



# **Is the Green Transition at Risk?**

## Investigating the Effects of the Pandemic on Green Bank Lending

by

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## **Abstract**

This thesis aims to analyze the relationship between bank lending and carbon dioxide (CO<sub>2</sub>) intensity and its implication on green bank lending. It also attempts to examine whether the COVID-19 pandemic has affected lending to low-carbon industries in any scope. Using bank-by-bank data from 23 countries, 89 banks, and 19 industries in Europe for 2019 and 2020 I explore the interconnection between volume of loans and carbon intensity with a panel model regression setup. The analysis shows that lending outcomes are related to carbon risk in general. In addition, the pandemic has not affected lending to less-polluting industries.

*Key words:* carbon risk, transition risk, COVID-19, green banking, climate finance.

## **Resumo**

Esta dissertação pretende analisar a relação entre o volume de empréstimos bancários e a intensidade de dióxido de carbono (CO<sub>2</sub>) e a implicação que esta relação tem nos empréstimos bancários verdes. Este trabalho propõe-se ainda a averiguar de que forma a pandemia de COVID-19 afetou o crédito a indústrias pouco intensivas em carbono. Utilizando dados individuais por banco de 23 países, 89 bancos e 19 indústrias na Europa relativos aos anos 2019 e 2020, nesta tese exploramos a relação entre volumes de empréstimos e intensidade carbónica, através de um modelo regressivo com dados de painel. No final desta análise concluímos que resultados de empréstimos estão relacionados ao risco carbónico em generalnas e que a pandemia a que nos referimos não afetou a emissão de empréstimos a indústrias menos poluentes.

*Palavras-chave:* risco carbónico, risco de transição, COVID-19, empréstimos verdes, finanças climáticas.

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## **List of Abbreviations**

BIS – Bank for International Settlements

CRR – Capital Requirements Regulation

CRD – Capital Requirements Directive

CSR – Corporate Social Responsibility

EBA – European Banking Authority

EC – European Commission

EEA – European Environment Agency

ESA – European Supervisory Authority

ESG – Environmental Social Governance

ESRB – European Systemic Risk Board

EU – European Union

FSB – Financial Stability Board

GHG – Green-house Gas

NGFS – Network for Greening the Financial System

OECD – Organisation for Economic Co-operation and Development

TCFD – Task Force on Climate-Related Financial Disclosures

IEA – International Energy Agency

IPCC – Intergovernmental Panel on Climate Change

PA – Paris Agreement

SDG – Sustainable Development Goals

UN – United Nations

UNEPFI – United Nations Environment Programme Finance Initiative

# 1 Introduction

The global alignment and realization that climate change poses major physical and transition risks to the global economy is assured. Extreme weather events have devoted and directed policymakers' dedication and urged the need to act. This is derived from how climate change affects retrieving resources, price modeling of energy and the valuation of companies.

Using granular bank-by-bank data from the European Banking Authority's (EBA) Transparency Exercise archive, the aim of this thesis is to investigate whether the COVID-19 pandemic, has had an impact on credit to polluting and non-polluting industries within the European Union (EU). It also intends to understand if the capital flows from European banks are subject to an increase in transition risks to greener sectors. The decision to exclusively focus on the EU is weighted by the exceptional scope of EU reforms in climate finance. I find that the COVID-19 outbreak did not impact the amount of loans granted to greener industries as the banks used in this sample avert their lending away from browner industries. In addition to previous literature, I confirm the existence of transition risk among banks.

The Intergovernmental Panel on Climate Change (IPCC) assured that the level of emissions has caused 1.0°C of global warming above pre-industrial levels, higher than the average over 1850-1900 period, and will increase to approximately 1.5°C between 2030 and 2052. The developments of global climate change policies are still in an evolving and developing phase. The landmark and common denominator of coordination among countries was framed under the Paris Agreement (PA) (COP21) in December 2015. It was the first international agreement to concretely state the role of finance with the aim to curtail the implications of climate change by keeping the rise in global temperature to be below 2.0°C and limit it to 1.5°C (IPCC, 2018). Within the EU, the primary starting point to commence the implementation of the PA was for the European Commission (EC) to establish the European Green Deal, an initiative that set the structure for how the EU could transition to a greener economy. Passing this deal, the Taxonomy Regulation, a cornerstone of the EU's sustainable finance strategy, postulates one of the tools of the Green Deal to reach the targets of the PA to prevent greenwashing (EC, 2018b). Moreover, the regulatory dynamics of the Taxonomy Regulation will demand those financial institutions to see over their role in mitigating climate change but to also increase their level of transparency.

Within the financial sector, banks are providers of credit and, as such, they serve as key components in the efforts to “make finance flows compatible with a pathway toward low greenhouse gas (GHG) emissions and climate-resilient development” (Altunbas et.al., 2021). The financial intermediaries additionally have responsibility beyond generating profit to undertake socially responsible lending (Gutiérrez-nieto et al., 2016). They equivalently unlock entrepreneurs to finance their new enterprises, while at the same time evaluating the risks (EBF, 2017; Schumpeter, 1939). However, this responsibility of funding of green firms can be subject to higher costs associated with the transition to the utilization of green technology. This logic stems from that firms nowadays are responsible to comply with laws that are aligned with norms and social ethics as well as actions fueling the transition to greener technology (Harjoto et.al., 2015; Ongena et.al., 2021). The coronavirus pandemic, with its very first outbreak in November 2019, has in some examples led governments to avert the light away from long-term sustainability objectives by towering unparalleled flows of different resources to save national economies. These packages have set the risk of putting the achievement of the United Nations’ (UN) Sustainable Development Goals (SDG’s) years behind in schedule (Quatrini, 2021).

Based on the above, the principal purpose of this thesis is to expand the literature on climate-related financial risk. Therefore, the two main research questions are:

- *Did the COVID-19 outbreak change the borrowing outcomes for greener industries in Europe?*
- *Are lending outcomes related to carbon risk?*

The contribution of this thesis to the already existing literature is twofold. Firstly, it intends to confirm the role of regulatory interventions in climate finance, and how these interventions can be a catalyst of transition risks for banks when transitioning to a green economy. Secondly, the thesis relates to literature on the role of banks in the fight against climate change. On top of already existing literature, I want to investigate if the pandemic has had any negative effects on funding greener firms in Europe through their credit. This topic has been scarcely explored in the literature which mainly focuses on estimating banks’ exposures to environmental risks by the price dimension of banks’ reaction via the interest paid (Mueller & Sfrappini, 2022). This scarcity could be due to the fact that paid interest is an easier way of differentiating the supply and demand of bank lending, as banks could potentially have a larger market power in their decision on granting loans.

The remainder of the thesis is organized as follows. Section 2 compiles current and still expanding literature on climate-related risks and the determinants of transition risk. Section 3 describes the data and the sample selection followed by section 4 that presents the model selection. Section 5 reports the results from the model selection and robustness check and caveats. Section 6 includes the conclusions and further research.

## **2 Literature on Climate-related Risks**

Even though the literature on the implications of climate change for bank lending is limited I aim to provide the reader with an empirical background and literature review of the two main focuses of this thesis, climate-related risks, and its complementary policy developments within the global and EU financial market. Additionally, I outline the relationship between economic distress and its relation to bank lending.

### **2.1 Climate-related Financial Risks: Physical & Transition Risk**

Climate-related financial risks are those that “may arise from climate change or from efforts to mitigate climate change, their related impacts and their economic and financial consequences” according to the Bank for International Settlements (BIS). The two main risks associated with climate change, or that arise from efforts to mitigate climate change, in the financial sector are physical and transition risk (BIS, 2021).

*Physical risks* are economic costs and financial losses resulting from the increasing severity and frequency of extreme weather events being heatwaves, landslides floods, wildfires, and storms. They also account for the sort that translates to indirect effects of change such as the loss of ecosystem facilities (BIS, 2021).

*Transition risks* are those related to the process of modification towards a low-carbon economy. Put differently, those are the costs that the society needs to spend to mitigate the physical risks that we are exposed to. The transition risk drivers are the unanticipated climate-related changes in public sector policies, legislation and regulation, changes in technology, that have the potential to achieve a decarbonized economy (BIS, 2021; Altunbas et.al., 2021).

Due to the close relation that transition risk has to climate policy interventions, I will exclusively focus on transition risk in this thesis as a measure of climate-related risk.

### **2.1.1 More on Transition Risk**

One of the most prominent and relevant components of a banks' risk metrics, is the level of carbon intensity that a firm release. Consequently, this thesis focuses on transition risk factors, that are derived from carbon intensity levels.

Extending the notion of transition, the time frame of which climate change commitments are subject to implementation corroborates with the economic weight to implement such commitments for financial institutions. The timeline and scale of structural change implied by proposed climate change mitigation initiatives makes the transition to a low-carbon economy different to other innovation pathways, since it is subject to policy intervention.

Indeed, in response to the PA the European Systemic Risk Board (ESRB), an institution responsible for mitigating and preventing systemic risk of the EU financial system, highlighted the importance of the early start of implementing the pledges of the agreement to reduce the costs subject to transitioning into a sustainable economy dividing the adaption time frame into a benign and adverse scenario. In the benign scenario the conversion to a less carbon intensive economy occurs progressively, i.e., transition risks are manageable, and the repricing of carbon assets is not a catalyst of any systemic risk. In the adverse scenario, the conversion to a less carbon intensive economy would materialize at a later state. This in turn could result in short implementation of quantity constraints using carbon intensive assets leading to higher transition risks (ESRB, 2016).

Putting it into the bank perspective, banks are presently exposed to carbon-intensive industries with business models that might not fit into the transition to a low-emission economy (Park & Kim, 2020). The low-carbon transition has similarly been framed as a transition that develops sunset industries being those industries that are carbon intensive (Semieniuk et.al., 2020). Therefore, the carbon risk<sup>1</sup> measurement also corroborates with transition risk.

However, even though climate-related policies within the climate finance field are subject to decreasing carbon emissions they have, on the contrary, also possessed unintended

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<sup>1</sup>See section 2.2 explaining the definition

consequences when trying to direct capital to greener sectors. In fact, Benincasa et.al. (2022) confirms that banks counters to domestic climate policies by increasing their cross-border lending to countries with less rigorous climate policies as a reaction to an increase in their home countries climate policy. This further develops regulatory arbitrage to lessen the transition risks that comes with the climate-related financial policies. This challenge for banks to comply with the climate-related policies has developed a sub-category of transition risk to regulatory risk (Jung et.al., 2018; Benincasa et.al., 2022). Regulation is a major channel in which climate and other types of environmental risks are reflected on firms operating costs and cash flows (Seltzer et.al., 2022). These counterproductive results are not simply derived from an immediate effect on banks physical risk, but also the costs that appears when transitioning to a sustainable economy. Moreover, the PA have sowed for banks' increased exposure to transition risks (Altunbas et.al., 2021) emerging the appearance of systemic risk acquainted with the regulatory interventions received to limit emissions by e.g., introducing carbon tax. These type of tax interventions are systemic in its nature as they would equally affect banks profitability of more carbon intensive sectors (Bolton & Kacperczyk, 2020).

## **2.2 Carbon risk**

Even though the literature on financing industries with higher level of carbon intensity is somewhat scarce, the attention to the intensity of carbon emissions for certain industries has been one of the most prominent themes for businesses. The United Nations Environment Programme Finance Initiative's (UNEPFI) (2013) definition of carbon risk, i.e., "physical assets with direct or indirect exposure to GHG emission constraints, such as those in the fossil-fuel industry or that are heavily reliant on fossil fuels" is the more generic form of carbon risk. In terms of debt financing businesses increase their internalization of the costs associated with carbon emissions (Jung et.al., 2018); an indicator to use this measurement as a proxy of carbon risk. Similarly, carbon premium on asset returns is found to be incorporated in asset pricing. Moreover, higher returns are indeed associated with a higher level of pollution (Bolton & Kacperczyk, 2020).

The underlying risk drivers for carbon emissions in terms of debt investing are primarily twofold. Firstly, the total level of emissions' relation to risk premium is tied to regulations (Bolton & Kacperczyk, 2020). As earlier mentioned, carbon risk is closely associated with transition risk as governments try to curb the carbon industry and reduce its emissions.

Therefore, firms in carbon-intensive industries are influenced by new carbon-related policy being introduced. This risk exposure increases the firms' liability to potential legal penalties and reputational risks as the carbon-intensive firms have a higher probability to violate environmental regulations (Zhang, 2021). Secondly, derived from the transition to a greener economy, technological change commonly involves a fixed cost shaping existing carbon-intensive technologies more expensive if carbon taxes are introduced (Bolton & Kacperczyk, 2020; BIS, 2021)

Applying this perspective of a bank as a credit supplier to more polluting and non-polluting industries, financing carbon in the field of innovation has been included in banks' metrics of risk management as the risks of financing carbon are closely connected to decarbonization policies. Banks with exposures to firms that are not capable to accommodate to carbon-neutral economies may in turn face higher probability of credit-related losses (BIS, 2021). Jung et.al. (2018), as mentioned above, consider carbon risk as regulatory risk, namely, "any corporate risk related to climate change or the use of fossil fuels" when they studied the debt market in Australia. One can therefore highlight the accuracy of measuring transition risk as an indicator of carbon risk<sup>2</sup>. Consequently, we should expect a negative correlation between credit and the level of carbon intensity.

### **2.3 Climate-related Frameworks for Credit Institutions: Europe and Global**

The EU is one of the most active regions in formulating environmental protection policies compared to others (Cifuentes-Faura, 2022). Given the above-mentioned relationship between regulation and carbon risk I provide a broad overview of current climate-related policies and frameworks on the European and global level respectively.

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<sup>2</sup> Thus, I use transition risk and carbon risk interchangeably

### **2.3.1 European Green Deal**

On the 11<sup>th</sup> of December 2019 the EC launched the Green Deal to revert every policy within the EU to make the region climate neutral by 2050 with a reduction of 55% by 2030. The deal is part of the Commissions' strategy to apply the UN's 2030 Agenda and its SDG's and the PA. One pillar of the deal is financing the transition to a greener economy and redirect capital flows to greener economic activities (EC, 2019).

EU's role in greening the financial system, as part of their plan to implement the PA, is a mandate by the EC with the intention to:

- redirect capital flows favoring sustainable investment in order to attain sustainable and inclusive growth;
- govern financial risks derived from climate change, resource deficiency, environmental deterioration, and social issues; and
- champion transparency and long-term gains in financial and economic activity (EC, 2018).

The objective of this announcement was a call on the European Supervisory Authorities (ESA:s), to provide supervision on how sustainable applications can be considered in EU financial services legislation and accordingly identify extant gaps.

In the light of the updated supervisory practice the expansion of the Capital Requirements Regulation (CRR 2) and Capital Requirements Directive (CRD 5) gave the EBA three updated mandated practices essentially relating to ESG and sustainable finance:

- assess the ESG risk inclusion their supervisory review and evaluation process.
- requirement for larger financial institutions that are publicly listed to disclose ESG risk, physical risk, and transition risk information; and
- assess whether dedicated effective treatment of exposures framed to assets or activities associated considerably with environmental and/or social objectives would be justified according to Article 501c of CRR 2 (EBA, 2019).

### **2.3.2 Global Recommendations & Voluntary Climate Reporting**

Since the initiation of the PA financial institutions have, on a voluntary basis, engaged in climate reporting to signal their commitment to Corporate Social Responsibility (CSR), i.e., to condense efforts to operate in a manner that enhances society and environment through the disclosing of climate-related information (Caby et.al., 2020), a strategy that have expanded during the latest decade basing decisions that are desirable to overall society (Bowen, 1953). A large piece of these corporate commitments and initiatives reaches far before the PA (e.g., Carbon Disclosure Project, Global Reporting Initiative, and the Sustainable Accounting Standards Board).

The performance of voluntary climate reporting of banks, with the goal to reduce GHG emissions, is still ambiguous and there is no clear consensus in the relationship between climate reporting and the level of decarbonization (Caby et.al., 2020). On the other hand, the role that the legislative nature of the policy interventions on sustainable finance to reach climate-related targets has appeared to be crucial (Ahlström & Monciardini 2021; Mazzucato & Perez, 2014).

Apart from capital flows from banks, climate policy interventions have had implications on investments and increased in other ESG asset classes in Europe compared to the United States (US). In fact, Contractor (2022) outlined that ESG exchange traded fund's asset growth have been higher in Europe compared to US in recent months stemming from the expectation on growing regulatory enhancements in the geographic area. In this context of legally enforcing climate reporting, the PA broke novel ground by additionally including an engagement that makes private finance flows persistent with a pathway towards a climate-resilient world (Ackom & Motty, 2020).

Both private and public financial institutions, individually and collectively try to curb the difficulties on the prospect of climate change from a risk management perspective. A primary example is the Network for Greening the Financial System (NGFS) being a contributor to merge financial sector participants to comply with the PA ambitions. This forum has mobilized the financial sector, such as central banks, financial supervisors, and international organizations since 2017, with the aim to increment synergies to mitigate climate change and support the transition to a sustainable economy (NGFS, 2022). The network has based their methodological framework on other initiatives such as the Task Force on Climate-related Financial Disclosures (TCFD), developed by the Financial Stability Board (FSB), an international body monitoring

recommendations about the global financial system, with a commission to promote international financial stability. The recommendations have outlined a core structure for the financial sector and governments on how to develop climate-related policies (TCFD, 2017).

In conclusion, the earlier literature on the determinants on the level of carbon emissions and its associated risk drivers has found relationships with different policy interventions and recommendations in climate-related risks in several different ways. The diversity of these results is one of the reasons I proceed to look at the discrepancies in volume of loans between banks.

## **2.4 The Role of Banks in Greening the Financial System**

At the bottom, one of the difficulties that the topic of banks' performance in climate finance faces is the large spread of different literature. Before dissecting the implications on the role of banks in greening the economy it is noteworthy to mention the difference between the carbon footprint of a banks' own operation as opposed to the users of the bank products. In fact, the main segment of a banks' contribution to climate finance is in its mediator role via the lending channel in the economy in terms of sustainable banking (Bussoli et.al., 2018). The effect credit has on greening industries is still in an expanding phase. On the other hand, it is still widely known that the banking sector is fundamental in meeting financial needs of the private sector, households, and individuals. The positive externalities that banks have generated through business development is also a key component in investigating the role of credit institutions in the green transition in this thesis.

Park & Kim (2020) defines green banking as:

*“Financing activities by banking and non-banking financial institutions with an aim to reduce greenhouse gas emissions and increase the resilience of the society to negative climate change impacts while considering other sustainable development goals such as economic growth job creation and gender equality”*

Firstly, banks possess an exclusive market position when it comes to the rigorous market knowledge and experience overlapping several economic sectors. Naturally, the role of it in financing the green transition should not be different. In terms of resiliency, they equivalently help to reduce the risks derived from climate change and sustainability by mitigating them

through the reallocation of finances to sectors more receptive to climate change (Park & Kim, 2020).

Secondly, the transitioning to a greener economy is closely associated with the expansion of green technology industries and renewable energy markets through both the securement of credit and investments. Investments in renewable energies have increased in recent years and are expected to grow in terms of market share (IEA, 2015). The mobilization of capital in renewable energy markets is according to the Organisation for Economic Co-operation and Development (OECD) essential to meet the international climate change goals towards decarbonization (Inderst et.al., 2012). Scaling up the innovation and the infrastructure around such innovation often relates to securing long-term predictable capital. In relation to renewable energy markets and green technology banks work with other market participants to increase market transparency by amending lenders' understanding of investments of decarbonization and unlock investment barriers. This is typically associated with syndicated loans to finance larger scaled projects. They can similarly address lack of information, data and skills to gauge transactions and underlying risks (OECD, 2015; Park & Kim, 2020).

In summary, the role and ability banks have in the transition to a green economy is fundamental in bridging the gap between risks and opportunities and unlock long term capital to green industries. As earlier mentioned, the proportion of studies exploring the interconnection between credit and the level of pollution is limited since it has mainly focused on the cost of debt (Mueller & Sfrappini, 2022). Given the recent exploration in this field I want to confirm the relationship between credit finance and carbon intensity.

## **2.5 Bank Resiliency under Economic Distress**

The pandemic had negative effects in several financial sectors in 2020 and for banks the case is no different. Different to many other economic crises, the pandemic outbreak was an exogenous shock stemming from outside of the financial system. Consequently, it is preeminent to have an overview of the impact the pandemic has on banking stability. This is to establish a sense of the interconnection between the level of green credit during an economic crisis to evaluate the resiliency in managing transition risk in this environment.

Analyzing the effects of the pandemic on bank lending is still in an expanding phase. Elnahass et.al. (2021) are among of the first studying the impact of COVID-19 on banks financial

performance and financial stability. Using risk-based indicators among others, before and after the outbreak of the virus, they studied information from 1090 banks from 116 countries over the first quarter of 2019 until the second quarter of 2020. Their evidence showed that the pandemic significantly reduced bank profitability and financial stability. Indeed, banks faced higher credit and default risks in the aftermath of lockdowns and business closures. Equivalently, banks level of lending decreased, and risk increased. In parallel, they also concluded that there was a sign of recovery for bank stability in the second quarter of 2020 which increased the amount of loans.

Compared to the global financial crisis in 2008-2009, the effects of the economic distress on the banking system during the outbreak of the pandemic were distinctive. The distress that the global financial crisis caused was derived from the banking sector. A sector that was over-leveraged with irregular bank lending patterns. To the contrary, the implications off the pandemic have been exogenous in its nature on both supply and demand due to rapid measures that governments implemented (Elnahass et.al., 2021).

As will follow in the later sections the structural relationship between variables under economic distress were transformed as some industries benefitted more than others during the pandemic. With the aim to save those industries that were severely hit by the pandemic governments injected large credit packages to save certain industries. Thus, one limitation in this thesis is the disruption of common relationships among variables which can explain the incomparability between 2019 and 2020 when encapsulating transition risk.

### 3 Data & Sample Selection

In this section I describe the data and sample being used in this thesis and the relationship among the variables. To investigate the ability of the amount of loans to be a good proxy of banks following green financing after the COVID-19 outbreak, I constructed a dataset based on annual public data.

The selection of the data is based on the availability of matching countries and years that have data on volume of loans and carbon intensity for the equivalent years. This merge of data leaves 3064 observations between 2019-2020, covering 23 countries<sup>3</sup>, 19 industries, and 89 banks within the EU where the list of the banks and industries are displayed in the appendix<sup>4</sup>. Data sources and variable description are displayed in Table 1. The industries used in this thesis follows the four-digit EU-classification system of economic activities abbreviated as NACE<sup>5</sup> Rev.2, which provides a framework for retrieving and presenting a broad range of statistical data in the fields of economic statistics and other statistical domains developed within the European Statistical System.

As previously mentioned, the thesis only includes observations within the EU due to data availability and to achieve granularity and comparability in the dataset. Additionally, the scope of EU reforms on climate-related policies are large and can consequently increase the ability to capture transition risks. Noteworthy to mention is the dropping of the countries Malta and Iceland as they have a larger set of missing values across the datasets and years. I also drop 349 observations where volume of loans is equal to zero as I treat them as missing variables.

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<sup>3</sup> Austria, Belgium, Bulgaria, Cyprus, Germany, Denmark, Estonia, Spain, Finland, France, Greece, Hungary, Ireland, Italy, Lithuania, Latvia, Netherlands, Poland, Portugal, Romania, Sweden, and Slovenia.

<sup>4</sup> Table A.1 and A.2

<sup>5</sup> Nomenclature Statistique des Activités Économiques dans la Communauté Européenne.

Table 1: Data Definitions and Sources

Variable	Name	Unit	Source
In Volume of Loans	ln(Y)	ln (gross carrying amount) (million €) per bank	EBA
CO2 Intensity	CI	level of CO2 emission to revenue (kg/€ current price) per industry	Eurostat
In Total Assets	ln(BankSize)	ln (carrying amount) (million €) per bank	EBA
NPL-ratio	NPL	number of NPL to total gross loans (%) per bank	EBA
Employment Growth	EMP	employment in $t$ less employment in $t-5$ to employment in $t-5$ (%) per industry	Eurostat
Gross Output	GO	relative share of gross output (%) per industry	EUKLEMS
PostOutbreak		dummy variable equal to 1 after September 2019, 0 otherwise	

The pairwise correlation matrix in table 2 provides a better sense if there are any signs of multicollinearity between the independent variables. For interpretation I have transformed bank size and volume of loans to their original scale.

If there were to be any sign of multicollinearity this could in turn interfere with the validity of the test statistics in section 5. Analyzing the correlation matrix there is no sign that two or more of the predictors are highly linearly related as none of the elements have a correlation coefficient higher than 0.7.

The negative correlation between volume of loans and carbon intensity is expected given the previously mentioned negative interconnection between the two variables stemming from transition risk at -2,7%. Bank size and the NPL also have signs that corroborates with previous literature on bank lending, i.e., lending should covary positively with the bank size, in this case by 33%. Similarly, the NPL should intuitively have a negative correlation with credit due to a higher default risk affecting bank lending here at -7,6%. Noteworthy to mention is the less intuitive linear relationship between the amount of loans and employment growth which should covary positively, however the pandemic has disrupted several structural relationships between

variables. Thus, the volume of loans was high in parallel with higher levels of unemployment. Nevertheless, structural disruptions between variables might have implications on the analysis in the forthcoming sections.

Table 2: Pairwise Correlation Matrix

Variables	Y	CI	BankSize	NPL	EMP	GO
Y	1.000					
CI	-0.027	1.000				
BankSize	0.329	-0.025	1.000			
NPL	-0.076	0.096	-0.095	1.000		
EMP	-0.056	-0.112	-0.046	0.170	1.000	
GO	0.201	0.034	0.003	-0.010	-0.040	1.000

In Table 3, the means, standard deviations, minimum, maximum, skewness, and kurtosis values are presented for the key measurements used in this thesis in 2019 and 2020. The values of the variables are presented in their regular form and in the transformed version as natural logs. The higher standard deviations of the total employment and volume of loans are due to their higher spreads. The high kurtosis for volume of loans, carbon intensity and gross output are related to the larger number of outliers in the dataset. Thus, to try and curb the lack of normality in the variables I have transformed volume of loans and carbon intensity into their natural logs where the kurtosis subsequently decreases.

Table 3: Summary Table

Variable	Mean	SD	Min	Max	Skew	Kurt
Y	3250.41	8416.27	1	100106	5.341	38.659
ln(Y)	6.154	2.247	0	11.514	-0.308	2.844
CI	0.333	0.997	0.00002	15.729	8.546	103.635
ln(BankSize)	8.154	3.693	1.058	14.635	-0.004	1.54
BankSize	135000	3310000	2.88	2269060	3.816	19.039
NPL	7.155	8.794	0	52.542	2.758	11.119
EMP	0.087	0.164	-0.506	1.083	0.934	6.881
GO	0.056	0.077	0.001	2.294	10.118	241.419
N.Obs.	3064					

### **3.1 Dependent Variable: Volume of Loans**

The bank-level data is collected under the EU Wide Transparency Exercise from the EBA labeled in Gross Carrying Amounts. The amounts are displayed in breakdowns of loans to each NACE Rev.2 industry. After each exercise the authority provides disclosure on banks' financial position such as assets and liabilities, capital positions, risk exposure amounts, leverage exposures and asset quality for banks across the EU and the European Economic Area (EBA, 2020). The eight exercises completed thus far constitutes bank-specific data for seventeen dates<sup>6</sup>. Data being used from the Transparency Exercise in this thesis are from the reference dates 30<sup>th</sup> of September 2019 and 30<sup>th</sup> of September 2020 to reassure that the data being used from 2019 was before the first outbreak of COVID-19 in November 2019. This leaves me with collecting data from the Spring 2020 Transparency Exercise and the 2021 Transparency Exercise respectively.

Inspecting the loan data, it is noteworthy to mention the commonalities in the minimum level of loans as displayed in table 4. Moreover, the standard deviation is relatively high for all the industries given the large spread in the volume of loans. The table also confirms that in the sample used in this thesis, banks lend more to the Real estate activities (L) on average compared to other industries.

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<sup>6</sup> December 2012; June 2013; December 2014; June 2015; December 2015; June 2016; December 2016; June 2017; December 2017; June 2018; December 2018; September 2019; December 2019; March 2020; June 2020; March 2021, and June 2021.

Table 4: Summary statistics volume of loans (million €) by industry

Industry (code)	N.Obs.	Mean	SD	Min	Max
Agriculture, forestry and fishing (A)	162	1785.08	4212.143	1	32831
Mining and quarrying (B)	156	1210.756	2616.553	1	13671
Manufacturing (C)	172	9554.797	16014.484	5	75174
Electricity, gas, steam and air conditioning supply (D)	170	2939.929	4692.622	1	25475
Water supply, sewerage, waste management and remediation activities (E)	166	543.5	813.534	1	4968
Construction (F)	174	3354.678	5153.519	23	29943
Wholesale and retail trade (G)	170	7824.135	12847.995	4	64384
Transport and storage (H)	172	3788.622	6059.332	1	32767
Accommodation and food service activities (I)	168	1673.411	2584.624	1	14365
Information and communication (J)	172	1607.884	2830.596	1	13237
Financial and insurance activities (K)	120	3115.467	6417.065	1	32709
Real estate activities (L)	158	13814.006	20743.321	1	100106
Professional, scientific and technical activities (M)	168	2875.19	4548.803	4	21406
Administrative and support service activities (N)	168	2284.506	5085.995	3	45818
Public administration and defence (O)	100	336.15	1123.481	1	10461
Education (P)	160	197.625	370.835	1	2138
Human health and social work activities (Q)	168	1084.786	1879.921	4	9645
Arts, entertainment and recreation (R)	170	361.824	516.251	1	2855
Other service activities (S)	172	2281.244	6413.956	1	48744

Visualizing the density of the reported loans sample the histogram affirms that the larger subset of the variable is relatively low in figure 1 as earlier indicated in table 3. Similarly, the number of times the amount of loans takes the same value is high.

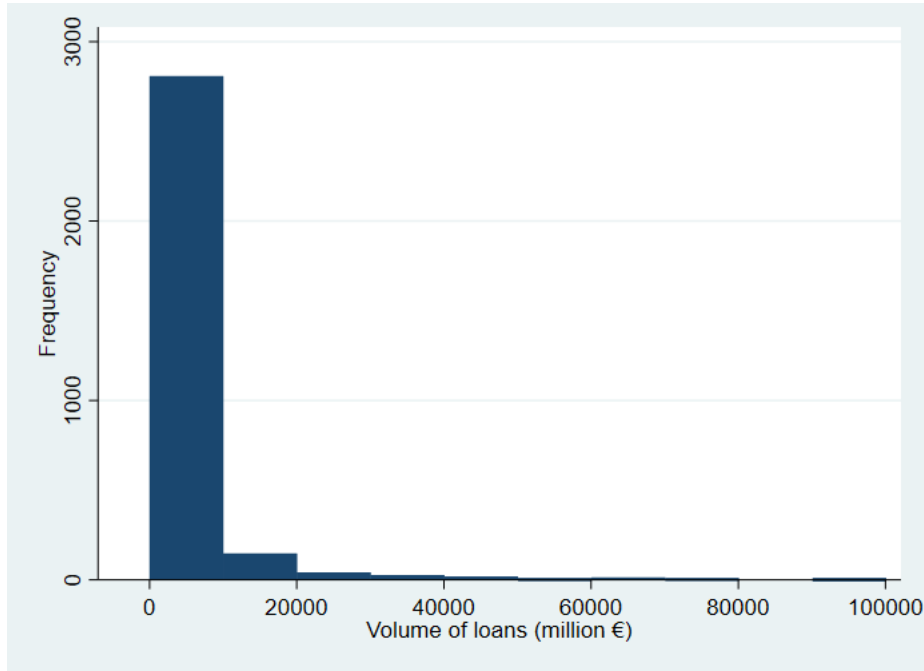


Figure 1: Frequency over volume of loans (million €)

### 3.1 Independent Variable: Carbon Intensity

Carbon intensity measures the relative carbon emission, i.e., it is expressed as the absolute carbon emissions distributed by an activity measure such as revenue or production. The design of the measure is to obtain different dimensions of a firms' GHG identity (Jung et.al., 2018). Carbon intensity is calculated by dividing the absolute carbon footprint by unit of revenue in a year illustrated in equation (1).

$$CI = \frac{\text{Amount of CO}_2 \text{ emissions}}{\text{Revenue}} \quad (1)$$

I use carbon intensity as measure of carbon risk exposure based on the assumption that industries with lower carbon intensities, and indirectly better environmental performance, have less exposure to carbon risk. The version of carbon intensity used in this thesis is from the annual dataset on air emission accounts by economic activity from Eurostat. The measure of revenue in this case is the gross value added that is represented as the denominator in equation (1). The nominator in the same equation is represented in kg. Eurostat collects the inventories for GHG on a national level from the European Environment Agency (EEA) which Eurostat in turn republishes (Eurostat, 2022).

I use the relative measure of carbon emissions instead of the absolute measure as the interpretation of the relative measurement is an indicator of the scale to which a firm's business depends on GHG emissions (Jung et.al, 2018). In this thesis the amount of carbon emissions used in the nominator in equation (1) are categorized as Scope 1. The Greenhouse Gas Protocol is the most widely used international accounting tool by business leaders to assess GHG emissions and classifies this scope as "the direct GHG emissions caused by the company's fuel combustion or emitted through industrial processes owned or controlled by the company" (UNEPFI, 2013).

In a context of higher transition risk, banks should be motivated to redirect credit to low-carbon industries. Before dissecting the volume of loans across industries it is meaningful to get a grip on the importance of the size of the economy and the overall energy efficiency in the economy measured as the amount of CO<sub>2</sub> emissions used to contribute of the industry production. Figure 2 displays a bar chart over the average carbon intensity and average volume of loans by each country. The volume of loans is presented in natural logs to diminish the size of the variable into a more manageable and comparable size to carbon intensity. It confirms that the Netherlands is the country with the biggest average level of credit across industries in the sample used in this thesis. Additionally, it confirms that the differences between the volume of loans in 2019 and 2020 is relatively small.

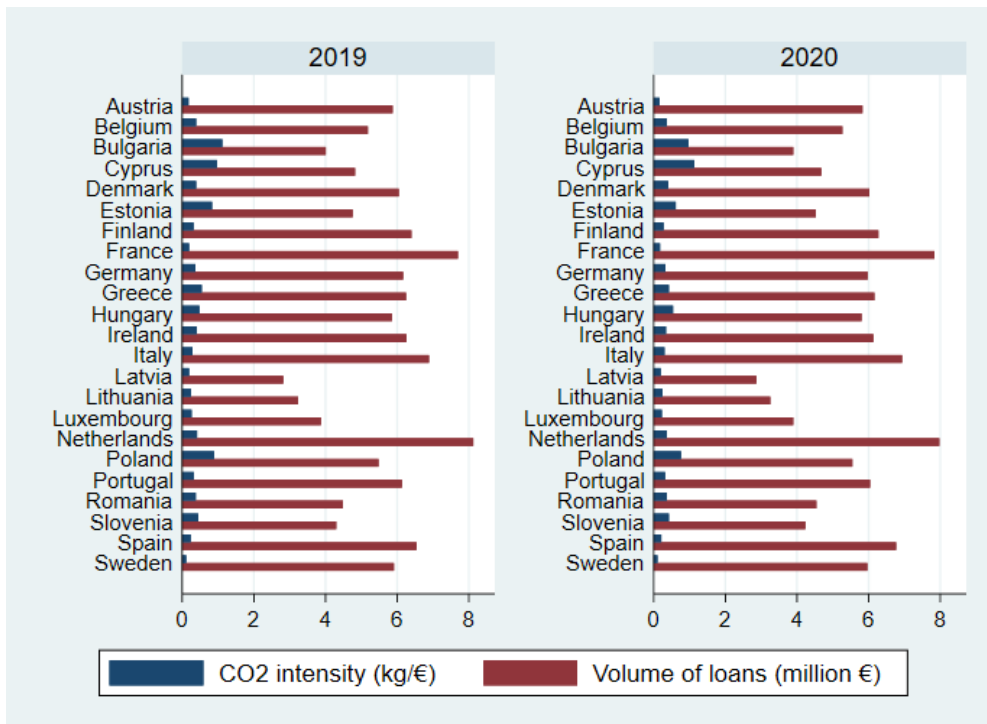


Figure 2: CO2 intensity (kg/€) and volume of loans (million €) by year

To capture the before-mentioned negative relationship between carbon intensity and volume of loans I have demonstrated the amount of loans across industries based on their level of carbon intensity in a specific sub-sample. The sub-sample encompasses the five biggest banks<sup>7</sup> subject to their bank size measured in total assets. The choice of countries relates to their relative size according to figure 2 being Germany, France, Spain, Netherlands, and Italy based on the average volume of granted loans across the industries. I then plot their respective bank loans against the level of carbon intensity across industries in 2019 and 2020 displayed in figure 3 in which one color represents one bank. The scatter plot confirms the negative linear relationship between the amount of loans from a reporting bank to a specific industry; the higher the amount of loans the lower the carbon intensity is. It is therefore worth to continue to dissect the level of carbon intensities across industries in the EU.

<sup>7</sup> BNP Parisbas, Banco Santander, Deutsche Bank, UniCredit, and ING Groep.

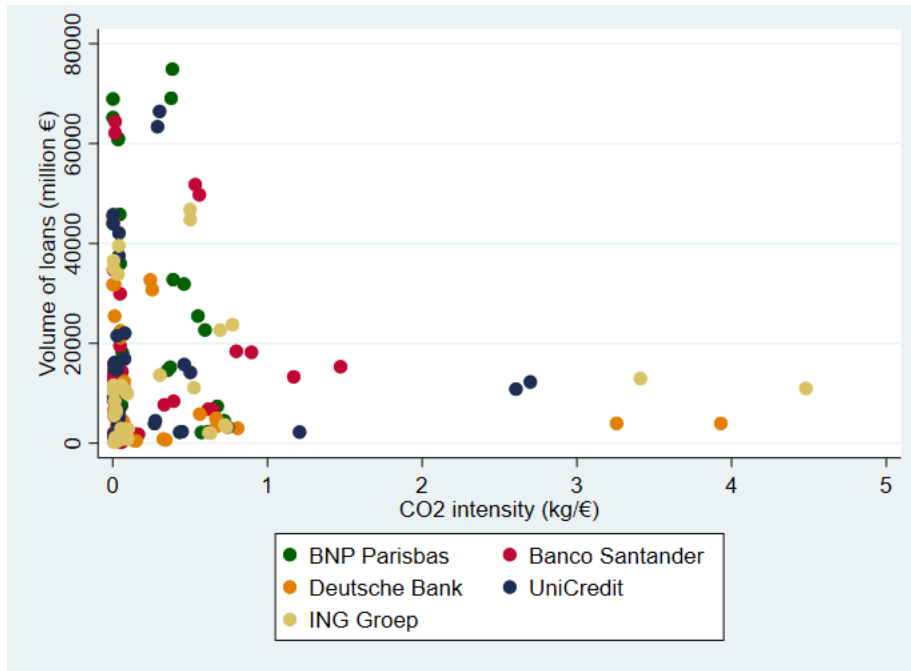


Figure 3: Top five largest banks: Volume of loans (million €) and CO2 intensity (kg/€)

Figure 4 demonstrates the maximum level of carbon intensity per industry. It is clear that the industry Electricity, gas steam and air conditioning supply (D), followed by the Transport and storage (H) industry, is significantly the highest emitter between 2019 and 2020 which is expected as the energy generation sector served for 76% of total EU GHG emissions in 2020 as opposed to its peer industries (EEA, 2022). Therefore, the level of carbon intensity follows the same trend in this sample period used in this thesis.

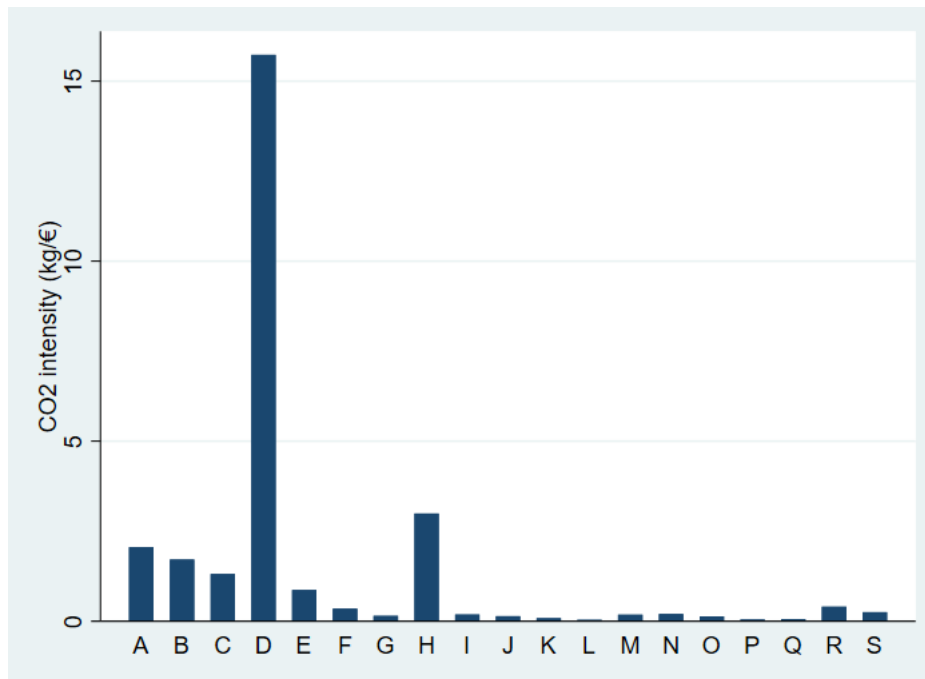


Figure 4: Maximum level of CO2 intensity (kg/€) by industry

Put differently, table 5 displays the summary statistics of carbon intensity in each industry between 2019 and 2020. The construction of the carbon intensity measure used in this thesis is similar to those used in earlier research related to carbon risk, i.e., the values of carbon intensity are expected to be lower as the measurement is constructed as a quota. The sample period is less extensive than earlier studies which can have an impact on the variability of the variable. It is here clear that industry Electricity, gas, steam and air conditioning supply (D) emits the most considering the outlying maximum value. Additionally, this also explains the larger standard deviation for the same industry due to the higher spread. In comparison, industries with lower levels of carbon intensity are those whose business rely on more administrative operations (K, L, Q, R). This could relate to e.g., the fact that a credit institutions' lower carbon footprint through its operations and products is much lower, in relation to the intermediary role in credit finance. This is also mentioned in the literature overview in section 2.

Table 5: Summary statistics CO2 intensity (kg/€) by industry

Industry (code)	N.Obs.	Mean	SD	Min	Max
Agriculture, forestry and fishing (A)	162	0.402	0.303	0.092	2.059
Mining and quarrying (B)	156	0.0664	0.339	0.103	1.715
Manufacturing (C)	172	0.434	0.247	0.055	1.31
Electricity, gas, steam and air conditioning supply (D)	170	2.984	2.932	0.548	15.729
Water supply, sewerage, waste management and remediation activities (E)	166	0.293	0.221	0.033	0.868
Construction (F)	174	0.077	0.046	0.022	0.351
Wholesale and retail trade (G)	170	0.043	0.026	0.004	0.149
Transport and storage (H)	172	0.893	0.706	0.210	2.994
Accommodation and food service activities (I)	168	0.052	0.038	0.001	0.189
Information and communication (J)	172	0.012	0.021	0.00037	0.143
Financial and insurance activities (K)	120	0.012	0.017	0.001	0.086
Real estate activities (L)	158	0.005	0.008	0.00002	0.04
Professional, scientific and technical activities (M)	168	0.018	0.027	0.001	0.183
Administrative and support service activities (N)	168	0.032	0.031	0.008	0.201
Public administration and defence (O)	100	0.036	0.025	0.013	0.137
Education (P)	160	0.015	0.010	0.003	0.047
Human health and social work activities (Q)	168	0.021	0.013	0.004	0.062
Arts, entertainment and recreation (R)	170	0.049	0.061	0.01	0.403
Other activities (S)	172	0.053	0.043	0.013	0.254

Table 6 demonstrates the average carbon intensity by industries over the years used in the sample. In relation to the two highest emitting industries, Electricity, gas, steam and air conditioning supply (D) and Transport and storage (H), their level of carbon intensity decreased from 2019 to 2020. However, Construction (F) is the industry with the highest decline of carbon emissions from 2019 to 2020 among all the industries. This is expected as these industries experienced both negative supply and demand shocks during the pandemic from already being

carbon intensive. Repeatedly, the more administrative driven industry's average level of carbon intensity is almost relatively constant except from industry Arts, entertainment and recreation (R). This is also expected since their level of carbon intensity is not mainly derived from their own operations and products.

Table 6: Average CO2 intensity (kg/€) by year

Industry (code)	Year		N.Obs.
	2019	2020	
Agriculture, forestry and fishing (A)	0.407	0.396	81
Mining and quarrying (B)	0.607	0.703	77
Manufacturing (C)	0.439	0.429	86
Electricity, gas, steam and air conditioning supply (D)	3.183	2.785	85
Water supply, sewage, waste management and remediation activities (E)	0.301	0.286	83
Construction (F)	0.786	0.074	87
Wholesale and retail trade (G)	0.043	0.043	85
Transporting and storage (H)	0.953	0.833	86
Accommodation and food service activities (I)	0.041	0.064	84
Information and communication (J)	0.012	0.011	86
Financial and insurance activities (K)	0.122	0.121	60
Real estate activities (L)	0.005	0.005	79
Professional, scientific and technical activities (M)	0.019	0.018	84
Administrative and support activities (N)	0.032	0.033	84
Public administration and defence (O)	0.038	0.035	50
Education (P)	0.015	0.014	80
Human health and social work activities (Q)	0.021	0.020	84
Arts, entertainment and recreation (R)	0.045	0.052	85
Other activities (S)	0.522	0.534	86
<b>Total</b>	<b>7.591</b>	<b>6.456</b>	<b>1532</b>

Bank lending behaviors with country-specific characteristics to more polluted industries, like industry Electricity, gas, steam and air conditioning supply (D), could be affected by the heterogeneity of primary source of energy used across countries but also the size of the economy. It is therefore important to capture the banks' exposure to different industries in relation to where they are located. Figure 5 ascertain that some banks direct their larger volume

of loans to more emitting industries depending on their regional location. Particularly, it displays the level of carbon intensity in each country sorted by the country's average amount of loans across the industries. Once more, I present the average volume of loans transformed into natural logs to diminish the size of the variable. The average is a favorable way of interconnecting the amount of loans across countries with different levels of industry carbon dependencies, this in turn means that the number of observations is the same in figure 5 for each country.

Among the high emitting countries Cyprus together with Bulgaria are the highest contributors of carbon intensity in industry Electricity, gas, steam and air conditioning supply (D). This should not be too surprising as e.g., Cyprus has, throughout the last decade, increased their GHG emissions in the same industry (EEA, 2022). Germany was the largest consumer of natural gas in Europe 2019 representing 25% of the country's total primary energy consumption (EIA, 2020). Together with Poland and the United Kingdom, Germany contributed with 59,5% of total GHG emissions in the energy industry 2020 (EEA, 2022). Regarding Italy with approximately the same level of carbon intensity in the same industry as Germany have a lower volume of reported bank loans, which could indicate the funding of less polluting industries to less carbon sensitive industries. The commonality and intensity of volume of loans at around 1 million € also corroborates with the results in figure 1 which in turn reflects the spread in the dataset. Noteworthy to mention are the low shares of carbon intensity levels of industry Electricity, gas, steam and air conditioning supply (D) in France. In the EU's annual GHG inventory report compiled by the EEA (2022) the low share stems from the country's use of nuclear and hydro energy for power formation. Therefore, the country-specific dependencies use of power source is appropriate to consider. In addition, Article 173 of France's Law on Energy Transition for Green Growth, adopted in August 2015, enacted new climate risk reporting requirements for credit institutions and investors in the country (Altunbas et.al., 2021).

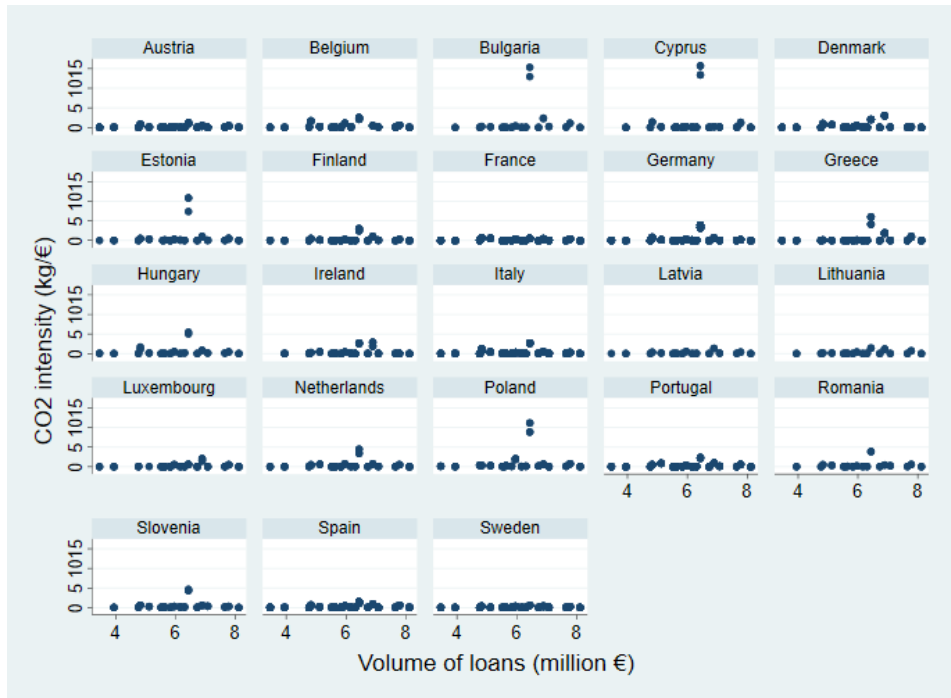


Figure 5: CO2 intensity (kg/€) and volume of loans (million €) by country

Throughout the latest decade EU countries have reduced their GHG emissions mainly sourced from the effects linked to the COVID-19 pandemic but also the larger use of renewable energy such as biofuels, wind, and solar. They have also improved their level of energy efficiency and the use of less carbon intensive fossil fuels (e.g., the coal consumption was three times higher in 1990 as opposed to 2020) (EEA, 2022). This transition among the EU-countries could potentially have an effect in capturing the variations of carbon risk among the countries.

### 3.2 Control Variables

To separate the effects that carbon intensity has on bank lending I include a set of control variables to remove the part of the relationship between loans and carbon intensity that is included in the error term. This is to ensure that the level of carbon intensity should affect bank lending and not the converse. It is rational to expect this assumption to hold as the level of carbon intensity is not driven by bank lending concerns (Altunbas et.al., 2021).

The control variables are sorted as industry specific and bank specific and are cited in parenthesis based on previous literature. I have limited these variables to the ones used by earlier literature subject to the data and its availability. Nevertheless, I have listed the control variables here starting with the ones being bank specific<sup>8</sup>:

$\ln(BankSize_{it}) = \ln(\text{bank size})$ , measured as the natural log of total assets for bank  $i$  in year  $t$  (Altunbas et.al., 2021; Benincasa et.al., 2022). Since the data on total assets covers larger ranges of values, the natural logarithms are used to diminish the broad range to a workable size. Earlier studies underline that the interconnection between the size of a bank and a business typically have a positive relationship; that smaller banks tends to allocate a higher subset of their loans to a smaller business than to a large business. However, larger banks typically charge smaller businesses with reduced interest rates and as a rule require less collateral from them (Mkhaiber & Werner, 2020).

$NPL_{it}$  = non-performing loans (NPL) ratio, measured as NPL to total loans for bank  $i$  and year  $t$ . This type of loan is measured as borrowed money whose scheduled payments have not yet been made by the debtor. In the literature, the NPL-ratio is a measure of default risk, thus a higher ratio is an indicator of poor credit quality for banks (Altunbas et.al., 2021). However, meaningful to state is that it could conversely be true that the same less creditworthy banks could be less risk averse by other characteristics that are unobservable.

$EMP_{jt}$  = employment growth, measured in thousands of employees in industry  $j$  and year  $t$ .  
On top of this unit of measure I calculate the number of thousand employees in industry  $j$  in

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<sup>8</sup> More details on unit of measure and data sources are found in table 1 in section 3

time  $t$  less employment in  $t-5$  to employment in  $t-5$ . Therefore, the unit of measure is in percentage. To capture the dynamism and the direction of change the measure of growth was considered which can be used as a proxy for the need of funding by a particular industry and therefore the demand of loans. Conversely, to the above-mentioned interconnection between bank size and firm size, the size of the firm in turn has explanatory power determining the volume of granted loans (Benmelech et.al., 2011).

$GO_{jt}$  = gross output (GO), measured in volume of gross output at current prices in national currencies in industry  $j$  and year  $t$  as an indicator of industry size through its total sales from production throughout the supply chain. The variable is a broader measure of economic activity as it adds sales and revenues at all stages of the production. Therefore, it is complementary to Gross Domestic Product (GDP) which only measures the value of all final goods and services. The macro measure has been used in growth accounting for industries (Jorgenson et.al., 2006). As part of one of the research framework programs, the EC has supported to update the EU KLEMS productivity database in collaboration with the LUISS University Rome (EC, 2022). The EU KLEMS dataset only provides GO data until 2019, therefore I contribute with calculations with existing data to get a view of the relative share and importance of an industry in a specific country. To reflect the relative size of the industry in a specific country I divide the average GO of a specific industry between 2013-2019 and 2014-2020 by the sum of the total average across all industries for each industry in a particular country. Then I use this as a measure for the relative importance of a specific industry. By way of estimating the relative size of a specific industry, the OECD (2021) has similarly used the relative market share metric to get a sense of the industry's position as a potential explanation for the existence of relatively high amount of loans granted to this industry compared to its competitors.

## 4 Methodology

Using a panel regression setup, I want to estimate the variation of bank loans to measure the transition risk in more polluting industries. I also want to see if the allocation of loans has averted from less carbon intensive industries to more carbon intensive industries. To do so the empirical environment centers around the COVID-19 outbreak as a shock that raises banks' level of distress. There is a sparse number of ways of going about the selection of model even within the climate finance literature, where some capture the effects better than others. For firmness reassuring consistency, I use the Altunbas et.al. (2021) approach together with other cited literature in section 2.

### 4.1 Model Selection

Even though the methodology on carbon intensity and its implications on bank lending is limited, previous studies explore the effect by using panel data methods. The method makes it possible to exploit the interconnection between carbon intensity and the volume of loans before and after the COVID-19. In an attempt to ascertain whether EU banks reallocate their lending to more carbon intensive industries after the first COVID-19 outbreak I specify the following model in equation (2).

$$\ln(Y_{ijt}) = \alpha_i + \gamma_j + \beta_1 CI_j + \beta_2 PostOutbreak_t + \beta_3 CI_j \times PostOutbreak_t + \beta_4 X_{it} + \beta_5 Z_{jt} + \varepsilon_{ijt} \quad (2)$$

In the equation,  $i$  is the reporting bank, and  $j$  the borrowing industry in time  $t$ .  $Y_{ijt}$  is the natural log of the dependent variable volume of loans from bank  $i$  to industry  $j$  in time  $t$ .  $CI_j$  is the independent variable which is the relative measure of the total level emissions labeled as carbon intensity, here an indicator of transition risk (carbon risk).  $PostOutbreak_t$  is a binary dummy variable which takes the value 1 after 2019, otherwise 0.  $X_{it}$  is a vector of the bank-specific control variables bank size and the NPL-ratio.  $Z_{jt}$  is a vector of the industry-specific control variables employment growth and gross output. The control variables are used to capture cross-bank and cross-firm heterogeneity over time which can affect the volume of loans from a bank. Finally,  $\varepsilon_{ijt}$  is the error term. Our coefficient of interest is  $\beta_3$  as it represents the average difference in a bank's volume of granted loans to polluting and non-polluting industries after the COVID-19 outbreak and answers the first research question.  $\beta_1$  gives the interpretation on the results of the second research question, i.e., if lending outcomes are related to carbon risk in general.

To absorb the identification, I also include fixed effects.  $\alpha_i$  represents the bank fixed effects to govern for unobservable time-invariant bank-characteristics that can affect bank lending. Similarly,  $\gamma_j$  is the industry fixed effects to take unobservable heterogeneity in the metrics across industries. Furthermore, robust standard errors are used to tackle the earlier indications of higher spreads among the predictors<sup>9</sup>. Additionally, they are clustered at the industry level<sup>10</sup>.

## 5 Results

In this section, I begin to present the main results of this study followed by a robustness check. First, I analyze the first research question, i.e., if the borrowing outcome changed for greener industries due to the COVID-19 pandemic. Then I examine the second research question, namely if lending outcomes in general are related to carbon risk. In addition, I discuss the limitations in this study.

### 5.1 Empirical Results

This section discusses the empirical results for the panel regression analysis based on the baseline equation (2). Columns 1-6 of table 7 reports the results based on the same equation. The entire set of results are presented with the inclusion of several combinations of fixed effects and control variables. The R-square are reported as a general measure of goodness of fit<sup>11</sup>.

Column 1 of table 7 shows that when carbon intensity of an industry increases this industry obtain less volume of loans on average. The effect is statistically significant. Thus, lending outcomes seems to be related to carbon risk in general within the EU. In column 2 carbon intensity is still significant where the post outbreak dummy variable indicates that the amount

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<sup>9</sup> I tested the standard errors for heteroskedasticity using the Breusch-Pagan test rejecting the null hypothesis to which states that there is constant variance among the residuals (they are homoscedastic).

<sup>10</sup> The clustering is a way of allowing the residuals within each industry to be dependant on eachother by assuming that they are random across industries.

<sup>11</sup> However, for panel data models the R-square measure is rather less relevant. Therefore, I have used the Wald-test rejecting the null hypothesis to which states that the independent variables jointly have less explanatory power than individually.

of loans decreased after 2019, however not statistically significant. In comparison column 3 indicates that the amount of loans to carbon intensive industries is lower after the COVID-19 outbreak and is also statistically significant. Thus, lending outcomes after the pandemic outbreak to greener industries does not seem to have been affected. Moreover, in columns 4-5 I include bank-specific (column 4) and industry-specific (column 5) controls that could affect credit. The significance level slightly decreases for the interaction term (CI\*PostOutbreak) when I include these characteristics. In column 6 I exclude the bank and industry fixed effects. The results show the time-invariant dependence of the variables as they lose their statistical significance as opposed to the other models. Moreover, the post outbreak dummy variable captures the relationship when the separation of bank and industry fixed effects are excluded.

Regarding the control variables, it can be observed that the NPL-ratio is displayed with a positive coefficient and statistically significant coefficient, stating that banks with a higher number of NPLs increase their amount of loans. In addition, bank size gives a less intuitive result with a negative coefficient. In this setting, the volume of loans decreases on average when the bank size increases. As earlier mentioned, structural relationships among the variables could be a possible explanation of the changed signs due the implications of the COVID-19 pandemic. One potential explanation to this negative relationship could be that smaller banks have more consistent relationships with its regional customers as opposed to larger less geographically spread banks. During economic distress the sustained relationships among smaller businesses, with smaller banks as explained in section 3, might have had a larger effect as it was mainly small-medium-enterprises (SME's) that were severely affected by the liquidity crunch. Similarly, employment growth and gross output have negative coefficients which could, in turn, have been affected by the structural changes among the relationship between the variables. Indeed, production decreased during the pandemic for many industries, but influx of credit from governments changed the circumstances.

Overall, I interpret these results as showing that the recent effects of the pandemic, did not change the borrowing outcomes for less polluting industries after the first outbreak. Additionally, lending outcomes in general are subject to carbon risk due to the negative effect that carbon intensity has on lending (Altunbas et.al., 2021; Jung et.al., 2018; Park & Kim, 2020), even though demand effects are not perfectly captured.

Table 7: CO2 intensity on bank lending

Variables	(1) ln(Y)	(2) ln(Y)	(3) ln(Y)	(4) ln(Y)	(5) ln(Y)	(6) ln(Y)
CI	-0.054* (0.027)	-0.057* (0.030)	-0.093*** (0.025)	-0.087*** (0.025)	-0.141*** (0.034)	-0.002 (0.071)
PostOutbreak		-0.007 (0.023)	0.000 (0.025)	-0.130 (0.191)	-0.023 (0.036)	4.687*** (0.279)
CI*PostOutbreak			-0.025*** (0.008)	-0.023** (0.008)	-0.024** (0.009)	-0.002 (0.011)
ln(BankSize)				-0.021 (0.029)		0.688*** (0.041)
NPL				0.008*** (0.002)		0.011*** (0.003)
EMP					-0.940 (0.657)	-0.695 (0.526)
GO					-0.058 (0.080)	0.965 (0.768)
Constant	6.172*** (0.009)	6.177*** (0.011)	6.189*** (0.015)	6.364*** (0.135)	6.301*** (0.056)	-1.871*** (0.330)
Observations	3,064	3,064	3,064	3,064	3,064	3,064
R-squared	0.000	0.001	0.002	0.005	0.050	0.007
Bank FE	YES	YES	YES	YES	YES	NO
Industry FE	YES	YES	YES	YES	YES	NO
Cluster	industry	industry	industry	industry	industry	industry

Note: *CI* is computed as total carbon emissions in a year divided by the gross value added from an industry. *PostOutbreak* is a dummy variable which takes a value of 1 after 2019, 0 otherwise. *ln(BankSize)* is the natural log of a bank's total assets. *NPL* is the ratio of non-performing loans to total gross loans. *EMP* is the employment growth between year *t* and *t-5* from an industry. *GO* is the relative share of an industry's gross output. Robust standard errors are in the parentheses. \*\*\* $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

## 5.2 Robustness

As a robustness check I included a cut-off for the carbon intensity levels in table 8. Specifically, I separate the industries that are more polluted with those that are less polluted. This allows me to control for non-linearities in carbon intensity levels subject to the amount of loans and to reassure the negative interconnection between volume of loans and carbon intensity. In column 1 the results from the industries with carbon intensity levels above or equal to the average carbon intensity level are displayed. The coefficient for carbon intensity is still significantly negative similar to the results in table 7 from the baseline regression. The negative interaction term in the same column also underline that the amount of loans was lower after the first COVID-19 outbreak, however not significant. In column 2 the results from the industries with carbon intensity levels under or equal to the average carbon intensity level is presented with a higher level of significance for carbon intensity. The interaction term is however not significant.

Table 8: Robustness Check

Variables	Over Average (1) ln(Y)	Under Average (2) ln(Y)
CI	-0.190** (0.072)	-0.410*** (0.108)
PostOutbreak	-0.114 (0.213)	-0.352 (0.297)
CI*PostOutbreak	-0.012 (0.012)	-0.040 (0.046)
ln(BankSize)	-0.003 (0.034)	-0.058 (0.043)
NPL	0.007 (0.004)	0.011** (0.002)
EMP	-1.499 (0.949)	-0.272** (0.093)
GO	-0.272 (0.341)	-0.057* (0.026)
Constant	7.385*** (0.349)	5.902*** (0.490)
Observations	1,520	1,544
R-squared	0.130	0.016
Bank FE	YES	YES
Industry FE	YES	YES
Cluster	industry	industry

*Note:* *CI* is computed as total carbon emissions in a year divided by the gross value added from an industry. *PostOutbreak* is a dummy variable which takes a value of 1 after 2019, 0 otherwise. *ln(BankSize)* is the natural log of a bank's total assets. *NPL* is the ratio of non-performing loans to total gross loans. *EMP* is the employment growth between year *t* and *t-5* from an industry. *GO* is the relative share of an industry's gross output. Robust standard errors are in the parentheses. \*\*\* $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$ .

### 5.3 Limitations

The analysis of the discrepancies at the country level appears how results can be affected by which countries the sample includes. How to go about measuring transition risk can possibly explain some of the divisions in the literature which stems from the accessibility of the different scopes of carbon emissions that industries report and which unit of measure that is more appropriate. In addition, the ability to capture demand of loans across industries is highly associated with more exact industry-specific characteristics. However, this thesis has not been able to fully replicate the exact method and data of earlier related literature due to the access of more granular data over a larger time frame. There are several ways to progress the analysis if

newer and more industry and bank specific data could be obtained on the bank lending of more banks. Additionally, more control variables could have been obtained such as liquidity and capitalization and dynamic changes within industries such as measurements for industry growth.

## **6 Conclusion**

This thesis aims to provide a closer look at the relationship between the volume of loans and the level of carbon intensity to capture the potential transition risk that banks are exposed to in Europe. It also tried look at the effects of COVID-19 and its implications on green bank lending to non-polluting industries.

Since earlier literature is significantly scarce on the effects of the pandemic on green bank lending, I dissect the analysis separating the transition risk between 2019 and 2020. A closer look at the coefficients showed that transition risk, measured as carbon risk, is present in bank lending in general. In addition, they showed that lending outcomes in general are related to carbon risk after the first COVID-19 outbreak. Therefore, the reallocation of credit to browner industries after the COVID-19 cannot be proved to be present in this study.

The findings of the relationship between carbon intensity and bank lending provide some evidence that we should continue investigating the topic further. As climate reporting will be mandated by financial institutions in the near future, the risk and opportunities that climate-related risks pose will be a core mechanism of a business. Therefore, with or without economics distress, the maintenance of sustaining environmental resiliency is a core metric when taking the temperature on the resiliency of a financial institution.

### **6.1 Further Research**

One of the main limitations in this study is the data availability and lack of methodology that encounters climate finance in general. In the preceding years the EBA will extend their dataset on banks' lending levels to specific industries. This could increase variability in the dataset being one concern when working with panel data.

Nevertheless, it would be interesting to compare two separate periods before and after the COVID-19 pandemic over a larger time frame including more observations.

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## Appendix

Table A1: NACE Rev.2 industry (code)

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Agriculture, forestry and fishing (A)
Mining and quarrying (B)
Manufacturing (C)
Electricity, gas, steam and air conditioning supply (D)
Water supply, sewerage, waste management and remediation activities (E)
Construction (F)
Wholesale and retail trade (G)
Transport and storage (H)
Accommodation and food service activities (I)
Information and communication (J)
Financial and insurance activities (K)
Real estate activities (L)
Professional, scientific and technical activities (M)
Administrative and support service activities (N)
Public administration and defense, compulsory social security (O)
Education (P)
Human health services and social work activities (Q)
Arts, entertainment and recreation (R)
Other services (S)

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Table A2: Banks

1 Aareal Bank	36 Deutsche Pfandbriefbank	65 Norddeutsche Landesbank Girozentrale
2 Abanca Corporacion Bancaria	37 DZ BANK Deutsche Zentral-Genossenschaftsbank, Frankfurt am Main	66 Nordea Bank
3 ABN AMRO Bank	38 Erste Group Bank	67 Nova Ljubljanska Banka d.d., Ljubljana
4 AIB Group	39 Erwerbgesellschaft der S-Finanzgruppe mbH & Co. KG	68 Nykredit Realkredit
5 Akciju sabiedriba "Citadele banka"	40 Eurobank Ergasias	69 OP Osuuskunta
6 Akcine bendrove Šiaulių bankas	41 First Investment Bank	70 OTP Bank Nyrt.
7 Alpha Bank	42 Groupe BPCE	71 Piraeus Bank
8 AXA Bank Belgium	43 Groupe Crédit Agricole	72 Powszechna Kasa Oszczedności Bank Polski
9 Banca Monte dei Paschi di Siena	44 Hamburg Commercial Bank	73 Precision Capital
10 Banca Popolare di Sondrio, Società Cooperativa per Azioni	45 HASPA Finanzholding	74 Raiffeisen Bank International
11 Banca Transilvania	46 Hellenic Bank	75 Raiffeisenbankengruppe OÖ Verbund eGen
12 Banco Bilbao Vizcaya Argentaria	47 Ibercaja Banco	76 RCI Banque
13 Banco BPM	48 ICCREA Banca – Istituto Centrale del Credito Cooperativo	77 SBAB Bank
14 Banco Comercial Português	49 ING Groep N.V.	78 Sberbank Europe
15 Banco de Crédito Social Cooperativo	50 Intesa Sanpaolo	79 SFIL
16 Banco de Sabadell	51 Investeringsmaatschappij Argenta	80 Skandinaviska Enskilda Banken
17 Banco Santander	52 Jyske Bank	81 Société générale
18 Bank of Cyprus Holdings	53 KBC Groep	82 State Street Europe Holdings Germany S.a.r.l. & Co. KG
19 Bank of Ireland Group	54 Kommuninvest	83 Svenska Handelsbanken
20 Bank Polska Kasa Opieki	55 Kuntarahoitus Oyj	84 Swedbank
21 Bankinter	56 Kutxabank	85 Sydbank
22 Banque Internationale à Luxembourg	57 La Banque Postale	86 Unicaja Banco
23 BAWAG Group	58 Landesbank Baden-Württemberg	87 UniCredit
24 Bayerische Landesbank	59 Landesbank Hessen-Thüringen Girozentrale	88 Volksbanken Verbund
25 Belfius Bank	60 LSF Nani Investments	89 Volkswagen Bank Gesellschaft mit beschränkter Haftung
26 BNP Paribas	61 Luminor Holding AS	
27 Caixa Geral de Depósitos	62 Länsförsäkringar Bank	
28 CaixaBank	63 Mediobanca – Banca di Credito Finanziario	
29 Citibank Holdings Ireland Limited	64 National Bank of Greece	
30 COMMERZBANK		
31 Confédération Nationale du Crédit Mutuel		
32 Credito Emiliano Holding		
33 Danske Bank		
34 DekaBank Deutsche Girozentrale		
35 Deutsche Bank		

