of 7.3%. The average profitability of the banks, measured by the ratio of net income to total assets (*Bank ROA*), is 0.3%. The liquidity ratio, measured as the ratio of cash and cash equivalents to total assets, averages 5.9%. The average ratio of fees and commissions to operating income (*Fees and commissions*), our proxy for banks' business models, is 34.7%. The bank capitalization (the ratio between Common Equity Tier 1 and risk weighting assets) for the banks in our sample is 14%. Risk-weighted assets over bank total assets (*RWA*) is on average circa 42%. Lastly, the average ratio of provisions over bank total assets (*Bank Provisions*) is 0.8%. Finally, Panel E of Table 2 provides the statistics

for the policy control variables. Specifically, we consider two variables to account for any confounding effects arising from other public policies in the credit sector implemented in response to the COVID-19 outbreak around the time of the experiment. First, we generate a variable called *Moratoria* to account for the measures associated with public moratoriums enacted by public authorities to address the distress caused by COVID-19.[10] The average share of bank-firm credit relationships affected by the moratoria is 0.022%. Second, we create a variable called *CB Liquidity* to capture the central bank liquidity allotment to each financial institution to control for the third series of the Targeted longer-term refinancing operations (TLTRO III) that were enacted on 7 March 2019.[11]The *CB Liquidity* averages 9.1%.

# 4 Empirical Results

## 4.1 Inside the "green-transition risk"

In this section, we look at whether exposures to greener firms are riskier than those to brown companies. For identification purposes, we examine how the PDs of firms operating within the same ILS cluster differ depending on GHG emission intensities. Given the likely effect of the COVID-19 pandemic on the perceived riskiness and the overall higher uncertainty during the pandemic, for this exercise we focus on the year 2019. Here, our econometric identification relies on the following specification:

$$PD_{f,b,q} = \beta GHGTot_f + \gamma_1 X_{f,c,q} + \alpha_{ils,q} + \alpha_b + u_{f,b,c,q} \tag{1}$$

where $PD_{f,b,q}$ is the probability of default of the firm $f$ as assigned by the bank $b$ in a given quarter $q$. The $GHGTot$ measures the firm's emission of greenhouse gases expressed as tonnes of GHG emissions per million EUR of revenues.

The model is gradually enriched with various combinations of fixed effects. We first include bank-fixed effects to account for bank unobservable characteristics, such as the different

[10]Which extended flexibility to the NPL classification of exposures covered by qualifying legislative and non-legislative moratoria following the EBA guidelines on legislative and non-legislative moratoria on loan repayments applied in the light of the coronavirus crisis (Budnik et al., 2021).

[11]The third TLTRO programme consisted of a series of ten targeted longer-term refinancing operations, each with a maturity of three years, starting in September 2019 at a quarterly frequency. https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/index.en.html

models used by banks for estimating default probabilities.[12] We then add ILS fixed effects ($\alpha_{ils,q}$) to control for the heterogeneity in the level of PDs across locations, sectors and firm sizes.[13] However, since firms PDs can vary within ILS clusters depending on firm-specific characteristics we introduce the vector $X_{f,c,q}$ that comprises lagged firm-level variables commonly used to assess firms' risk or financial health. Larger firms are often perceived as less risky due to their diversified business operations and superior resource access. Their well-established relationships with banks and extensive credit history can lead to a reduction in their perceived risk. Consequently, these larger firms might exhibit a lower expected PD (Beck et al., 2005; Berger and Udell, 1998). Firms with higher Return on Assets (ROA) are generally considered more efficient and profitable, which can mitigate their perceived risk and, consequently, their expected PDs (Altman, 1968; Beaver, 1966; Ohlson, 1980). It is plausible that firms with higher working capital ratios are perceived as more aggressive in their growth strategies or investment activities, leading to an elevated risk of default. Alternatively, these firms may be viewed as less efficient in managing their short-term assets and liabilities, resulting in financial instability and an increased PD (Fazzari and Petersen, 1993; Petersen and Rajan, 1997). Firms with higher cash reserves (or cash equivalents) are considered less risky because they have more resources to meet their short-term obligations. Therefore, these firms may have a lower expected PD (Opler et al., 1999). The *Firms Debt* measures a firm's financial leverage. Firms with higher levels of debt relative to their assets are generally considered riskier because they have more financial obligations to fullfil, which can increase their expected PD (Bharath and Shumway, 2008; Campbell et al., 2008; Jensen and Meckling, 1976; Molina, 2005; Myers, 1977; Opler and Titman, 1994). $u_{f,b,c,q}$ is the error term. Standard errors are two-way clustered at the bank and firm levels. All firm control variables are lagged by one quarter and winsorized at the 1% level.

Table 3 presents the results obtained from estimating Equation 1. The Table consists of four columns. In column 1, we estimate the relationship between $PD$ and $GHGTot$,

[12] Bank fixed effects allows us to control for banks information advantages due to private information and direct monitoring, as well as banks screening and monitoring ability, which may affect the probability of default of green and brown companies.

[13] To classify the industrial sectors, we follow the Statistical Classification of Economic Activities in the European Community (NACE Rev.2) code, which we employ at the fourth digit level of granularity. The location clusters are based on the postal code of the firms' headquarters, while for size, we follow the definition provided in AnaCredit (as already mentioned in footnote 14).

controlling for ILS fixed effects without incorporating firm-level controls. Columns 2 to 4 include firm-specific characteristics that may influence PDs and various combinations of fixed effects.

We find a statistically significant negative relationship between $PDs$ and $GHGTot$, indicating that banks estimate a higher likelihood of loan defaults for firms with lower emissions within ILS clusters. Moreover, the effect is also economically meaningful.

Two standard deviations decrease in $GHGtot$ leads to approximately 48 bps increase in PDs.[14] Considering an average PD of 3.61% in our sample, this effect is not negligible. The coefficient for $GHGTot$ remains robust, even after controlling for firm-specific traits and including bank-fixed effects. This is particularly important as most of the firm-specific characteristics included in the specification, aimed at addressing omitted variable concerns, display a statistically significant relationship with firm PDs.

We offer several intuitive explanations for the negative coefficient on $GHGTot$ that we largely borrow from the extant literature.

Overall green financing entails certain risks, such as the uncertain viability of projects (Clark et al., 2018). Financial institutions approach this with skepticism, as they are concerned about the possibility of project delays or abandonment, which could result in negative returns on investment. Another risk arises from commercial banks being unaware of the potential hazards associated with environmentally harmful projects (Linh and Anh, 2017). This risk creates a dilemma where the expected returns of financial institutions may differ from the business goals of the companies involved (Falcone and Sica, 2019). Moreover, the high cost of green projects or technologies (Taghizadeh-Hesary and Yoshino, 2020) contributes to the perception of green financing as a high-risk endeavor, potentially resulting in lower returns on investment for financial institutions (D'Orazio and Löwenstein, 2022).

***Green policy dependence and uncertainty***. Companies investing in greener technologies rely more on government policies such as subsidies, preferential tariffs, or tax incentives (Rodrik, 2014). Changes in these policies can impact the profitability and competitiveness of these firms. Corporations rely on regulations and public subsidies to start their

[14] In the case that we consider the firms with the lowest GHG emissions (126 tonnes of GHG emissions to total revenues) the PDs is approximately 110 basis points higher than firms with the highest GHG emissions (5,395 tonnes of GHG emissions to total revenues).

projects and financial institutions rely on them to structure their funding. Such projects therefore are fundamentally heavily regulatory reliant. Over the last years, certain countries have retroactively replaced regulations and tariff structures and such deepening in the rupture in legal security has been increasing over the last years (Sendstad et al., 2022).[15][16]

Moreover, Flora and Tankov (2023) shows that scenario uncertainty can lead to considerable delays in implementing green investment projects. For example, the government's decision to reduce subsidies for green energy could affect the expected profitability of companies more reliant on those energy sources. It is, therefore as well plausible to think that the green policy uncertainty has important credit implications for lenders (Guesmi et al., 2023) and real investment implications for corporate decision-making (Ren et al., 2022). As green policies are thus in a very early stage of implementation, the absence of a precise, stable and predictable institutional setting, with a clear climate cross jurisdictional regulatory strategy contributes to a heightened uncertainty, which makes financial markets and institutions to experience inefficiencies due to their inability to effectively risk price and allocate funds (Berg et al., 2023).

***Technological uncertainty***. Greener companies often rely on new, unproven technologies, which carry inherent risks (Day and Schoemaker, 2011; Geels, 2002; Porter and Linde, 1995). Moreover, in the green sector exists a rapid pace of technological advancement, this means that today's cutting-edge technology may be completely obsolete tomorrow (e.g., in the car industry, hydrogen technology is expected to replace electric batteries in the future (Castellini et al., 2021)).[17]

[15]See in the case of Spain, where the Council of Ministers sanctioned a new policy, effective retroactively, to supplant the feed-in tariff. Critics argued that this move "intensifies the breach in legal certainty" regarding Spain's renewable energy strategy and would likely exacerbate the challenges facing the country's solar industry. The article stated that "The law approved today by the Council of Ministers does not only penalize the past but also the future," [...] "With the legal insecurity which has been created in this nation, it will be very difficult in the future to convince investors to come to the sector, or they will only come with risk premiums which will damage the competitiveness of the technology." Institute of Energy for South East Europe (IENE). https://www.iene.eu/spain-approves-retroactive-policy-to-replace-feed-in-tariff-p692.html.

[16]See as well the case of Italy, where the Italian Parliament and Senate passed a decree that cut solar feed-in tariffs (FiTs) for operational plants exceeding 200 kW and altered the payment schedule throughout the year. https://renewablesnow.com/news/italian-parliament-okays-retroactive-solar-fit-cuts-433823/).

[17]Path to hydrogen competitiveness: A cost perspective, Hydrogen Council, January 20, 2020, hydrogencouncil.com; Green hydrogen cost reduction: Scaling up electrolysers to meet the 1.5°C climate goal, International Renewable Energy Agency, 2020, irena.org. Available at: https://hydrogencouncil.com/

***Market uncertainty***. The market for greener products and services is still developing and it remains unclear how large and rapidly it will grow (Roper and Tapinos, 2016).[18] This might create uncertainty about the future revenues of firms investing more in greener technologies increasing their perceived riskiness.

***Operational challenges***. Companies relying more on greener technologies may face unique operational challenges, such as the need to source new, environmentally eco-friendly materials or develop *ad-hoc* supply chains. These challenges can increase operational complexity and costs, making these companies riskier to banks.

In a nutshell, the perception among European banks that greener companies are riskier can be attributed to the future uncertainty and potential hidden costs intrinsic to greener technologies and projects.

**[Place Table 3 about here]**

## 4.2 PGLs as a means to green the environment

In the previous section, we tested and provided a possible explanation for banks' appetite to lend to browner firms. In this section, we begin by exploring whether and to what extent banks leveraged on PGLs to extend credit to less-polluting firms. Our econometric specification is based on the following equation:

$$PGL_{f,b,q} = \beta GHGTot_f + \gamma_1 X_{f,c,q} + \gamma_2 Z_{b,c,q} + \alpha_{ils,q} + \alpha_b + \alpha_{c,t} + u_{f,b,c,q} \tag{2}$$

The dependent variable of interest, $PGL_{f,b,q}$, represents the proportion of loans from bank $b$ to firm $f$ subject to government guarantees in quarter $q$. As in Equation 1, the variable $GHGTot$ represents firm-level greenhouse gas emissions, measured in tonnes of GHG

wp-content/uploads/2020/01/Path-to-Hydrogen-Competitiveness_Full-Study-1.pdf. "Innovating to net zero: An executive's guide to climate technology. McKinsey & Company 2021". Available at: https://www.mckinsey.com/capabilities/sustainability/our-insights/innovating-to-net-zero-an-executives-guide-to-climate-technology).

[18] "Identifying opportunities and starting to build a new green business in the industrial sector. McKinsey & Company 2022". Available at: https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/identifying-opportunities-and-starting-to-build-a-new-green-business-in-the-industrial-sector.

emissions per million EUR of revenue. Our main coefficient of interest is $\beta$, which indicates whether banks extended more PGLs to greener firms.

Arguably, equation 2 presents some empirical challenges. First, the impact of the pandemic might be heterogeneous across firms and, as such, the demand for PGLs. To tackle this identification issue, we employ ILS*quarter fixed effects ($\alpha_{f,q}$) to control for the heterogeneity in the demand of PGLs across firms over time. Indeed, the negative repercussions of the pandemic on firms should be homogeneous within the ILS cluster and, *ceteris paribus*, their demand for PGLs. Nevertheless, even within the ILS cluster, some firms may face greater liquidity and/or working capital needs, thereby affecting their credit demand and banks' appetite for granting PGLs. To address this further concern, we complement ILS*time fixed effects with time-variant firm-specific controls used to capture variation in firm-specific traits. As in equation 1, we include lagged firm-level characteristics: the logarithm of total assets (*Firms Size*), the return on assets (*Firm ROA*), the working capital to total assets ratio (*Firm Working capital*), the ratio of cash holdings to current liabilities (*Firm Cash*), and the ratio of current liabilities plus non-current liabilities to total assets (*Firm Debt*).

A second source of endogeneity concerns lenders' decision to grant PGLs that could be affected by the ability to provide credit or take more risks. Here, we first include bank fixed effects ($\alpha_b$) to capture time-invariant unobservable factors at the bank level affecting the decision to grant PGLs. In addition, a wide array of bank-level variables ($Z_{b,c,q}$) are employed to control bank-specific characteristics that may influence the decision to grant PGLs. The CET1 ratio, a measure of *Bank Capitalization*, controls for bank solvency. We also control for the *Bank Size*, proxied by the logarithm of total assets. In contrast, the non-performing loan ratio ($NPL$) and the provisions to total assets ratio ($Provision$) account for the credit quality of the loan portfolio. The risk weight density ($RWA$), defined as the ratio of risk-weighted assets to total original exposures, is a proxy for the bank's asset portfolio riskiness. The return on assets ($ROA$) measures the profitability of the banks' credit portfolio. In contrast, the liquidity ratio of liquid assets to total assets is used to assess the liquidity of the bank's assets. The deposit ratio, which is the ratio of deposits to total assets, represents a crucial element of the bank's liabilities and funding structure.

A third econometric challenge is to isolate the effect on PGLs from other pandemic-

related measures, most notably, monetary policy measures and moratoria schemes. Moratoria schemes may affect firms' demand for PGLs as firms demanding debt repayment moratoria to mitigate liquidity concerns might have less need for guaranteed credit. Contrarily, monetary policy measures may impact the supply side of PGLs as banks benefiting from large uptake of Targeted Longer-Term Refinancing Operations (TLTROs) may be better able to provide credit independently of government guarantee schemes. Figure 2 shows a surge in monetary measures and moratoria on debt repayment in banks' balance sheet visible from 2020Q1, confirming the importance of controlling for these measures in our empirical strategy. In equation 2, we include the share of loans under moratoria ($Moratoria$) at the bank-firm level, and incorporate the ratio of central bank liquidity to total assets ($CBLiquidity$) at the bank level to account for the impact of Targeted Longer-Term Refinancing Operations (TLTROs) and Asset Purchase Programs.

Finally, we include Country*time fixed effects ($\alpha_{c,t}$) to control for variations in the pandemic's impact across countries and differences in the regulation and implementation of PGLs' schemes. All the bank and firm control variables are lagged by one quarter and winsorized at the 1% level.

In a complementary set of econometric specifications, we investigate whether the impact of GHG emission intensities on the share of PGLs depends on some firm-specific characteristics. In particular, we interact $GHGTot$ with firm profitability, working capital, liquidity and leverage.

Table 4 presents the results from estimating Equation 2. Columns (1) and (2) display the results with ILS*Quarter and Bank fixed effects, while Column (2) additionally includes Country*time fixed effects. The estimated $\beta$ indicates a negative and statistically significant (at the 5% level) relationship between $GHGTot$ and the PGLs share at the bank-firm level ($PGL$). This confirms that, following the policy's implementation, PGLs were primarily directed, in relative terms, towards companies with lower GHG emissions, even if they are estimated to have a higher probability of default than brown companies (as observed in Table 3). In other words, firms with lower GHG emissions received a higher share of guaranteed credit over total credit than similar firms with higher GHG emissions. It is important to note

that these results are consistent across both specifications, with and without Country*time fixed effects, reinforcing the robustness of the findings.

Although not large, the effect is economically relevant considering that supporting greener firms during the Covid-19 pandemic was not the main aim of PGLs. In particular, a two standard deviations decrease in *GHGtot* leads to approximately 30 basis points increase in the share of guaranteed credit over total credit.[19]

These findings unveil an unexplored approach to mitigating the "green transition risk". Specifically, PGLs can play a pivotal role in assisting banks in transitioning their loan portfolios away from environmentally detrimental firms. Consequently, this enables the provision of credit to socially responsible companies. Notably, PGLs enable banks to expand their lending to green firms, even in cases where these firms demonstrate a higher predicted probability of default than their polluting counterparts. This outcome is likely due to the government absorbing the risk associated with the green transition, thereby shielding banks from potential adverse consequences in the event of the failure of a green enterprise. As a result, implementing the PGL framework alters the incentive structure for banks regarding green lending, as they are no longer exposed to the downside risk associated with financing eco-friendly businesses. Our findings suggest that this implicit protection may incentivize banks to "embrace higher risks", leading to increased credit allocation to greener firms at the expense of brown businesses.

To further support the aforementioned channel, we inspect the behaviour of banks in proximity of the Maximum Distributable Amount (MDA or CET1 MDA Distance).[20] Since exposures to greener firms are riskier, thus requiring higher capital allocation, PGLs are relatively more appealing for less capitalised banks which are able to economize on the increase

[19]This results in a PGLs increase of approximately 1.41% compared to the average PGLs. Considering the firms with the lowest GHG emissions received about 95 basis points higher share of guaranteed credit over total credit than those with the highest GHG emissions. To assess the robustness of our findings, we conducted a comprehensive analysis by replicating the estimation using the sample of 1030 banks available on Anacredit. Notably, the results exhibited are virtually the same, reinforcing the reliability and consistency of our findings, as delineated in Table A2. Please see the online appendix of the paper here.

[20]The MDA is a regulatory limit on dividend or earnings distribution which is triggered when a bank's capital level falls below the regulatory minimum capital requirement, or capital buffer requirements are not fully met. As such, dipping into the MDA leads to limitations to earning distributions, additional supervisory scrutiny fall and market stigma, *Capital Requirements Directive (CRD) 2013/36/EU, Art. 141.* (Dautović et al., 2023).

in risk-weighted assets. Therefore, less capitalised banks should be more tempted to extend guaranteed loans to greener firms to preserve their capital headroom on top of the MDA. To test this hypothesis, we interact *GHGTot* with a dummy (*MDA_Tercile*) equal to one for banks below the lowest tercile of the distance to the MDA distribution, and 0 otherwise. The results reported in column 3 of table 4 confirm that banks closer to the MDA extended more PGLs to greener firms relative to banks with more capital headroom on top of the MDA. Specifically, a two standard deviations decrease in *GHGtot* corresponds to approximately 75 basis points higher share of PGLs granted by banks closer to the MDA in comparison to banks far away from it.

**[Place Table 5 about here]**

Table 5 presents our investigation into the influence of *GHGTot* on *PGL*, considering firm heterogeneity. The table displays four specifications (1 to 4) that examine the interaction between *GHGTot* and various firm-level characteristics: Firm ROA, Firm Working Capital, Firm Cash, and Firm Debt. These interaction terms aim to assess whether the relationships between firms' GHG emissions intensities and PGLs are amplified or weakened by specific firm-specific characteristics.

Columns 1 and 3 reveal statistically significant negative interaction terms, *GHGTot*Firm ROA* and *GHGTot*Firm Cash*, at the 1% level. This indicates that firms with higher profitability, liquidity, and lower GHG emissions receive more PGLs. In contrast, the interaction term *GHGTot*Firm Debt* is statistically significant at the 10% level and positive, suggesting that greener firms with higher debt levels receive a smaller share of PGLs. These findings align with expectations as banks tend to favour financially sustainable firms, irrespective of whether credit risk is transferred to a guarantor, such as in the case of PGLs. Furthermore, in some jurisdictions, PGL schemes are designed to require banks to share part of the credit risk exposure with the government, thus motivating them to provide PGLs to sound and profitable firms.

However, the interaction term *GHGTot*Firm Working Capital* is found to be not statistically significant, implying that the relationship between GHGTot and PGLs is not dependent

on the firm's working capital level.[21]

## 4.3 Did PGLs translate into extra credit to greener firms?

### 4.3.1 Intensive margin

From a policymaker's perspective, it is important to appreciate whether PGLs provided greener firms with extra credit relative to browner firms. As such, in this section, we investigate whether the provision of credit to green firms benefiting from PGLs was higher than that to more polluting firms. We start by analysing the intensive margin, i.e. the growth rate of outstanding loans at the bank-firm level. Specifically, our econometric identification strategy is based on the following equation:

$$\begin{aligned} Y_{f,b,q} = \beta_0 + \beta_1 GHGTot_f + \beta_2 PGL_{f,b,c,q} + \beta_3 GHGTot_f * PGL_{f,b,c,q} \\ + \gamma_1 X_{b,c,q} + \gamma_2 Z_{b,c,q} + \alpha_{f,q} + \alpha_b + \alpha_c + u_{f,b,c,q} \end{aligned} \tag{3}$$

The bank-firm dependent variable of interest $Y_{f,b,q}$ represents the lending growth, which is calculated as the log difference of the credit granted by bank $b$ to firm $f$ in quarter $t$.

We gradually enhance the model by incorporating several combinations of fixed effects. We employ within firm-time estimations via the inclusion of firm*quarter fixed-effects ($\alpha_{f,q}$) (Altavilla et al., 2023) to account for time-varying unobservable firm-specific characteristics, most notably for the heterogeneity in credit demand among firms. In some specifications and for consistency with the baseline results, we replace firm*quarter fixed effects with ILS*quarter fixed effects (Acharya et al., 2019; Degryse et al., 2019).

The inclusion of ILS*time fixed effects is particularly suitable for our empirical setting as the PGLs were primarily directed to micro and small firms that typically have a relationship with one bank. We also include bank fixed effects ($\alpha_b$) to enable us to capture the average differences in credit growth across banks. We control for the same range of firm $X_{f,c,q}$ and bank characteristics $Z_{b,c,q}$ as in the previous analysis. In equation (3), $\beta_3$ is our coefficient of interest, indicating whether banks exploit PGLs to extend more credit to less polluting firms

[21] We performed an extensive analysis by reproducing the estimation using the dataset of 1030 banks. The results demonstrate a high level of consistency, providing further support for the robustness of our findings, as shown in Table A3. Please see the online appendix of the paper here.

at the onset of the pandemic.

Table 6 shows the main findings estimated from equation 3. Columns (1) and (2) display the results with Firm*Quarter and Bank fixed effects, while Column (2) additionally includes Country*time fixed effects. Columns (3) and (4) include ILS*quarter fixed effects.

The findings displayed in Table 6 are important for two reasons. First, the single coefficient *PGL* is positive and statistically significant at the 1% level, suggesting that a higher share of government guarantees results in a stronger bank lending supply.[22] Second, the double interaction *GHGTot*PGL* is negative and statistically significant at the 1% and 10% level - depending on the econometric specification - indicating that the positive effect of granting PGLs on lending supply decreases as the level of GHG emissions intensity increases. Importantly, the coefficient for $\beta_3$ remains robust even after controlling for Country*Quarter fixed effects and including ILS*quarter fixed effects.

The effect is also economically meaningful. Considering a 10% bank-firm share of guaranteed loans, a two standard deviations decrease in *GHGTot* corresponds to approximately 0.16% higher lending at the bank-firm relationship on a quarterly basis.[23]

Such findings help us conjecture that, before the public guarantee policy, lending to green companies sits on an equilibrium where banks face the tradeoff in which they have a marginal utility or return on lending to green companies. This is characterized by, on one side, incentives to provide green lending to comply with a plethora of regulatory expectations, standards and sustainability goals, as well as motives to improve their environmental and social standing since sustainability is linked to customer loyalty and reduced capital costs (Albuquerque et al., 2019; Dhaliwal et al., 2011). Conversely, such institutions face a green lending challenge or "green-transition-risk", as several fundamental sources of uncertainty arise around the credit provision to green firms.

The public guarantee policies *even though as a spillover of the intended main policy effects*, help banks partially overcome the challenge or "green-transition-risk" and not bear the green-

[22] In columns 1 and 2, *GHGTot* is absorbed by firm*time fixed effects.

[23] Notably, with a 10% share of guaranteed loans, firms with the lowest GHG emissions experience approximately a 50 basis points increase in lending compared to those with the highest GHG emissions. These findings remain consistent when we replicate the analysis using all available bank-firm relationships in Anacredit, indicating the robustness of our results (see Table A4). Please see the online appendix of the paper here.

related uncertainties (Allen et al., 2015). Thus, only one side of the tradeoff remains: the need to comply with regulatory expectations, standards and sustainability goals.[24] Banks can green their balance sheets at the margin, contributing to the economy's greening.

**[Place Table 6 about here]**

### 4.3.2 Extensive margin

From the standpoint of policymakers, it is also important to shed light on whether the probability of establishing new "greener" bank-firm relationships is a function of PGLs. In this section, we delve into the extensive margin, specifically focusing on the origination of new loans or adjustments to existing loan exposure at the bank-firm level. To accomplish this, we consider all combinations of bank, firm, and quarter observations $(f, b, q)$ present in the lending portfolios of at least one bank. Subsequently, we construct a dummy variable named "*Bank-Firm New Relationship*". This variable is a dummy variable taking the value one if a new relationship is formed between a firm and a bank following the implementation of the public guarantee policy and zero otherwise. The baseline specification for our analysis is as follows:

$$\begin{aligned} Bank-Firm\ New\ Relationship_{f,b,c} = \beta_0 + \beta_1 GHGTot_f + \beta_2 PGL_{f,b} + \beta_3 GHGTot_f * PGL_{f,b} \\ + \gamma_1 X_{f,c} + \gamma_2 Z_{b,c} + \alpha_{ils} + \alpha_c + u_{f,b,c} \end{aligned} \tag{4}$$

The $GHGTot * PGL$ is our variable of interest and tests whether the probability of establishing new bank-firm relationships with greener vis-á-vis browner firms depends on PGLs. We control for the same range of firm $X_{f,c}$ and bank $Z_{b,c}$ characteristics as in the previous analysis. We also control for ILS and bank country fixed effects.

Table 7 presents the results from Equation 4. Columns (1) and (2) display the results with ILS fixed effects, while Columns (2) further include Country fixed effects. The results are interesting for several reasons. First, the single coefficient *GHGTot* is positive and statistically significant at the

[24] Taghizadeh-Hesary and Yoshino (2020) propose two recommendations. Firstly, financial institutions can establish a Green Credit Guarantee Scheme, offering a government guarantee to assist investors or borrowers in meeting their debt obligations in case of credit default. Secondly, financial de-risking can be employed by transferring a significant portion of the risk to another party.

1% level, suggesting that, in the absence of PGLs, banks are more likely to establish new bank-firm relationships with more polluting firms.

Specifically, a 1pp (one percentage point) increase in GHG emission intensities leads to approximately a 0.13% higher probability of establishing a new bank-firm relationship. This result validates the main hypothesis of this paper, suggesting that banks face a "green-transition risk," which drives their increased inclination to lend to more polluting firms. However, this effect is reversed when examining the interaction term *GHGTot*PGL*, which shows a negative and statistically significant relationship. This indicates that as the share of PGLs increases, the probability of forming new bank-firm relationships with more polluting firms decreases. This finding further confirms the pivotal role of PGLs in assisting banks in transitioning their loan portfolios away from environmentally detrimental firms. To put it into perspective, considering a two standard deviation increase in *GHGTot* results in a mere 0.07% increase in the probability of establishing a new bank-firm relationship with less polluted firms. Specifically, when considering a 10% share of guaranteed loans, the increase translates to a 0.70% change.[25]

Our findings hold significant implications for policymakers and financial institutions. For instance, they indicate that government guarantee policies effectively incentivize banks to engage in new lending activities that support environmentally friendly projects, despite the higher probability of default. The results support the idea that when banks do not bear the "green-transition-risk" entirely, they become more inclined to lend to new companies undertaking green projects. This evidence suggests that such policies can positively impact the green lending credit intermediation structure, enhancing competitiveness and establishing new green bank-company relationships post facto.

According to Degryse et al. (2020), the market structure of the banking system plays a crucial role in facilitating a transition towards a green economy. These findings emphasize the importance of implementing policies that address the impact of existing non-sustainable investments. Furthermore, the results imply that public guarantee policies have the potential to foster greener economic growth and development. By facilitating the formation of new bank-firm relationships, these policies can promote increased access to capital for firms actively working towards reducing their environmental impact. This, in turn, can stimulate innovation, investment, and job creation in sectors that prioritize sustainability.

[25]To ensure the robustness of our results, we replicated the analysis using the entire set of bank-firm relationships available in Anacredit. The findings are reiterated (Table A5). Please see the online appendix of the paper here.

**[Place Table 7 about here]**

# 5 Robustness

## 5.1 Prior credit relationships

Jiménez et al. (2022) examines how public loan guarantee schemes influenced bank lending amid the COVID-19 pandemic, and investigate the factors affecting the supply of loans guaranteed by the government. Among the mechanisms, they highlight the importance of prior credit relationships between banks and firms as a primary factor shaping the distribution of credit under such government guarantees.[26] In order to sharpen our identification strategy and since such credit exposure may affect our main findings, we re-run our analysis and re-estimate the specifications in equations 2, 3 and 4. Specifically, we augment the set of controls by adding the share of the firm's total outstanding credit with the bank before the COVID-19 pandemic. Our main findings remain robust at the inclusion of this additional control, as shown in Table A6.[27]

## 5.2 Alternative measures of greenhouse gas emission

Throughout this paper, we rely on Urgentem for firm-level greenhouse gas (GHG) emissions.[28] It is worth noting that Urgentem has been chosen as the GHG data provider for the ECB-wide climate stress test, as highlighted by Alogoskoufis et al. (2021).

However, it is essential to acknowledge the existence of inconsistencies documented in recent literature across different database providers, as noted by Busch et al. (2020) and Papadopoulos (2022). Specifically, while cross-sectional differences in Scope 1 emissions remain limited, these differences progressively escalate when considering Scope 2 and Scope 3 emissions. Adding to this complexity, a study by Aswani et al. (2024) reveals a statistically significant relationship between stock returns and emissions when estimated by data vendors. Interestingly, this relationship vanishes

[26] The study reveals that banks with a greater pre-existing share of loans in the company and longer remaining loan durations on outstanding loans with the firm, are more prone to extending PGL. This effect is more pronounced for risky firms, for firms in more pandemic-affected sectors, for banks lower capital and higher nonperforming loans.

[27] Please see the online appendix of the paper here.

[28] Urgentem provides GHG emissions data for approximately 6,000 firms. The methodology employed by Urgentem involves utilizing industry-specific statistical models, financial fundamentals, and calibrations based on disclosed emissions data from a subset of public companies to estimate emissions for the remaining firms in the sample.

when focusing on emissions directly disclosed by firms. This observation implies a weak correlation between vendor-estimated emissions and emissions disclosed by the firms themselves.

In light of these arguments, we provide variation to our baseline results by relying on disclosed emissions rather than estimated emissions that we collect from a different vendor. If the results hold, we can be more confident that spurious correlations are not driving our results. Specifically, we replicate the baseline findings by using the ECB Climate data library dataset, known as the ISS[29], which provides firm-level GHG emissions based solely on disclosed and self-reported data at the corporate level. It is noteworthy to mention that the ISS emission database provides information only for listed non-financial corporations. Arguably, this reduces the sample size relative to the dataset used for the baseline results that are based on Urgentem. In particular, while in the baseline specification, we have 307,130 firms entering the estimation, when merging AnaCredit with the ISS database we are left with 534-554 firms, depending on the econometric specification. The lower number of firms coming from the ISS emission database requires a different computation of the industry-location-size cluster. Since the ISS database considers only listed firms, the size dummy in the construction of the industry-location-size cluster would be unnecessary. Therefore, we replace industry-location-size fixed effects with industry-location fixed effects.

In Table A7 in the Appendix, we present the results of our baseline regressions for PDs (columns 1-3) and PGL (columns 4-5). Notably, our main findings are robust to disclose rather than estimated emissions as well as to a different vendor. This gives us assurance on the validity of our baseline findings.

## 5.3 Public guarantee loans and greenness during the pandemic

Newly emerging findings suggest that the behavior of investors and lenders during the COVID-19 crisis differed significantly from that observed in "normal times". Some authors argue that companies with strong Environmental, Social, and Governance (ESG) performance are inclined to experience lower tail risk and reduced financial risks during the COVID-19 period (Albuquerque et al., 2020; Hoepner et al., 2018; Ilhan et al., 2021).

In this subsection, we investigate the relationship between public-guaranteed loans (PGL) and greenness during the COVID-19 pandemic. In Table A8 in the Appendix [30] , in order to evaluate the impact of the COVID-19 pandemic and firms' greenhouse gas emissions on public-guaranteed

[29]see here: https://www.issgovernance.com/esg/

[30]Please see the online appendix of the paper here.

loans (PGL), we re-estimated the main regression by incorporating the interaction between firms' greenhouse gas emissions (GHGTot) and the COVID-19 pandemic dummy. These supplementary analyses not only strengthen the robustness of our main findings but also provide additional insights indicating that PGLs were largely redirected to less polluted firms during the COVID-19 pandemic.

# 6 Conclusion

Our analysis of 91 banks across 12 European countries provides valuable insights into the dynamics of green lending and the role of PGLs in encouraging banks to support greener firms, facilitating the climate transition process. Specifically, our research has led to two main findings.

First, we established that European banks face a "green-transition-risk," as less polluting firms have higher probabilities of default (PDs) than their more polluting counterparts (browner firms). This means lending to less polluting firms (green firms) is riskier for banks due to higher estimated capital risk-weighted charges and monitoring costs. This higher implicit risk, called "green-transition-risk," leads to a natural preference for lending to more polluting firms (browner firms). Secondly, we discovered that deploying PGLs during the pandemic resulted in a relative increase in lending to greener firms, indicating that such loans can effectively reallocate banks' lending portfolios towards more environmentally friendly companies. In fact, thanks to the public guarantee, the risk of default is partially or entirely transferred to the government. In other words, PGLs eliminate (or drastically reduce) the "green-transition-risk."

Our findings have important implications for European policymakers. By leveraging the power of PGLs, governments can change banks' lending behaviour, promoting greener industries' growth and supporting the global economy's decarbonization. Our research contributes to the literature on the effectiveness of the banking sector and public intervention (in terms of PGLs) in facilitating the green transition. The large-scale guarantee programs under analysis in this paper were intended to sustain private credit in response to the COVID-19 pandemic. From a policymaker's point of view, public credit guarantees have been utilized either as a response to shocks that weaken economic fundamentals or as a stimulating device for businesses that may be credit-constrained in normal times. The effectiveness of PGLs in promoting the green transition depends on the ability of policymakers to design and execute these government-backed credit guarantees skillfully. Indeed, finding the right balance is essential: Policymakers must encourage banks to finance greener businesses while avoiding undue risk-taking, which could result from relying too heavily on PGLs and

ultimately burden public finances and European citizens. Policymakers should consider implementing appropriate eligibility criteria, monitoring mechanisms, and loan pricing to ensure that PGLs effectively support the intended beneficiaries without unduly increasing the risk profile of banks' loan portfolios (Altavilla et al., 2021; Bertrand et al., 2007; De Blasio et al., 2018).

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# Figures

Figure 1: Figure 1 presents a comprehensive analysis of the dynamics surrounding the key variable of interest: Public Guarantee Loans (PGLs) and Lending Growth. The blue line represents the proportion of loans subject to government guarantees at the bank-firm level. In contrast, the dashed orange line depicts Lending Growth, capturing the logarithmic changes in outstanding nominal loan amounts as they move from bank $i$ to firm $f$.

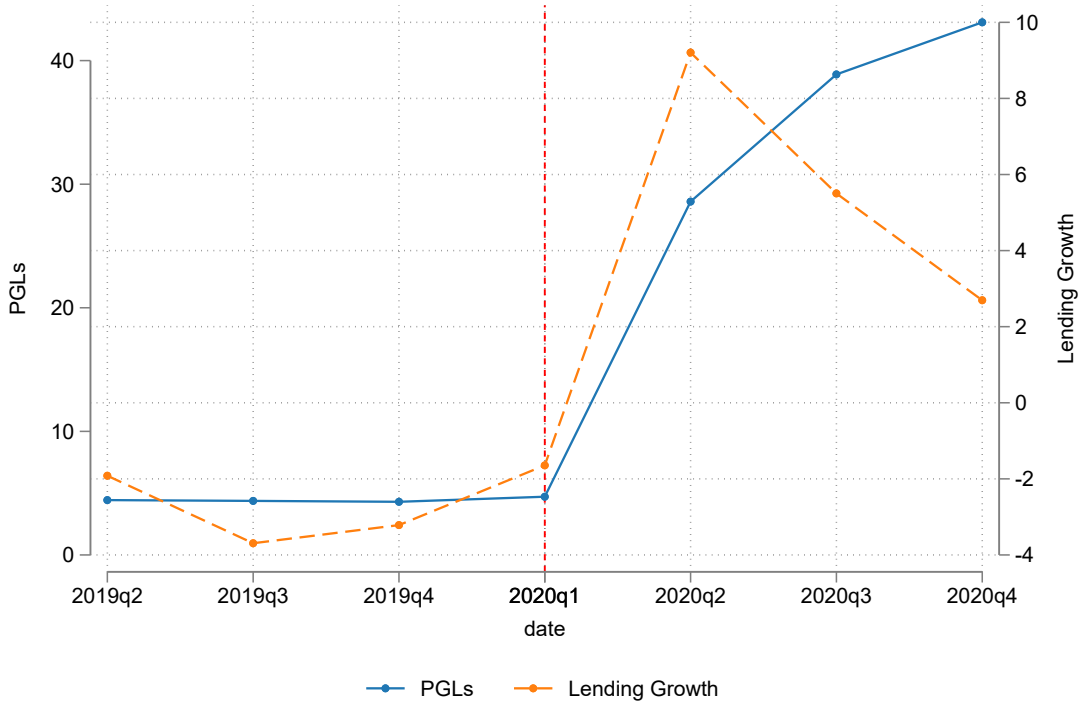
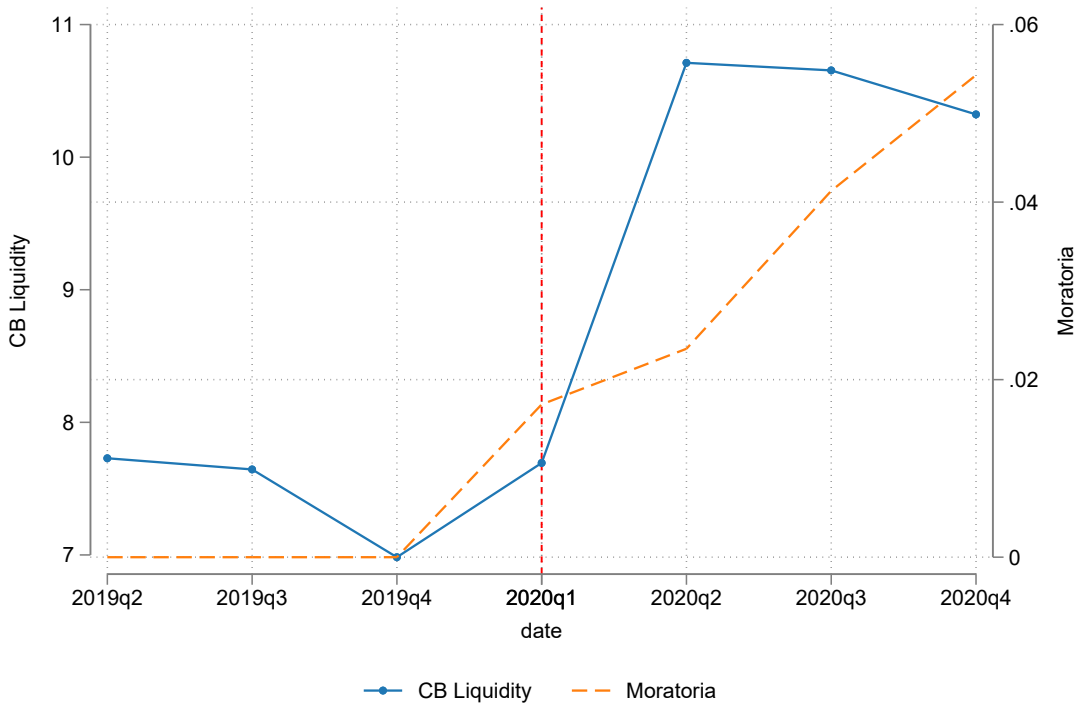


Figure 2: Figure 2 shows the timeline of the key variables that capture the fluctuations resulting from monetary and fiscal policy measures implemented to sustain lending. The red dashed vertical line represents the reference point of 2020Q1. The dashed orange line depicts the proportion of debt repayment moratoria, which is calculated as the average share of total loans to total credit aggregated at the bank-firm level. The CB Liquidity (blue line) represents the ratio of cash and cash held at the central bank to total assets and serves as a proxy for ECB asset purchases.



# Tables

Table 1: **Key Variables Definition.**

Table 1 reports the definitions and the sources of the variables for the sample.

| Variable (*label*) | Definition | Source |
|---|---|---|
| *Dependant Variables* | | |
| $Probability of Default (PD_{f,b,q})$ | The weighted average probability of the default of the firm $f$ taking part in the loan instruments as assigned by the bank $i$. | AnaCredit |
| Public Guarantee Loans (*PGLs*) | Bank-firm level share of loans subject to government guarantees | AnaCredit |
| $Interestrate (Irt)$ | The annualized weighted average interest rate charged by bank $i$ from firm $f$ | AnaCredit |
| Bank-Firm New Relationship | The variable is equal to one if there is a new bank-firm lending relationship between bank $b$ and firm $f$ after the COVID-19 outbreak and zero otherwise. | AnaCredit |
| $Lending (Lending\ growth)$ | Change in the logarithm of loans (outstanding nominal amount) from bank $i$ to firm $f$ | AnaCredit |
| *GHG emission variable* | | |
| Scope 1-3 GHG relative emission | Sum of Scope 1, 2 and 3 GHG emissions to firm's revenues | Urgentem |
| Carbon intensity Scope 1-3 (GHGTot) | Sum of Scope 1, 2 and 3 GHG emissions to firm's revenues (tonnes GHG 1,2,3/EUR m.)/100 (Bolton and Kacperczyk, 2021) | Urgentem |
| *Bank control variables* | | |
| Size (*Bank Size*) | The natural logarithm of bank total assets | ECB Supervisory data |
| Deposits (*Deposits*) | The ratio of customer deposits to total liabilities | ECB Supervisory data |
| NPLs (*NPL*) | The ratio of non-performing loans to gross loans | ECB Supervisory data |
| ROA (*Bank ROA*) | The ratio of net income to total assets | ECB Supervisory data |
| Liquidity (*Liquidity ratio*) | The ratio of cash and cash equivalent to total assets | ECB Supervisory data |
| Fees and commissions (*Fees and commissions*) | The ratio of fees and commissions to operating income | ECB Supervisory data |
| Capitalization (*Bank Capitalization*) | The ratio of common equity tier1 capital to risk-weighted assets | ECB Supervisory data |
| Risk weight density (*RWA*) | The ratio of risk-weighted assets over bank total assets | ECB Supervisory data |
| Provisions (*Bank Provisions*) | The ratio of provisions over bank total assets | ECB Supervisory data |
| *Firm control variables* | | |
| Size (*Firm Size*) | The natural logarithm of firm total assets | Orbis |
| ROA (*Firm ROA*) | The ratio of earnings before interest and taxes over firm total assets | Orbis |
| Working capital (*Firm Working capital*) | The ratio of working capital over total assets | Orbis |
| Liquidity (*Firm cash*) | The ratio of cash and cash equivalent over firm current liabilities | Orbis |
| Debt (*Firm Debt*) | The ratio of current liabilities plus the non-current liabilities over firm total assets | Orbis |
| *Policy control variables* | | |
| Share of Debt Repayment Moratoria (Moratoria) | Bank-firm level share of loans subjected to debt moratoria | AnaCredit |
| Monetary policy (*CB Liquidity*) | The ratio of central bank liquidity to bank total assets | ECB Market Operations Database |

Table 2: **Summary Statistics for the Full Sample (2019Q1-2020Q4)**. This table provides the summary statistics for the variables utilized in our empirical analysis. More specifically, Panel A provides the statistics for the dependent variables, Panel B for the GHG emission variables, Panel C for the state guarantee policy variable, Panel D for the firm control variables, Panel E for the bank-specific variables and Panel F for other policy control variables. A description of each variable and the related source is provided in Table 1.

| | Obs | Min | Max | p25 | Median | p75 | Mean | SD |
|---|---|---|---|---|---|---|---|---|
| **Panel A. Dependent Variable** | | | | | | | | |
| **Sample period:2019** | | | | | | | | |
| PD (%) | 1,395,166 | 0.030 | 47.270 | 0.520 | 1.290 | 3.080 | 3.616 | 7.186 |
| **Full Sample** | | | | | | | | |
| PGL (%) | 2,130,020 | 0.000 | 100.000 | 0.000 | 0.000 | 40.549 | 21.266 | 34.348 |
| Bank-Firm New Relationship | 517,616 | 0.000 | 100.000 | 0.000 | 0.000 | 37.500 | 20.719 | 35.738 |
| Lending (€) | 1,357,947 | 25,000.000 | 7,253,081.000 | 51,255.000 | 132,245.109 | 360,126.719 | 468,081.470 | 1,088,995.422 |
| Lending growth (%) | 1,357,947 | -72.635 | 97.772 | -8.313 | -1.354 | 5.716 | 1.652 | 30.371 |
| **Panel B: GHG emission variables** | | | | | | | | |
| Scope 1-3 GHG relative emission | 2,130,020 | 126.100 | 5395.300 | 300.500 | 564.700 | 847.400 | 734.500 | 820.600 |
| GHGTot | 2,130,020 | 1.261 | 53.953 | 3.005 | 5.647 | 8.474 | 7.345 | 8.206 |
| ISS_GHGTot | 8,043 | 0.028 | 94.888 | 0.643 | 1.954 | 5.110 | 7.944 | 17.386 |
| **Panel C: Firm control variables** | | | | | | | | |
| Firm size (€ml) | 2,130,020 | 0.001 | 148.515 | 0.619 | 1.618 | 4.755 | 7.889 | 21.985 |
| Firm size (ln total assets) | 2,130,020 | 11.357 | 18.816 | 13.335 | 14.297 | 15.375 | 14.434 | 1.567 |
| Firm Roa (%) | 2,130,020 | -27.770 | 27.790 | 0.280 | 1.630 | 4.760 | 2.564 | 7.097 |
| Firm Working Capital (%) | 2,130,020 | -27.893 | 89.020 | 3.200 | 21.787 | 43.054 | 25.268 | 25.631 |
| Firm Cash (%) | 2,130,020 | 0.006 | 57.765 | 0.917 | 3.681 | 10.978 | 8.385 | 11.492 |
| Firm Debt (%) | 2,130,020 | 11.540 | 133.702 | 56.813 | 74.410 | 87.396 | 70.890 | 22.749 |
| **Panel D: Bank control variables** | | | | | | | | |
| Bank size (€bl) | 2,130,020 | 1.057 | 2017.196 | 166.974 | 352.335 | 871.243 | 623.277 | 541.001 |
| Bank size (ln total assets) | 2,130,020 | 20.779 | 28.333 | 25.841 | 26.588 | 27.493 | 26.665 | 1.111 |
| Deposits (%) | 2,130,020 | 42.811 | 97.859 | 71.797 | 76.912 | 82.951 | 76.896 | 7.785 |
| NPL (%) | 2,130,020 | 1.464 | 27.378 | 3.700 | 4.899 | 10.032 | 7.346 | 5.268 |
| Bank ROA (%) | 2,130,020 | -1.003 | 0.973 | 0.166 | 0.297 | 0.471 | 0.301 | 0.242 |
| Liquidity ratio (%) | 2,130,020 | 0.505 | 15.381 | 3.820 | 6.165 | 8.114 | 5.905 | 2.876 |
| Fees and commissions (%) | 2,130,020 | 12.975 | 53.532 | 26.826 | 34.257 | 42.676 | 34.738 | 8.201 |
| Bank Capitalitation (%) | 2,130,020 | 10.729 | 32.323 | 13.141 | 13.644 | 14.896 | 14.084 | 1.468 |
| RWA (%) | 2,130,020 | 26.159 | 86.401 | 37.333 | 41.863 | 44.286 | 41.984 | 6.454 |
| Bank provision (%) | 2,130,020 | 0.031 | 1.746 | 0.523 | 0.896 | 0.993 | 0.818 | 0.371 |
| **Panel E: Policy control variables** | | | | | | | | |
| Moratoria (%) | 2,130,020 | 0.000 | 86.413 | 0.000 | 0.000 | 0.000 | 0.022 | 0.869 |
| CB Liquidity (%) | 2,130,020 | 0.000 | 41.644 | 6.547 | 9.190 | 12.894 | 9.130 | 4.759 |

Table 3: **The Riskiness of Lending to Green Companies**

Table 3 reports estimates from equation 1 where the impact of Greenhouse Gas Emission (GHGTot) on the firm probability of default (PD) is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the firm's revenues. In column (1), we include ILS fixed effects; in column (3), we include ILS and Bank fixed effects; and in column (4), we include ILS* Quarter and Bank fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2019. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| | | Sample period 2019 | | |
|---|---|---|---|---|
| DEPENDENT VARIABLE | (1) | (2) | (3) | (4) |
| **Probability of Default (PD)** | | | | |
| GHGTot | -0.029*** | -0.027*** | -0.028*** | -0.029*** |
| | (-3.793) | (-3.715) | (-3.844) | (-3.375) |
| Firm Size | | -0.000 | -0.000 | -0.000 |
| | | (-0.528) | (-0.014) | (-0.003) |
| Firm ROA | | -0.053*** | -0.053*** | -0.053*** |
| | | (-6.540) | (-6.546) | (-5.762) |
| Firm Working capital | | 0.004** | 0.005*** | 0.005*** |
| | | (2.481) | (3.626) | (3.321) |
| Firm Cash | | -0.037*** | -0.036*** | -0.036*** |
| | | (-5.945) | (-5.980) | (-5.010) |
| Firm Debt | | 0.027*** | 0.029*** | 0.029*** |
| | | (7.582) | (8.477) | (7.508) |
| Observations | 1,395,166 | 1,246,356 | 1,246,352 | 679,678 |
| R-squared | 0.641 | 0.642 | 0.653 | 0.526 |
| Bank FE | NO | NO | YES | YES |
| ILS FE | YES | YES | YES | NO |
| ILS*Quarter FE | NO | NO | NO | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N.Banks | 91 | 89 | 85 | 76 |
| N. Firms | 307,130 | 268,295 | 268,295 | 128,685 |

Table 4: **Green State Guarantee Lending**

Table 4 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) on the Public Guarantee Loan share (PGL) is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the firm's revenues. In column (1), we include ILS* Quarter and Bank fixed effects; in columns (2-3), we add Country fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE **PGL** | (1) | (2) | (3) |
|---|---|---|---|
| GHGTot | -0.018** | -0.018** | -0.002 |
| | (-2.056) | (-2.109) | (-0.109) |
| GHGTot*MDA_Tercile | | | -0.046*** |
| | | | (-2.893) |
| Firm Size | -0.033*** | -0.033*** | -0.033*** |
| | (-8.798) | (-8.825) | (-8.822) |
| Firm ROA | -0.005 | -0.006 | -0.005 |
| | (-0.389) | (-0.384) | (-0.383) |
| Firm Working capital | 0.048*** | 0.047*** | 0.047*** |
| | (2.733) | (2.725) | (2.725) |
| Firm Cash | 0.108*** | 0.108*** | 0.108*** |
| | (5.877) | (5.891) | (5.895) |
| Firm Debt | -0.033*** | -0.033*** | -0.033*** |
| | (-7.045) | (-7.152) | (-7.152) |
| Bank Size | 0.098 | 0.098 | 0.098 |
| | (0.741) | (0.422) | (0.423) |
| Deposit | -0.245 | -0.228 | -0.228 |
| | (-0.628) | (-0.530) | (-0.530) |
| NPL | 0.231 | 0.304 | 0.304 |
| | (1.222) | (1.131) | (1.131) |
| Bank ROA | -2.668 | -2.865 | -2.863 |
| | (-1.589) | (-1.434) | (-1.432) |
| Liquidity ratio | -0.341 | -0.313 | -0.313 |
| | (-1.129) | (-0.930) | (-0.930) |
| Fees and commissions | -0.032 | -0.026 | -0.026 |
| | (-0.128) | (-0.086) | (-0.086) |
| Bank Capitalitation | 1.814** | 1.936* | 1.937* |
| | (2.025) | (1.817) | (1.816) |
| RWA | 0.349 | 0.398 | 0.398 |
| | (1.319) | (1.225) | (1.227) |
| Bank Provisions | 6.196 | 6.914 | 6.910 |
| | (1.015) | (1.103) | (1.103) |
| Moratoria | -0.398*** | -0.397*** | -0.397*** |
| | (-3.773) | (-3.740) | (-3.736) |
| CB Liquidity | -0.445** | -0.470** | -0.470** |
| | (-2.065) | (-2.186) | (-2.186) |
| Observations | 2,130,020 | 2,130,020 | 2,129,947 |
| R-squared | 0.601 | 0.602 | 0.602 |
| Bank FE | YES | YES | YES |
| ILS*Quarter FE | YES | YES | YES |
| Country*Quarter FE | NO | YES | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 84 | 84 | 80 |
| N. Firms | 305,290 | 305,290 | 305,279 |

Table 5: **Green State Guarantee Lending: Firm Heterogeneity**

Table 5 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) on the Public Guarantee Loan share (PGL) and firm heterogeneity is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the firm's revenues. All models include ILS*Quarter, Bank and Country fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE **PGL** | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| GHGTot | -0.013* | -0.019* | 0.011 | -0.057** |
| | (-1.691) | (-1.692) | (1.631) | (-2.117) |
| Firm ROA | 0.005 | | | |
| | (0.321) | | | |
| GHGTot*Firm ROA | -0.002** | | | |
| | (-2.087) | | | |
| Firm Working capital | | 0.047** | | |
| | | (2.510) | | |
| GHGTot*Firm Working capital | | 0.000 | | |
| | | (0.171) | | |
| Firm Cash | | | 0.130*** | |
| | | | (5.583) | |
| GHGTot*Firm Cash | | | -0.003*** | |
| | | | (-3.010) | |
| Firm Debt | | | | -0.037*** |
| | | | | (-8.475) |
| GHGTot*Firm Debt | | | | 0.001* |
| | | | | (1.692) |
| Observations | 2,130,020 | 2,130,020 | 2,130,020 | 2,130,020 |
| R-squared | 0.601 | 0.601 | 0.601 | 0.601 |
| Bank FE | YES | YES | YES | YES |
| ILS*Quarter FE | YES | YES | YES | YES |
| Country*Quarter FE | YES | YES | YES | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 84 | 84 | 84 | 84 |
| N. Firms | 305,290 | 305,290 | 305,290 | 305,290 |

Table 6: **Green State Guarantee Lending: Lending growth.**

Table 6 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) and the Public Guarantee Loan share (PGL) on lending growth is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the Firm's revenues. In column (1), we include Firm* Quarter and Bank fixed effects; in column (2), we add Country fixed effects; in column (3)-(4), we substitute Firm fixed effects with ILS fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE<br>**Lending (Lending growth)** | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| GHGTot | | | 0.001 | 0.001 |
| | | | (0.049887) | (0.021528) |
| PGL | 0.172*** | 0.171*** | 0.157*** | 0.156*** |
| | (13.594509) | (13.873) | (9.291) | (9.458) |
| GHGTot*PGL | -0.001*** | -0.001*** | -0.001* | -0.001* |
| | (-3.357) | (-3.367) | (-1.675) | (-1.700) |
| Firm Size | | | 0.003*** | 0.003*** |
| | | | (2.787) | (2.908) |
| Firm ROA | | | 0.045*** | 0.045*** |
| | | | (6.681) | (6.625) |
| Firm Working capital | | | 0.010*** | 0.010*** |
| | | | (3.577) | (3.651) |
| Firm Cash | | | -0.038*** | -0.038*** |
| | | | (-8.062) | (-8.023) |
| Firm Debt | | | 0.012*** | 0.012*** |
| | | | (5.124) | (5.251) |
| Bank Size | 0.221 | 0.224 | 0.124 | 0.172 |
| | (1.496) | (1.062) | (1.026) | (0.798) |
| Deposit | -0.329 | -0.267 | -0.320 | -0.244 |
| | (-1.481) | (-1.049) | (-1.327) | (-0.942) |
| NPL | -0.243 | 0.054 | -0.203 | 0.039 |
| | (-1.188) | (0.294) | (-0.900) | (0.191) |
| Bank ROA | -2.842** | -4.155** | -2.883* | -4.270** |
| | (-2.017) | (-2.261) | (-1.725) | (-2.042) |
| Liquidity ratio | -0.452 | -0.371 | -0.277 | -0.211 |
| | (-1.379) | (-0.983) | (-0.899) | (-0.583) |
| Fees and commissions | -0.289** | -0.090 | -0.216 | -0.057 |
| | (-2.080) | (-0.339) | (-1.506) | (-0.211) |
| Bank Capitalitation | 2.170** | 2.535** | 1.844* | 2.244* |
| | (2.119) | (2.171) | (1.746) | (1.869) |
| RWA | 0.435 | 0.607* | 0.349 | 0.542* |
| | (1.594) | (1.956) | (1.339) | (1.806) |
| Bank Provisions | -14.114*** | -12.316*** | -11.819** | -10.663** |
| | (-3.184) | (-2.678) | (-2.511) | (-2.165) |
| Moratoria | -0.021 | -0.037 | -0.021 | -0.033 |
| | (-0.588) | (-1.064) | (-0.683) | (-0.980) |
| CB Liquidity | -0.142 | -0.154 | -0.142 | -0.141 |
| | (-1.229) | (-1.304) | (-1.136) | (-1.106) |
| Observations | 1,012,839 | 1,012,839 | 1,357,947 | 1,357,947 |
| R-squared | 0.486 | 0.487 | 0.438 | 0.439 |
| Bank FE | YES | YES | YES | YES |
| Firm*Quarter FE | YES | YES | NO | NO |
| ILS*Quarter FE | NO | NO | YES | YES |
| Country*Quarter FE | NO | YES | NO | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 78 | 78 | 81 | 81 |
| N. Firms | 111,280 | 111,280 | 203,125 | 203,125 |

Table 7: **Green State Guarantee Lending: Bank-Firm New Relationships.**
Table 7 reports estimates from equation 4 where the impact of Greenhouse Gas Emission (GHGTot) on the Bank-Firm New Relationship is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the Firm's revenues. In column (1), we include ILS fixed effects; in column (2), we add Country fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE<br>**Bank-Firm New Relationship** | (1) | (2) |
|---|---|---|
| GHGTot | 0.133*** | 0.131*** |
| | (5.880) | (5.858) |
| PGL | 0.233*** | 0.227*** |
| | (11.819) | (11.585) |
| GHGTot*PGL | -0.004*** | -0.004*** |
| | (-5.806) | (-5.734) |
| Firm Size | -5.022*** | -5.130*** |
| | (-8.741) | (-8.925) |
| Firm ROA | -0.029 | -0.030 |
| | (-1.431) | (-1.535) |
| Firm Working capital | -0.042*** | -0.041*** |
| | (-8.865) | (-8.852) |
| Firm Cash | 0.315*** | 0.312*** |
| | (14.863) | (14.404) |
| Firm Debt | -0.106*** | -0.106*** |
| | (-14.260) | (-14.847) |
| Bank Size | 1.257 | 1.137031 |
| | (0.775) | (0.701) |
| Deposit | -0.420** | -0.427* |
| | (-2.153) | (-1.756) |
| NPL | -1.539*** | -1.435*** |
| | (-5.994) | (-5.279) |
| Bank ROA | -2.178 | 1.247 |
| | (-0.437) | (0.146) |
| Liquidity ratio | -1.919*** | -1.915*** |
| | (-3.222) | (-2.781) |
| Fees and commissions | 0.111 | 0.053 |
| | (0.790) | (0.341) |
| Bank Capitalitation | 1.979** | 2.057* |
| | (2.345) | (1.863) |
| RWA | 22.6505 | 10.4737 |
| | (1.527) | (0.504) |
| Bank Provisions | -3.772 | -1.482 |
| | (-0.930) | (-0.311) |
| Moratoria | 0.133 | 0.182 |
| | (1.037) | (1.452) |
| CB Liquidity | 2.048*** | 2.237*** |
| | (5.276) | (6.124) |
| Observations | 517,616 | 517,616 |
| R-squared | 0.576 | 0.579 |
| ILS FE | YES | YES |
| Country FE | NO | YES |
| Cluster | Firm Bank | Firm Bank |
| N. Banks | 89 | 89 |
| N. Firms | 313,012 | 313,012 |

# A Institutional framework

## A.1 EU Banks' Role in Transitioning to a Low-Carbon Economy

On December 12, 2015, 195 nations signed the "Paris Agreement" at the UN Climate Change Conference (COP21). This legally binding international treaty, along with the UN 2030 Agenda for Sustainable Development[1] represents the most significant initiative aimed at transitioning from a high-carbon economy ("brown economy") to a low-carbon economy ("green economy"). In November 2021, during the 26th Conference of the Parties (COP26), the guidelines for the Paris Agreement were approved and formally adopted. The Paris Agreement, with its goal of limiting the increase in global average temperature to a maximum of 2°C above pre-industrial levels, marks a turning point in creating a truly low-carbon and climate-resilient global economy.

The EU has been leading in the worldwide effort to significantly decrease carbon emissions. In 2016, the European Commission (EC) appointed a "High-Level Expert Group On Sustainable Finance (HLEG)" with the aim of creating guidelines for the establishment and development of sustainable finance in Europe. The main goal of the HLEG is to guide the European capital market towards financing projects that promote "sustainable economic growth".

In 2018, the EC announced its strategic mid-term goal to limit greenhouse gas emissions by at least 55% by 2030 and its long-term goal to create a climate-neutral European economy by 2050.[2] In March 2018, the EC published the "Action Plan: Financing Sustainable Growth".[3] This plan has three main goals: "i) reorient capital flows towards sustainable investment in order to achieve sustainable and inclusive growth; ii) manage financial risks stemming from climate change, resource depletion, environmental degradation and social issues; and iii) foster transparency and long-term in financial and economic activity.[4] Other key characteristics of the Action Plan include establishing a common taxonomy for sustainable finance, creating EU common standards for "European green financial products", giving a mandate to the European Banking Authority (EBA) to assess how ESG risks can be included in the three pillars of prudential supervision, and, above all, incorporating sustainability in prudential requirements for insurance companies and banks (i.e., recalibrating

[1] Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld.

[2] European Commission communication, November 2018 "A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy" Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0773.

[3] Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0097.

[4] Page 2 paragraph 1 "Finance for a more sustainable world" in the "Action Plan: Financing Sustainable Growth." Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0097.

capital requirements for banks to consider climate-related and environmental risks). As described in the Action Plan, the banking sector is expected to play a pivotal role in the transition toward a more sustainable economy *"The financial system is being reformed to address the lessons of the financial crisis, and in this context, it can be part of the solution towards a greener and more sustainable economy. Reorienting private capital to more sustainable investments requires a comprehensive shift in how the financial system works"*.[5] In 2019 and 2020, the Single Supervisory Mechanism (SSM)[6] identified climate-related risks as a significant risk driver on the SSM Risk Map[7] for the Euro area banking system. The ECB believes that institutions must adopt a comprehensive and forward-looking approach to evaluating climate-related and environmental risks. In May 2020, the ECB published its first draft[8] of the "Guide on climate-related and environmental risks".[9] This guide describes the meaning of climate-related and environmental risks for banks and defines its two main drivers (i.e., physical and transition risks). The "physical risks" refer to the financial impact of adverse climatic events (e.g., floods, wildfires and storms). The "transition risks", on the other hand, may arise from implementing policies to shift the economy away from its dependence on fossil fuels. This guide also describes the climate-related and environmental key performance indicators (KPIs) that EU banks are expected to integrate into their strategy. Specifically, a European bank must integrate and disclose the following environmental KPIs indicators: "i) the carbon emission footprint of its assets; ii) the average energy label of its mortgage portfolios; iii) the number of homes that saw an energy label improvement thanks to its financing; and iv) the share of assets under management that was invested according to a predefined green investment mandate".[10] Finally, this guide requests banks to include climate-related and environmental risks in their: risk appetite framework (RAF); business strategy; management body; committees; organizational structure; reporting; existing risk management framework. We can say that European banks are under strong regulatory pressure to decrease their exposure to brown companies and increase their exposure to

[5]Page 1 paragraph 1 "Setting the scene" in the "Action Plan: Financing Sustainable Growth". Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018DC0097.

[6]The Single Supervisory Mechanism (SSM) is the banking supervisory arm of the ECB. See: https://www.bankingsupervision.europa.eu/about/thessm/html/index.en.html.

[7]SSM Risk Map 2019. Available at: https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ra/ssm.ra2019.en.pdf. SSM Risk Map 2020. Available at: https://www.bankingsupervision.europa.eu/ecb/pub/ra/html/ssm.ra2020~a9164196cc.en.html.

[8]Subject to public consultation

[9]Guide on climate-related and environmental risks. Available at: https://www.bankingsupervision.europa.eu/legalframework/publiccons/html/climate-related_risks.en.html..

[10]Page 18, "Guide on climate-related and environmental risks". Available at: https://www.bankingsupervision.europa.eu/legalframework/publiccons/html/climate-related_risks.en.html..

green companies, facilitating the transition to a greener economy.

## A.2 Public-Guaranteed Loans in Europe as a Response to COVID-19

Since the first reported cases on January 21, 2020, in Northern Italy, COVID-19 has spread throughout the EU with devastating and shocking impact (Ding et al., 2021). The first wave, which peaked in April 2020, led to a surge in infections and fatalities. The unprecedented containment measures adopted by European governments, such as travel restrictions, lockdowns, school closures, and bans on large gatherings, helped reduce the virus's spread. However, the containment measures drastically affected firms' activities, negatively affecting the real economy (OECD, 2020). For this reason, European governments issued a series of relief mechanisms, such as tax deferrals, grants, equity injections, and changes to accounting policies, to avoid corporate failures and protect the economy (Kirti et al., 2022). Furthermore, numerous European countries have implemented (or enhanced) their guarantee schemes to address firms' liquidity shortages as a critical component of their policy response (Altavilla et al., 2021; Schivardi and Romano, 2020).

As EU Commission Regulation No. 651/2014 defined, the PGLs schemes EU countries designed during the pandemic had several common features. Specifically, the Commission has established: i) limits on the total size of guaranteed loans, which cannot exceed 25% of the beneficiary's total turnover in 2019 or twice the annual wage bill of the beneficiary for 2019; ii) minimum guarantee premiums that increase with maturity and are more rigorous for large enterprises compared to Small and Medium Enterprises (SMEs); iii) a maximum maturity period of six years for all loans. Interestingly, the EC designed PGLs schemes to ensure that banks have enough "accountability" to remain aware of the creditworthiness of firms when granting guaranteed loans (Altavilla et al., 2021). For example, if losses are shared equally between the bank and the state, the public guarantee cannot exceed 90% of the loan principal, and if the state has a lower priority than the bank, the public guarantee cannot exceed 35% of the loan principal.

However, certain details of these schemes are determined by *ad-hoc* national policies. Table A1 in this Appendix reports the PGLs schemes for the twelve European countries considered in our study. Both the Italian and German governments also offered 100% guaranteed loans, with Italy providing this for all loans up to €30,000 for small firms. However, as shown in the table, the guaranteed portion typically ranged from 70% to 90%, with smaller percentages given to larger firms.

The table also highlights that the Italian, German, Spanish, and French schemes are more complex, with *ad-hoc* limitations. We can observe that during the COVID-19 pandemic, PGLs were primarily issued to address liquidity shortages faced by firms. Numerous European countries implemented or expanded their guarantee schemes as a crucial component of their policy response. While this approach aimed to alleviate liquidity issues, it may have also led to unintended consequences on the real economy.

Table A1: **State Guarantee Framework**

| Country | Program Name | Type of firm | Turnover Firm size | N. Employees | Max amount | Limit | % Guarantee | Interest rate |
|---|---|---|---|---|---|---|---|---|
| Austria | SME loan guarantee program | All | | | 2,5 M (excluded in specific cases) | (never >25% rev. in 2019) or (twice wage bill 2019) | 90% | Capped 2% |
| Belgium | Regional | | | | | | | Not disclosed |
| Finland | FSA | All non financial corporations | | | Ad-hoc agreement | Ad-hoc agreement | 80% | Not disclosed |
| France | PGE | Small | <1,5 BN (turn.) | <5,000 empl. | 5 M | (never >25% rev. in 2019) | 90% | 0,25% to 0,50% first year after 0,50% to 2% |
| | PGE | Medium | >1,5 BN but <5 BN (turn.) | >5,000 empl. | 5 M | (never >25% rev. in 2019) | 80% | 0,25% to 0,50% first year after 0,50% to 2% |
| | PGE | Large | >5 BN (turn.) | >5,000 empl. | 5 M | (never >25% rev. in 2019) | 70% | 0,25% to 0,50% first year after 0,50% to 2% |
| Germany | KFW | Companies in the KFW-Schnellkredit programme | | >10 empl. | 1 BN | (never >25% rev. in 2019) or (twice wage bill 2019) | 100% | 3% |
| | KFW | SMEs | <50 M turnover <= 43 M (balance sheet) | <50 empl. | 1 BN | (never >25% rev. in 2019) or (twice wage bill 2019) | 90% | 1% to 1,46% |
| | KFW | All the others (except "large" see below) | | | 1 BN | (never >25% rev. in 2019) or (twice wage bill 2019) | 80% | 2% to 2,12% |
| | WSF | Large | Firms with two of the following characteristics >43 M turnover >50 M sales >249 employees | | Ad-hoc agreement | Ad-hoc agreement | Ad-hoc agreement | Not disclosed |
| Greece | SGF-SMEs | SMEs | <50 M turnover | <250 empl. | 1,5 M | (never >25% rev. in 2019) | 80% | Not disclosed |
| Ireland | CGS | SMEs | <50 M turnover | <499 empl. | 1,5 M | Ad-hoc agreement | 80% | Maximum 4% |

## Continued Table from previous page

| Country | Program Name | Type of firm | Turnover Firm size | N. Employees | Max amount | Limit | % Guarantee | Interest rate |
|---|---|---|---|---|---|---|---|---|
| Italy | CGF | Small | | <500 empl. | <= 30,000 | (never >25% rev. in 2019) or (twice wage bill 2019) | 100% | 0,25% to 0,50% first year 0,50% to 1% second year 0,50% to 1% third year. 1% to 2% after |
| | CGF | Small | <3,2 M turnover | <500 empl. | >30,000 but <= 80,000 | (never >25% rev. in 2019) or (twice wage bill 2019) | 100% | 0,25% to 0,50% first year 0,50% to 1% second year 0,50% to 1% third year. 1% to 2% after |
| | CGF | Small | | <500 empl. | >30,000 but <= 5M | (never >25% rev. in 2019) or (twice wage bill 2019) | 90% | 0,25% to 0,50% first year 0,50% to 1% second year 0,50% to 1% third year. 1% to 2% after |
| | SACE | Medium | <1,5 BN | >500 but <5,000 empl. | No Max Amount | (never >25% rev. in 2019) or (twice wage bill 2019) | 90% | 0,25% to 0,50% first year 0,50% to 1% second year 0,50% to 1% third year. 1% to 2% after |
| | SACE | Medium /Large | >1,5 BN but <5 BN | >5,000 empl. | No Max Amount | (never >25% rev. in 2019) or (twice wage bill 2019) | 80% | 0,25% to 0,50% first year 0,50% to 1% second year 0,50% to 1% third year. 1% to 2% after |
| | SACE | Large | >5 BN | | No Max Amount | (never >25% rev. in 2019) or (twice wage bill 2019) | 70% | 0,25% to 0,50% first year 0,50% to 1% second year 0,50% to 1% third year. 1% to 2% after |
| Luxemburg | | Small /Medium | <50 M turnover | <250 empl | 2,5 M | (never >25% rev. in 2019) | 85% | 1,5% to 3% |
| Netherlands | SME CGS | Small /Medium | | <250 empl | No Max Amount | (never >25% rev. in 2019) | 80% | Not disclosed |
| Portugal | MPE | All | | | No Max Amount | (never >25% rev. in 2019) | 90% | Not disclosed |
| Spain | ICO | Small /Medium | <50 M turnover <= 43 M (balance sheet) | <50 empl. | No Max Amount | (never >25% rev. in 2019) or (twice wage bill 2019) | 80% | 0,20% to 1,20% |
| | ICO | Large | >50 M turnover >43 M (balance sheet) | >50 empl. | No Max Amount | (never >25% rev. in 2019) or (twice wage bill 2019) | 70% | 0,20% to 1,20% |
| | ICO | Renewals | >50 M turnover >43 M (balance sheet) | >250 empl. | No Max Amount | (never >25% rev. in 2019) or (twice wage bill 2019) | 60% | 0,20% to 1,20% |

Table A2: **Green State Guarantee Lending**

Table A2 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) on the Public Guarantee Loan share (PGL) is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the firm's revenues. In column (1), we include ILS* Quarter and Bank fixed effects, and in column (2), we add Country fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE **PGL** | (1) | (2) |
|---|---|---|
| GHGTot | -0.024*** | -0.024*** |
| | (-3.357) | (-3.357) |
| Firm Size | -0.023*** | -0.023*** |
| | (-10.266) | (-10.266) |
| Firm ROA | 0.017** | 0.017** |
| | (2.202) | (2.202) |
| Firm Working capital | 0.041*** | 0.041*** |
| | (3.862) | (3.862) |
| Firm Cash | 0.095*** | 0.095*** |
| | (5.093) | (5.093) |
| Firm Debt | -0.025*** | -0.025*** |
| | (-8.564) | (-8.564) |
| Bank Size | -0.100*** | -0.100*** |
| | (-2.680) | (-2.680) |
| Deposit | -0.665*** | -0.665*** |
| | (-2.640) | (-2.640) |
| NPL | -0.257 | -0.257 |
| | (-1.123) | (-1.123) |
| Bank ROA | -2.358* | -2.358* |
| | (-1.662) | (-1.662) |
| Liquidity ratio | -0.272 | -0.272 |
| | (-1.318) | (-1.318) |
| Fees and commissions | 0.104 | 0.104 |
| | (0.626) | (0.626) |
| Bank Capitalitation | 0.029 | 0.029 |
| | (0.100) | (0.101) |
| RWA | 0.128 | 0.128 |
| | (0.892) | (0.892) |
| Bank Provisions | 2.027 | 2.027 |
| | (0.784) | (0.784) |
| Moratoria | -0.126* | -0.126* |
| | (-1.954) | (-1.954) |
| CB Liquidity | -0.488*** | -0.488*** |
| | (-3.094) | (-3.094) |
| Observations | 4,528,330 | 4,528,330 |
| R-squared | 0.536 | 0.536 |
| Bank FE | YES | YES |
| ILS*Quarter FE | YES | YES |
| Country*Quarter FE | NO | YES |
| Cluster | Firm Bank | Firm Bank |
| N. Banks | 1,030 | 1,030 |
| N. Firms | 478,141 | 478,141 |

Table A3: **Green State Guarantee Lending: Firm Heterogeneity**

Table A3 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) on the Public Guarantee Loan share (PGL) and firm heterogeneity is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the firm's revenues. All models include ILS*Quarter, Bank and Country fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE **PGL** | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| GHGTot | -0.019*** | -0.023*** | 0.007 | -0.054*** |
| | (-2.640) | (-2.641) | (0.942) | (-4.184) |
| Firm ROA | 0.029*** | | | |
| | (3.479) | | | |
| GHGTot*Firm ROA | -0.002*** | | | |
| | (-3.088) | | | |
| Firm Working capital | | 0.042*** | | |
| | | (3.528) | | |
| GHGTot*Firm Working capital | | -0.000 | | |
| | | (-0.107) | | |
| Firm Cash | | | 0.118*** | |
| | | | (5.690) | |
| GHGTot*Firm Cash | | | -0.003*** | |
| | | | (-6.531) | |
| Firm Debt | | | | -0.028*** |
| | | | | (-9.367) |
| GHGTot*Firm Debt | | | | 0.001** |
| | | | | (2.498) |
| Observations | 4,528,330 | 4,528,330 | 4,528,330 | 4,528,330 |
| R-squared | 0.537 | 0.536 | 0.537 | 0.537 |
| Bank controls | YES | YES | YES | YES |
| Firm controls | YES | YES | YES | YES |
| Bank FE | YES | YES | YES | YES |
| ILS*Quarter FE | YES | YES | YES | YES |
| Country FE | YES | YES | YES | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 1,030 | 1,030 | 1,030 | 1,030 |
| N. Firms | 478,141 | 478,141 | 478,141 | 478,141 |

Table A4: **Green State Guarantee Lending: Lending growth.**

Table A4 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) and the Public Guarantee Loan share (PGL) on lending growth is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the Firm's revenues. In column (1), we include Firm* Quarter and Bank fixed effects; in column (2), we add Country fixed effects; in column (3)-(4), we substitute Firm fixed effects with ILS fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE<br>**Lending (Lending growth)** | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| GHGTot | | | 0.013 | 0.013 |
| | | | (0.919) | (0.919) |
| PGL | 0.163*** | 0.163*** | 0.155*** | 0.155*** |
| | (9.448) | (9.448) | (7.409) | (7.409) |
| GHGTot*PGL | -0.001*** | -0.001*** | -0.001* | -0.001* |
| | (-3.608) | (-3.608) | (-1.663) | (-1.663) |
| Firm Size | | | 0.001* | 0.001* |
| | | | (1.899) | (1.899) |
| Firm ROA | | | 0.032*** | 0.032*** |
| | | | (10.564) | (10.564) |
| Firm Working Capital | | | 0.009*** | 0.009*** |
| | | | (5.430) | (5.430) |
| Firm Cash | | | -0.037*** | -0.037*** |
| | | | (-9.573) | (-9.573) |
| Firm Debt | | | 0.009*** | 0.009*** |
| | | | (7.648) | (7.648) |
| Bank Size | 0.012 | 0.012 | 0.012 | 0.012 |
| | (0.720) | (0.720) | (0.683) | (0.683) |
| Deposit | -0.139 | -0.139 | -0.110 | -0.110 |
| | (-0.717) | (-0.717) | (-0.556) | (-0.556) |
| NPL | -0.295* | -0.295* | -0.286* | -0.286* |
| | (-1.960) | (-1.960) | (-1.811) | (-1.811) |
| Bank ROA | -2.264*** | -2.264*** | -2.382*** | -2.382*** |
| | (-2.645) | (-2.645) | (-2.582) | (-2.582) |
| Liquidity Ratio | -0.129 | -0.129 | -0.103 | -0.103 |
| | (-0.942) | (-0.942) | (-0.723) | (-0.723) |
| Fees and Commissions | -0.103 | -0.103 | -0.090 | -0.090 |
| | (-1.437) | (-1.437) | (-1.142) | (-1.142) |
| Bank Capitalitation | 0.150 | 0.150 | 0.134 | 0.134 |
| | (0.786) | (0.786) | (0.678) | (0.678) |
| RWA | -0.045 | -0.045 | -0.041 | -0.041 |
| | (-0.618) | (-0.618) | (-0.543) | (-0.543) |
| Bank Provisions | -6.392*** | -6.392*** | -5.528*** | -5.528*** |
| | (-3.213570) | (-3.213) | (-2.617) | (-2.617) |
| Moratoria | -0.047*** | -0.047*** | -0.041** | -0.041** |
| | (-2.838) | (-2.838) | (-2.031) | (-2.031) |
| CB Liquidity | -0.066 | -0.066 | -0.053 | -0.053 |
| | (-1.066) | (-1.066) | (-0.806) | (-0.806) |
| Observations | 2,502,658 | 2,502,658 | 3,077,158 | 3,077,158 |
| R-squared | 0.425 | 0.425 | 0.379 | 0.379 |
| Bank FE | YES | YES | YES | YES |
| Firm*Quarter FE | YES | YES | NO | NO |
| ILS*Quarter FE | NO | NO | YES | YES |
| Country*Quarter FE | NO | YES | NO | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 953 | 953 | 961 | 961 |
| N. Firms | 210,107 | 210,107 | 343,725 | 343,725 |

Table A5: **Green State Guarantee Lending: Bank-Firm New Relationship.**
Table A5 reports estimates from equation 4 where the impact of Greenhouse Gas Emission (GHGTot) on the Bank-Firm New Relationship is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the Firm's revenues. In column (1), we include ILS fixed effects; in column (2), we add Country fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| DEPENDENT VARIABLE<br>**Bank-Firm New Relationship** | (1) | (2) |
|---|---|---|
| GHGTot | 0.001*** | 0.001*** |
| | (5.400) | (5.657) |
| PGL | 0.187*** | 0.186*** |
| | (10.756) | (10.296) |
| GHGTot*PGL | -0.004*** | -0.004*** |
| | (-11.431) | (-11.381) |
| Firm Size | -0.056*** | -0.057*** |
| | (-16.653) | (-17.329) |
| Firm ROA | -0.022 | -0.023* |
| | (-1.518) | (-1.683) |
| Firm Working capital | -0.036*** | -0.035*** |
| | (-11.748) | (-12.053) |
| Firm Cash | 0.339*** | 0.336*** |
| | (18.517) | (17.946) |
| Firm Debt | -0.081*** | -0.081*** |
| | (-14.608) | (-14.699) |
| Bank Size | -0.002 | -0.004 |
| | (-0.730) | (-1.378) |
| Deposit | -0.071 | -0.079 |
| | (-1.028) | (-0.914) |
| NPL | -0.248** | -0.238 |
| | (-1.964) | (-1.568) |
| Bank ROA | 2.720 | 4.733 |
| | (1.169) | (1.486) |
| Liquidity ratio | -0.162 | -0.170 |
| | (-0.833) | (-0.868) |
| Fees and commissions | 0.095* | 0.067 |
| | (1.824) | (1.338) |
| Bank Capitalitation | 0.153 | 0.029 |
| | (0.692) | (0.134) |
| RWA | -0.034 | -0.066 |
| | (-0.660) | (-1.155) |
| Bank Provisions | 1.266 | 2.563*** |
| | (1.499) | (3.016) |
| Moratoria | 0.073 | 0.028 |
| | (0.790) | (0.344) |
| CB Liquidity | 0.331* | 0.414** |
| | (1.776) | (2.001) |
| Observations | 940,979 | 940,979 |
| R-squared | 0.535 | 0.537 |
| ILS FE | YES | YES |
| Country FE | NO | YES |
| Cluster | Firm Bank | Firm Bank |
| N. Banks | 1,029 | 1,029 |
| N. Firms | 470,213 | 470,213 |

Table A6: **Robustness test: Controlling for share lending.**

Table A6 reports estimates from equations 2-3-4. *GHGTot* is the sum of Scope 1, 2 and 3 GHG emissions to the Firm's revenues. *Share* represents the portion of a company's overall credit from the bank, calculated precisely at the firm-bank level, based on committed loan sums as of December 2019. is Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | PGL | Lending (Lending growth) | Lending (Lending growth) | Bank-Firm New Relationship |
| PGL | | 0.166*** | 0.152*** | 0.194*** |
| | | (14.332) | (9.657) | (7.306) |
| GHGTot | -0.018* | | 0.001 | 0.122*** |
| | (-1.953) | | (0.042) | (5.343) |
| GHGTot*PGL | | -0.001*** | -0.001* | -0.004*** |
| | | (-3.348) | (-1.694) | (-5.612) |
| Share | -0.160*** | -0.020*** | -0.013*** | -0.088*** |
| | (-8.582) | (-6.047) | (-3.672) | (-3.779) |
| Observations | 2,130,020 | 1,012,839 | 1,357,947 | 517,614 |
| R-squared | 0.622 | 0.488 | 0.439 | 0.585 |
| Firm controls | YES | YES | YES | YES |
| Bank controls | NO | YES | YES | YES |
| Bank FE | YES | YES | YES | YES |
| Firm*Quarter FE | NO | YES | NO | NO |
| ILS*Quarter FE | YES | NO | YES | NO |
| Country*Quarter FE | YES | YES | YES | NO |
| ILS FE | NO | NO | NO | YES |
| Country FE | NO | NO | NO | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 84 | 78 | 81 | 89 |
| N. Firms | 305,290 | 111,280 | 203,125 | 313,012 |

Table A7: **ISS greenhouse gas emission proxy**

Table A7 reports estimates from equation 2 where the impact of disclosed Greenhouse Gas Emission (ISS_GHGTot) on both the firm probability of default (PD) and the Public Guarantee Loan share (PGL) is analyzed. In column (1), we include ILS fixed effects; in column (2), we include IL and Bank fixed effects; in columns (3-4), we include IL*Quarter and Bank fixed effects; and in column (5), we include IL*Quarter, Country*Quarter and Bank fixed effects. Standard errors are two-way clustered at the Firm Bank level. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| | Sample period: 2019 | | | Full sample | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| VARIABLES | PD | PD | PD | PGL | PGL |
| ISS_GHGTot | -0.427** | -0.389** | -0.404** | -0.170** | -0.171** |
| | (-2.380) | (-2.653) | (-2.389) | (-2.153) | (-2.144) |
| Firm Size | 0.010 | 0.010 | 0.017 | -0.013* | -0.013* |
| | (0.549) | (0.548) | (0.754) | (-1.779) | (-1.751) |
| Firm ROA | -0.773*** | -0.772*** | -1.121*** | 0.080 | 0.081 |
| | (-3.287) | (-3.256) | (-3.339) | (0.668) | (0.671) |
| Firm Working capital | 0.017 | 0.035 | -0.005 | -0.024 | -0.024 |
| | (0.206) | (0.502) | (-0.043) | (-0.263) | (-0.264) |
| Firm Cash | 0.007 | -0.011 | 0.099 | 0.077 | 0.077 |
| | (0.074) | (-0.124) | (0.798) | (0.716) | (0.712) |
| Firm Debt | 0.191** | 0.171** | 0.198** | -0.071 | -0.068 |
| | (2.616) | (2.447) | (2.565) | (-1.577) | (-1.480) |
| Bank Size | | | | 0.102 | 0.055 |
| | | | | (1.555) | (0.724) |
| Deposit | | | | 0.151 | 0.100 |
| | | | | (0.479) | (0.301) |
| NPL | | | | -0.194 | -0.212 |
| | | | | (-0.694) | (-0.550) |
| Bank ROA | | | | -0.076 | -0.690 |
| | | | | (-0.037) | (-0.255) |
| Liquidity ratio | | | | -0.225 | -0.295 |
| | | | | (-0.504) | (-0.534) |
| Fees and commissions | | | | -0.215 | -0.241 |
| | | | | (-1.234) | (-1.168) |
| Bank Capitalitation | | | | 0.512 | 0.634 |
| | | | | (0.972) | (0.921) |
| RWA | | | | -0.232 | -0.299 |
| | | | | (-0.738) | (-0.719) |
| Bank Provisions | | | | 2.007 | 4.965 |
| | | | | (0.672) | (1.422) |
| Moratoria | | | | -0.233 | -0.297 |
| | | | | (-1.133) | (-1.206) |
| CB Liquidity | | | | 0.300 | 0.467 |
| | | | | (1.090) | (1.418) |
| Observations | 3,240 | 3,238 | 2,313 | 5,971 | 5,966 |
| R-squared | 0.790 | 0.808 | 0.775 | 0.734 | 0.735 |
| Bank FE | NO | YES | YES | YES | YES |
| IL FE | YES | YES | NO | NO | NO |
| IL*Quarter FE | NO | NO | YES | YES | YES |
| Country*Quarter FE | NO | NO | NO | NO | YES |
| Cluster | Firm Bank | Firm Bank | Firm Bank | Firm Bank | Firm Bank |
| N. Banks | 58 | 56 | 55 | 59 | 59 |
| N. Firms | 554 | 554 | 534 | 534 | 534 |

Table A8: **Robustness: Green State Guarantee Lending - COVID19 outbreak.**
Table A8 reports estimates from equation 2 where the impact of Greenhouse Gas Emission (GHGTot) on the Public Guarantee Loan share (PGL) during the Covid outbreak is analyzed. GHGTot is the sum of Scope 1, 2 and 3 GHG emissions to the firm's revenues. COVID19 is a dummy variable that equals one from 2020Q1-Q4, and zero from 2019Q1-Q4. In column (1), we include ILS*Quarter and Bank fixed effects; in column (2), we add Country*Quarter fixed effects. Standard errors are two-way clustered at the Firm Bank level. Observations are between Q1-2019 and Q4-2020. All variables are defined in Table 1. *, **, and *** indicate significance at the 10%, 5%, and 1% level, respectively.

| | Full Sample | |
|---|---|---|
| DEPENDENT VARIABLE | (1) | (2) |
| **PGL** | | |
| GHGTot | 0.014 | 0.013 |
| | (1.513) | (1.469) |
| GHGTot*COVID19 | -0.051*** | -0.051*** |
| | (-4.142) | (-4.229) |
| Firm Size | -0.033*** | -0.033*** |
| | (-8.794) | (-8.822) |
| Firm ROA | -0.006 | -0.005 |
| | (-0.389) | (-0.384) |
| Firm Working capital | 0.048*** | 0.048*** |
| | (2.734) | (2.726) |
| Firm Cash | 0.109*** | 0.109*** |
| | (5.878) | (5.892) |
| Firm Debt | -0.033*** | -0.033*** |
| | (-7.047) | (-7.155) |
| Bank Size | 0.098 | 0.099 |
| | (0.742) | (0.424) |
| Deposit | -0.246 | -0.229 |
| | (-0.628) | (-0.530) |
| NPL | 0.232 | 0.304 |
| | (1.223) | (1.132) |
| Bank ROA | -2.672 | -2.871 |
| | (-1.592) | (-1.437) |
| Liquidity ratio | -0.341 | -0.314 |
| | (-1.129) | (-0.930) |
| Fees and commissions | -0.032 | -0.027 |
| | (-0.129) | (-0.087) |
| Bank Capitalitation | 1.815** | 1.938* |
| | (2.026) | (1.819) |
| RWA | 0.349 | 0.399 |
| | (1.320) | (1.227) |
| Bank Provisions | 6.194 | 6.911 |
| | (1.015) | (1.103) |
| Moratoria | -0.398*** | -0.398*** |
| | (-3.774) | (-3.741) |
| CB Liquidity | -0.446** | -0.471** |
| | (-2.066) | (-2.188) |
| Observations | 2,130,020 | 2,130,020 |
| R-squared | 0.601 | 0.602 |
| Bank FE | YES | YES |
| ILS*Quarter FE | YES | YES |
| Cluster | Firm Bank | Firm Bank |
| N. Banks | 84 | 84 |
| N. Firms | 305,290 | 305,290 |

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