CHAPTER 1

The Market Reaction to Climate Risk: Evidence from the European Banking Industry

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1.1 Introduction

Nowadays, discussion on climate change is a widespread issue in the world debate. The mean global temperature of the Earth has seen an increase of 0.87 °C since 1900 according to Intergovernmental Panel on Climate Change (IPCC, 2014). At this rate, if detected emission levels since 1950

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continue to rise, global warming is likely to reach 1.5 °C above pre-industrial levels between 2030 and 2052 (IPCC, 2018). The progressive increase in global warming is destined to cause unstoppable catastrophes, provoking a significant impact not only for humankind, but also for the ecosystem and natural resources. Scientific articles by the IPCC reveal that one of the causes of global temperature rise is the continuous increasing concentration of greenhouse gas emission in the atmosphere (IPCC, 2014).

A rise of the greenhouse gases concentrations in the air produces a significant climate forcing, or warming effect. Over the period that goes from 1990 to 2019, the global warming effect provoked by human activities' greenhouse gases increased by almost 45% (Environmental Protection Agency, 2021). Therefore, it is plausible to believe that one of the reasons that the planet heats up is largely due to anthropogenic activities (human activities), which is considered the biggest contributor to climate change (U.S. Global Change Research Program, 2021). In order to reduce the global warming effect, one of the main recommendations that scientists suggest is to lower greenhouse gas emissions, encouraging the transition to a low-carbon economy (IPCC, 2014).

A first step toward the abatement of gas emissions was made by the Paris Agreement in 2015, an international treaty where most of the countries representing 97% of worldwide greenhouse emissions, agreed to keep global warming below 2 °C, preferably at 1.5 °C, compared to pre-industrial levels. The Paris Agreement, which represents a real milestone for combating climate change, raised awareness among policymakers, academics, financial institutions and companies regarding the variability of weather's temperatures as a future challenge and concrete threat in the next decades (ESRB, 2016). The Paris treaty can be considered the first climate deal that has contributed to rethinking a new way of doing business by favoring the transition from an economy with a high greenhouse gas emission to a low-fossil-fuel-economy (LFFE) or commonly called low-carbon economy.

One of the three long-term goal commitment of the agreement, indeed, was to "making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development" (Paris Agreement, Article 2.1c).[1] In this context, the European Union has taken

[1] https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

giant steps in reducing its greenhouse gas (GHG) emissions. The latest statistics show that GHG emissions in Europe have decreased sharply in the last years, reaching 24% below 1990 levels, which is expected to be 31% in 2020 (European Environment Agency, 2021). This is attributable not only to the transition of the use of fossil fuels to a clean energy source (such as renewable resources), which has led to structural changes in European economies, but also to the implementation of EU and national policies and regulations. On 7 March 2018, indeed, the European Commission launched one of the most important action plans for financing sustainable growth, facilitating the transition to a low-carbon economy by increasing investments in green projects and promoting a new financial sustainability strategy in the long-term.

The policy is well-known under the name of Sustainable Finance Action Plan, whose ultimate goal is to shape the financial system in a way to support the sustainable transition. The Action Plan recommends three key objectives to be taken at European level. The first purpose is to redirect cash and capital flows toward sustainable investments shifting away from those activities and sectors that make intensive use of fossil fuels that encourage the global warming issue. The second goal is to manage financial risks deriving from climate change, resource depletion and environmental degradation. The third aim is to enhance the transparency and long-termism in each financial activity as to realize sustainable and inclusive growth. These three objectives are divided into ten actions which include initiatives on various fronts with the aim of involving all the players in the financial system in reducing information asymmetries related to climate risks, thus improving the allocation of capital to sustainable investments. In detail, the scope of the action plan encourages to better classify economic activities along with an appropriate EU sustainable taxonomy, clarifying to all market participants, such as asset managers, pension funds, and European banks their responsibilities regarding sustainability. This allows the possibility to assess the feasibility of including the risks associated with the climate and other environmental factors in the risk management policies.[2]

[2] European Commission (2018), communication from the Commission to the European Parliament, the European Council, the Council, the European Central Bank, the European Economic and Social Committee, and the Committee of the Regions Action Plan: Financing Sustainable Growth. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0097&from=EN.

In this view, financial institutions are not exempt in increasing their transparency only on the integrated sustainability in investment decisions levels, but also in reference to their own activities. Indeed, banks contribute to GHG emissions in two ways: indirectly and directly.

On the first hand, banks help to raise global warming through the financing of companies' projects and the implementation of firms' business plans which, in turn, boost GHG emissions. Even nowadays, banks continue to play a major role as principal financiers of the most polluting sectors, such as coal, oil, and gas industry, delaying the transition from an economy with a high use of coal and fossil fuel-based to an efficient renewable and sustainable-based economy. However, at the same time, financial institutions play an important role in managing climate change, by helping the overall financial system to move toward a low-carbon economy (Bank of England, 2021; European Central Bank, 2021; FED, 2021).

On the other hand, banks, such as all companies, generate greenhouse gases (GHG) directly through their activities. According to the European Central Bank report on institutions' climate-related and environmental risk disclosures (2020),[3] only 8% of all financial institutions report the percentage of carbon-related assets in each portfolio, 14% the carbon footprint of one or more portfolios where the main metrics reported are referred to Scope 1, Scope 2, and Scope 3 carbon emissions.

Following the Greenhouse Gas Protocol standards, which determines the criteria for measuring carbon firm issue, carbon footprint for each entity could be grouped into three macro-classes, defined by the GHG Protocol Scope 1, Scope 2, and Scope 3. This label categorization is necessary to show which emission sources are under the direct control of the company, and such under the control of other third-parties' organizations, in order to distinguish between direct and indirect emission sources.

From the need to mitigate climate change, carbon footprints and disclosure metrics are thus considered important tools not only for the safeguard of the environment, but also for investors in their investment decision strategies (Krueger et al., 2020). Indeed, there is a growing

[3] ECB (2020), available at https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.ecbreportinstitutionsclimaterelatedenvironmentalriskdisclosures202011~e8e2ad20f6.en.pdf.

strand of literature that certifies a strong correlation between the intensity of carbon emission and financial performances. Some authors claim for positive relationship, meanwhile others state the opposite (Boiral et al., 2012; Gallego-Álvarez et al., 2015; Hatakeda et al., 2012; Ziegler et al., 2007).

In this context, it is, therefore, essential that carbon emissions of firms are constantly monitored by investors in order to obtain superior returns (Siddique et al., 2021). At the same time, investors should consider in their investment decision process also the effects of environmental regulation. According to Krueger et al. (2020), a great percentage of financial institutions declare that climate risks related to new regulations are already in place. Therefore, depending on the stringency of the regulation, investors would demand superior returns for those firms that have higher environmental regulation's risk (Testa et al., 2011).

By applying a panel data analysis over 45 listed European banks, spanning from the period that goes from 2014 to 2020, we find that before the introduction of the EU Sustainable Finance Action Plan, investors required higher compensation for those financial institutions that included carbon-intensive activities, as a hedge against climate risk. After the launching of the European sustainable guideline, the correlation between banks' carbon emissions and returns dropped, leading investors to initiate the so-called portfolio decarbonization process. Our work is organized as follows. Section 1.2 reviews the academic literature about carbon premium and specifies our research questions. Section 1.3 describes our sample and data sources, introducing the variables used and the specification model. Section 1.4 comments our main results meanwhile Sect. 1.5 concludes.

1.2 Research Hypothesis and Related Literature

The problem of climate change leaves neither investors nor companies indifferent. From this point of view, investors can no longer stand by and ignore the impact that global climate change has on their portfolios. The emerging economic literature offers both theoretical and empirical proofs that financial actors should take carbon-transition risk into account in their investment decision process (Ilhan et al., 2021; Krueger et al., 2020). In this view, investors will seek a greater economic return, depending on carbon risks and opportunities. The literature

about the relationship between carbon emissions and corporate financial performance is still scant, and the empirical evidence offers different and ambiguous results. For example, some authors claim for a "carbon premium" (Karydas & Xepapadeas, 2019; Pindyck, 2013; Tol, 2008). Bolton and Kacperczyk (2020) discovered that the carbon emission impacts positively and significantly the US firms' stock returns in both direct and indirect emissions. Again, Bolton and Kacperczyk (2021b) estimated a market-based carbon premium in a cross section where they take in consideration almost 80 countries with 14,400 firms analyzed. They found out that greater returns are related with higher levels and growth rates of carbon emissions mostly in all sectors suggesting the so-called carbon premium, i.e., higher stock price returns are retained to be for all firms that are considered carbon inefficient.

In other words, investors would require higher compensation for those firms that are highly exposed to climate change risks. Along the same idea Oestreich and Tsiakas (2015) provided an empirical investigation about the consequence of the European Union's Emissions Trading Scheme on German stock returns. They noticed that those firms in charge of free carbon emission allowances presented higher returns in relation to firms that did not. As a result, they found a presence of "carbon premium" mainly clarified by greater cash flows because of the free carbon emission allowances. Weitzman (2009) and Litterman (2013) claim that investors demand higher returns to polluting companies as compensation for climate risk-taking, as a result of climate change. Lastly, Monasterolo and De Angelis (2020) found out that after the Paris Agreement signed in 2015, investors require higher compensation premia for those assets which are involved with carbon-intensive sectors.

However, there are new studies that find that the nature of the relationship between carbon emissions and financial performance is not always positive (Alvarez, 2012; Gallego-Álvarez et al., 2014). Indeed, a different strand of literature suggests a negative relationship between firms' carbon emission and stock returns (Delmas et al., 2015; Galema et al., 2008; Heinkel et al., 2001). For example, Matsumura et al. (2014) show that firms' value is linked with levels emission in negative way, i.e., displaying a decrease in terms of value for each higher level of carbon released. Again, Busch and Hoffmann (2011) report an inverse relationship between carbon emission intensity and different financial performance measures, such as Tobin's Q. Consistent with this result is the work of Aggarwal and Dow (2013), where claim for a negative correlation.

Other studies display that stock market downweighs firms that act badly in environmental terms in favor of those which perform well (Bernardini et al., 2021; Ferrell et al., 2016; Trinks et al., 2020).

Regardless of the nature of the relationship, the debate about this relationship has been stimulated mainly by the tightening of environmental regulations, increasing investors' environmental perception and awareness. A study conducted by Hsu et al. (2020) demonstrated that firms which pollute the most are the more vulnerable to environmental regulation' risks. This is in line with the vision of Bolton and Kacperczyk (2020), where it is stated that firms that release disproportionately levels of CO2 emissions are more exposed to regulatory interventions. According to Chapple et al. (2013) instead, good environmental performance eludes financial risks arisen by direct and indirect costs, such as increased regulatory intervention. Therefore, environmental regulatory and directive stringency affect stock prices and returns (Hong & Kacperczyk, 2009; Pastor & Veronesi, 2012).

Examining a sample of the 45 major listed European-zone banks over the period from 2014 to 2020, the aim of this study is to explore the relationship between European banks' carbon emissions and stock returns before and after the introduction of the EU Sustainable Finance Action Plan in 2018.

This work contributes to the strand of literature on the topic in several ways. Firstly, despite a number of studies have analyzed the impact of carbon emissions on non-financial firms' returns, ours is the first attempt that takes into consideration only the European banking industry. For this reason, this study is unique in its kind since there is no regression analysis in the literature that looks at the European banking sector. Secondly, this study contributes to the literature that analyses the effect of the EU Sustainable Finance Action Plan on the European banking industry emissions. Indeed, in this chapter, we investigate the impact of climate change-related policies on European banks' emissions. Thirdly, this work focuses on evaluating a bank's exposure to climate risks and on examining the investors' reaction. What is found out is that stock market participants take carbon emissions in consideration in their investment decisions, in view of the so-called portfolio decarbonization process, aimed at reducing GHG intensity by entering low-carbon activities stocks. Overall, the aim of this analysis enlightens the following two testable hypotheses:

Hypothesis (H1) Banks which include high-carbon activities have higher returns prior to the introduction of the EU Sustainable Finance Action Plan in 2018.

Starting from this point, our next consideration comes to light which brings us to specify the second hypothesis to be tested in our work:

Hypothesis (H2) After the introduction of the EU Sustainable Finance Action Plan in 2018, high-carbon-intensive banks have lower returns as a result of the European environmental guideline.

1.3 Sample Data and Methods

The list of sample entities refers to 45 listed European banks with a market capitalization higher than 1 billion of Euros with a time horizon that goes from 2014 to 2020. In total, European banks belong to 17 different countries. These are: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Holland, Hungary, Ireland, Italy, Norway, Portugal, Spain, Sweden, and lastly, UK. Officially, UK left Europe on 31 January 2020, but nevertheless, both sides agreed to keep many things the same until 31 December 2020, to allow enough time to agree to the terms of a new trade deal. In addition to that, the UK government reiterated its intention to maintain an equivalent regime to manage cross-border finance activities. So, the UK sustainable goal matches the ambition of the European Union's sustainable finance action plan through a series of package decisions being granted before the end of the transition period and beyond, in maintaining dialogue with the EU. The same goes for Norway, which, because of the Agreement on the European Economic Area (EEA), ensures the participation in the EU internal market. Table 1.1 reports the list of the European banks taken in consideration in our analysis.

Consistently with our purposes, our dependent variable is the weekly annualized stock bank return. As explanatory variables, we collect different selection of indicators that measures the strength of different business activities extrapolated from the bank balance sheet and income statement information from Thomson Reuters Eikon. Yearly data are acquired.

Table 1.1 European Banks sample

Bank name	*Country*
Aareal Bank AG	Germany
ABN AMRO	Holland
AIB Group plc	Ireland
Alpha Services and Holdings SA	Greece
Banca Monte dei Paschi di Siena SpA	Italy
Banco Bpm	Italy
Banco Comercial Portugues SA	Portugal
Banco de Sabadell	Spain
Bankinter	Spain
Barclays PLC	UK
BAWAG Group AG	Austria
BBVA	Spain
BNP Paribas	France
Bper Banca	Italy
Caixabank	Spain
Close Brothers Group PLC	UK
Commerzbank	Germany
Credit Agricole	France
Danske Bank A/S	Denmark
Deutsche Bank	Germany
Erste Bank	Austria
Eurobank Ergasias Services and Holdings SA	Greece
HSBC Holdings PLC	UK
ING Groep	Holland
Intesa	Italy
Jyske Bank A/S	Denmark
KBC Groep NV	Belgium
Komercni Banka as	Czech
Lloyds Banking Group PLC	UK
Mediobanca	Italy
National Bank of Greece SA	Greece
Natwest Group PLC	UK
Nordea Bank Abp	Finland
OTP Bank Nyrt	Hungary
Piraeus Financial Holdings SA	Greece
Raiffeisen Bank	Austria
Santander	Spain
Skandinaviska Enskilda Banken AB	Sweden
Société Générale	France
Sparebank 1 SR Bank ASA	Norway

(continued)

Table 1.1 (continued)

Bank name	*Country*
Standard Chartered PLC	UK
Svenska Handelsbanken AB	Sweden
Swedbank AB	Sweden
Sydbank A/S	Denmark
UniCredit	Italy

The table reports the list of the 45 European banks used in our sample. The sample period is 2014–2020

We include several bank-specific control variables to account for the bank performance. Following the work of Bolton and Kacperczyk (2021a), we consider Total Assets, Book to Market, Debt on Equity as proxies of size, valuation, and leverage ratio in our main regression. In addition to that, we take in account other financial metrics, such as Profit Margin, Loan to Deposit, and Capital Adequacy Ratio to account for profitability, liquidity, and solvency (European Banking Authority, 2021).[4]

In relation to our key independent variables, we include determinants of carbon emissions (Bolton & Kacperczyk, 2021a). Thomson Reuters Eikon database provides unique annual information for each bank-level carbon emission and related Greenhouse Gas emission (GHGs) for all over the sample period analyzed. Indeed, the databank accounts all three scopes of carbon emissions in units of tons of CO_2 emitted yearly.

The Scope 1 is linked to the direct GHG emissions from installations within the borders of the organization due to the use of fossil fuels and the emission of any greenhouse gas into the atmosphere. Direct emissions are, for example, the emissions deriving from the combustion of fossil fuels in heating systems; emissions due to the consumption of fuel for company vehicles; leaks of fluorinated greenhouse gases from air conditioning systems.

The Scope 2 is connected to indirect GHG emissions resulting from the production of electricity, heat, and steam imported and consumed by

[4] European Banking Authority (2020), Risk Dashboard, Data as of Q4 2020, available at https://www.eba.europa.eu/sites/default/documents/files/document_library/Risk%20Analysis%20and%20Data/Risk%20dashboard/Q4%202020/972092/EBA%20Dashboard%20-%20Q4%202020%20-%20footnote%20%281%29.pdf?retry=1.

the organization, as the importer is indirectly responsible for the emissions generated by the supplier for the production of the required energy. The Scope 3 is related to indirect emissions due to the company's activities. This class includes emission sources that are not controlled directly by the company, but whose emissions are indirectly due to company activity. Finally, a Dummy variable that represents the introduction of the Sustainable Finance Action Plan in 2018 is taken in consideration.

1.3.1 Variables and Univariate Analysis

Table 1.2 reports the main statistical features of the variables used in our regression analysis.

The definitions of the variables used are provided below.

- *Bank Returns* is computed as the annualized weekly percentage return on banks' shares over the period analyzed. Specifically, it represents the annualized weekly change in price of the sample banks' securities during the period 2014–2020. This ratio indicates the stock's ability to increase or lower the wealth of its shareholders.

Table 1.2 Descriptive statistics

	Obs.	*Mean*	*Std. Dev.*	*Min*	*Max*
Bank returns	315	−0.042	0.341	−0.996	2.559
Size	315	26.348	1.381	23.171	28.742
Book to market	315	1.803	1.787	0	20.164
Profit margin	315	0.149	0.266	−1.430	0.586
Loan to deposit	315	1.065	0.391	0.490	3.005
Debt on equity	315	1.749	2.475	−2.298	10.923
Capital adequacy ratio	315	0.181	0.036	0.104	0.318
Carbon scope 1	315	3.708	0.833	1.380	4.868
Carbon scope 2	315	4.296	0.964	1.259	5.816
Carbon scope 3	315	3.978	0.975	2.040	8.156
Dummy EU	315	0.428	0.495	0	1
Time trend	315	4	2.0031	1	7
Carbon Footprint 1 *x* Dummy EU	315	1.590	1.9132	0	4.8157
Carbon Footprint 2 *x* Dummy EU	315	1.8329	2.2033	0	5.6871
Carbon Footprint 3 *x* Dummy EU	315	1.6837	2.0257	0	5.0977

The table reports summary statistics (mean, medians, standard deviations, min, and max) of the variables used in regressions. The sample period is 2014–2020

Stock performance is usually measured by its fluctuations in price. Higher is the stock price of the bank, better is the performance, meanwhile a decrease in price is often referred to a poor performance (Bolton & Kacperczyk, 2021a).

- *Size* is computed as the natural logarithm of the banks' total assets at the end of the year in Euro. This metric is widely used as firm's factor, since it represents the total volume of business operations or, alternatively, the magnitude of the business activities. This ratio is fundamental in defining bank performance because of the theory of economies of scale, understood as the ability of the company to produce goods or deliver a service at lower cost (Cichello, 2005).
- *Market to Book* is a financial ratio that measures a company's market value relative to its current book value and is felt as an indicator to assess market's perception of a particular value's stock. In addition to that, the ratio reflects if a company's stock is overvalued or undervalued. This variable is one of the most important proxies used by investment advisors and fund managers to measure the value of a company. It is important for investors in their decision-making process, as they need to assess whether the investment is worthwhile (Pioh et al., 2018).
- *Profit Margin* which is one of the most popular profitability ratios to measure how much money the financial institution makes for each dollar of sales generated. The net profit margin is often calculated as the ratio of net income by sales. Both numbers are found on a bank's net income or profit-and-loss statement. Typically expressed as a percentage, profit margin is an important indicator since it represents the capability of a company or business activity to turn sales in profits (Fama & French, 2004).
- *Loan to Deposit* represents the liquidity metric and is expressed as the percentage of bank's total loans to its total deposit. This ratio represents the bank's strength to pay its debits when there is an excessive demand of customer' deposits withdraw. Generally, a lending financial institution that takes deposits should be aware to have a certain amount of liquidity to sustain its normal daily operations. If this ratio is too high, it means that bank lend too much of their deposits, incurring in liquidity shortage mainly in situation of unexpected contingencies. If the ratio is too low, it means that banks lend too few and might have less interest earnings on deposit income (Sari & Septiano, 2020).

- *Debt on Equity* is used to point out the company's financial leverage computed dividing company's total liabilities on shareholders equity. This ratio is very used in finance because it reveals at what percentage the company is financing its growth through its debt. A high Debt on Equity ratio is often referred to high risk, meaning that a company is financing aggressively its growth with debt (Bhandari, 1988).
- *Capital Adequacy Ratio* is a proxy of solvency measured by the ratio of bank's available capital on banks' risk-weighted credit exposure. This is an important indicator because it guarantees the efficiency of the financial system ensuring that banks have enough capital to absorb potential and future losses. A bank with high capital adequacy ratio is considered to have enough capital on reserve to withstand financial losses and unforeseen downturn. In turn, it means that the bank has enough capital available to be above the minimum requirements in terms of reserves (Barnor & Odonkor, 2012).
- *Carbon Scope 1* are the set of all direct emissions that belong to the organization and/are owned by the company. They refer to those greenhouse emissions released into the atmosphere as a consequence of a set of firm-level activities. This category includes all those fuels that produce greenhouses gas emissions that come from combustion (all vehicles owned or controlled by a firm), fugitive installations (leaks of fluorinated greenhouses gases from air conditions systems, heating systems), and industrial and on-site manufacturing process (factory fumes, chemical) (Busch & Lewandowski, 2018).
- *Carbon Scope 2* are all those indirect emissions that derive from the production and generation of purchased energy. Generally speaking, the electricity produced and consumed falls within the Scope 2 borders. In short, emissions are released by the production of the energy and eventually employed by the organization (Lewandowski, 2017).
- *Carbon Scope 3* refers to those indirect emissions that belong to the value chain and companies' business activities, including both upstream and downstream emissions. In short, this kind of scope is strictly linked to the company's operations. The GHG Protocol divides Scope 3 emissions into 15 categories: for this work the most relevant category refers to investments, which are mostly involved in financial institutions' processes. Investments include four main sub-classes, such as equity investments, debt investments, project

finance, managed investments, and client services (Hertwich & Wood, 2018).

- *Dummy EU*, which takes the value of 0 in 2014, 2015, 2016, and 2017, represents the EU Sustainable Finance Action Plan recognized in 2018. Therefore, the dummy takes the value of 1 in 2018, 2019, and 2020, the years in force of the Plan. We include the Sustainable Finance Action Plan as European stimulus to encourage a new sustainable financial strategy shifting away from highly intensive-fossil-fuel-economy and thus improving the allocation of capital to sustainable investments.
- *Time trend* or time index is defined as ordered set of natural numbers. In details 2014 = 1, 2015 = 2, 2016 = 3, 2017 = 4, 2018 = 5, 2019 = 6, 2020 = 7 and it measures the time span between observations. The slope of a time-trend line represents the growing of a variable.

Table 1.3 reports correlations between bank-specific control variables, carbon emissions and the European banks' return between 2014 and 2020.

The model specification utilized in this work is the panel fixed effect analysis, which allows to examine the relationship between banks' carbon emissions and performance. First, the F test statistic was performed ($F(44, 252) = 1.50$ and Prob > $F = 0.01$) to let us prefer panel-data regression over the pooled OLS model. The panel data methodology raises the power of empirical analysis, since it combines and mixes information from both cross-section dimensions and time, allowing a greater flexibility in modeling (Greene, 2005). After the F test, we performed the Hausman test as to decide between the fixed or random effects model. The Hausman test showed a statistic chi2(1) = 41.68, $P = 0.0012$ meaning that the fixed effect panel model best fits our data. At this point, we incorporate both year fixed effects, capturing unobservable factors which are time-variant and may influence banks' stock returns, and country fixed effects, in order to account for unobserved time-invariant heterogeneity across several countries. Robust standard errors are clustered at bank level. Individual time-trend variable is also included, so as to assume whether there is some permanent deterministic pattern across time. In definite, our panel-data regression is as follows:

Table 1.3 Correlation matrix

Correlation matrix	*Bank returns*	*Size*	*Book to market*	*Profit margin*	*Loan to deposit*	*Debt on equity*	*Capital ratio*	*Carbon scope 1*	*Carbon scope 2*	*Carbon scope 3*	*Dummy EU sust*	*Time trend*
Bank returns	1											
Size	0.001	1										
Book to market	−0.321	−0.052	1									
Profit margin	0.423	−0.094	−0.417	1								
Loan to deposit	0.121	−0.220	−0.202	0.335	1							
Debt on equity	0.089	−0.035	−0.181	0.212	0.869	1						
Capital Adequacy Ratio	0.095	0.041	−0.245	0.305	0.270	0.252	1					
Carbon Scope 1	−0.060	0.590	0.102	−0.247	−0.490	−0.387	−0.2686	1				
Carbon Scope 2	−0.008	0.574	0.017	−0.137	−0.365	−0.278	−0.035	0.607	1			
Carbon Scope 3	0.066	0.786	0.012	0.025	−0.222	−0.085	0.005	0.572	0.495	1		
Dummy EU	−0.134	0.023	0.206	0.072	−0.052	−0.148	0.157	0.011	−0.017	0.016	1	
Time Trend	−0.054	0.024	0.212	0.072	−0.069	−0.207	0.256	0.009	−0.025	0.006	0.866	1

$$
\begin{aligned}
RET_{i,t} = {} & a_0 + a_1 Carbon.Emiss(SCOPE1)_{i,t} \\
& + a_2 Carbon.Emiss(SCOPE2)_{i,t} + a_1 Carbon.Emiss(SCOPE3)_{i,t} \\
& + Dummy * Carbon.Emiss(SCOPE1)_{i,t} + Dummy * Carbon.Emiss(SCOPE2)_{i,t} \\
& + Dummy * Carbon.Emiss(SCOPE3)_{i,t} + a_3 Controls_{i,t-1} \\
& + \delta t + u_t + e_{i,t}
\end{aligned}
$$

1.4 Empirical Analysis and Results

Table 1.4 provides the results of the main econometric analysis. Consistently with our purposes, our dependent variable is the stock performance of the European banks. By using all three alternative key independent variables in terms of different kind of carbon emission scopes, the empirical analysis supports our hypotheses. We first find consistent evidence for a strong positive impact of our key interested variables on stock returns (Hypothesis 1) and, after the introduction of the Sustainable Action Plan in 2018, we found a negative impact (Hypothesis 2).

What turns out by the analysis conducted shows interesting results. The first explanatory variable statistically important with a negative sign is *Size* (Table 1.4, coefficient = −0.7501, significant at 1%). From a theoretical background, small firm theory conveys that small firms, i.e., those companies which has a small market capitalization, outperform large ones (Gan et al., 2013; Liu, 2006).

Thus, there is evidence that smaller banks have higher expected returns than larger ones, and this is also commonly known under the name of "size premium" (Banz, 1981; Van Dijk, 2011; Zakamulin, 2013).

The Market to Book ratio has a positive and statistically significant coefficient (Table 1.4, coefficient = 0.2273, significant at 1%). This is consistent with that line of research in the economic literature which explains that the market to book ratio has a significant power in describing the cross-sectional changes in stock returns (Asness et al., 2013; Diether et al., 2002; Fama & French, 2015; Hou & Robinson, 2006; Zhang, 2005).

The stock market attributes a higher value to companies which display more earnings power than their assets. It suggests that investors believe the company has excellent future prospects for growth, which in turn increases profits and returns.

Table 1.4 Regression results

	Bank returns
Size	−0.7501***
	(0.1729)
Market to book	0.2273***
	(0.0719)
Profit margin	0.5151***
	(0.927)
Loan to deposit	−0.077
	(0.2002)
Debt on equity	0.0100
	(0.0304)
Capital adequacy ratio	0.6236
	(1.0623)
Carbon scope 1	−0.0335
	(0.0838)
Carbon scope 2	−0.0524
	(0.0444)
Carbon scope 3	0.0961**
	(0.0518)
Dummy EU sustainable plan	1.3673***
	(0.1872)
Time trend	−0.2448***
	(0.0700)
Carbon Footprint 1*Dummy EU	−0.0715
	(0.0577)
Carbon Footprint 2*Dummy EU	0.9670
	(0.0473)
Carbon Footprint 3*Dummy EU	−0.1011***
	(0.0413)
_cons	19.3937
	(4.4349)
Observations	315
Banks	45
R-Squared	0.4332
Country FE	YES
Time FE	YES

The table reports the panel data fixed effect regression results. The sample period goes from 2014 to 2020

Note Standard errors are shown below coefficient estimates

P-values are shown below test statistics

*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$

With reference to Profit Margin coefficient (Table 1.4, coefficient = 0.5151, significant at 1%), there is a positive and significant effect on annualized weekly banks' returns.

This relationship should not be surprising since investors prefer companies that offer better profitability ratio, which is translated into higher company prices and, in turn, increases the overall stock returns. This relationship is widely demonstrated in the empirical literature (Allozi & Obeidat, 2016; Endri, 2018; Endri et al., 2019; Er & Vuran, 2012; Fathony et al., 2020; Nurhakim et al., 2016).Our dummy variable is positive and significant, meaning that the introduction of the EU influences the composition of listed banks' returns. The time-trend variable is statistically significant with a negative sign (Table 1.4, coefficient = −0.2448, significant at 1%), meaning that the dependent variable decreases over time, in line with our assumption.

The empirical findings show that, among our key interested independent variables, the Scope 3 emission carbon turns out to be statistically significant. This should not be surprising, since the emissions attributable to the financial and banking industry fall above all in the category of Scope 3: depending on the direction in which they direct their investments, financial operators can in fact increase or reduce their exposure to the fossil fuel sector. The empirical results indicate that, before the introduction of the sustainable guideline introduced by European Commission, banks' Scope 3 carbon emissions have a positive impact on stock returns (Table 1.4, coefficient = 0.0961, significant at 5%), which in turn supports our hypothesis (H1), which could be explained by the fact that banks that include high-carbon-intensive activities have higher carbon exposures (Bolton & Kacperczyk, 2021a, b; Litterman, 2013; Monasterolo & De Angelis, 2020; Weitzman, 2009). This phenomenon is called "carbon premium" (Bolton & Kacperczyk, 2020, 2021a, b; Hsu et al., 2020; Wen et al., 2020). It implies that stock market participants consider carbon emissions as a risk factor when assessing the companies' performance (Matsumura et al., 2014). As a result, investors would require higher compensation for the higher climate risk exposure of these financial institutions (Ilhan et al., 2021).

However, after the introduction of the EU Sustainable Finance Action Plan in 2018, the coefficient of carbon risk factor decreases over time ending up being significantly negative (Table 1.4, coefficient = −0.1011, significant at 1%). The coefficient interaction between the pre and post Sustainable Action Plan in terms of Scope carbon emission 3 is overall

negative ($\lambda = 0.0961 - 0.1011 << 0$). In definitive, the negative coefficient of Carbon Footprint 3*Dummy EU (−0.1011***) is really tiny and talking about of a reversal in the effect is really risky but, at the same time, there is a possible feeble indication that the European directive has in a way counterbalance the incentive of banks to pollute.

Indeed, results could indicate that European banks start to internalize the EU guidelines' information, and this could capture the attention of investors to move monetary flows away from polluting banks because of the EU sustainable structural shift.

In a certain sense, the market could rationally discount future cash flows of polluting industries after the European directive, hinting investors to migrate away from carbon-intensive business models. However, what is certain is that the increasing attention to sustainability issues may motivate market participants to allocate their capital to those banks that are environmental-friendly, prompting the decarbonization process, by divesting fossil fuel companies from portfolios (Galema et al., 2008; Henikel et al., 2001; Riedl & Smeets, 2017). This supports in a way our hypothesis (H2).

In sum, the results of this work suggest that there is an indication that pro-environmental EU directives may influence market participants to shift away from firms that include high-carbon-intensive activities (Hong & Kacperczyk, 2009; Pastor & Veronesi, 2012), seeking better financial performance in those that behave ethically in terms of carbon emissions and have low environmental impact (Bauer & Smeets, 2015; Nilsson, 2008). Overall, in the light of new European sustainable guidelines, market participants could select in the long run companies which consider climate change in their business strategy and are better prepared for the transition to a low-carbon economy, seeking for superior returns and low-climate risk exposures (Cheema-Fox et al., 2021; Reghezza et al., 2022).

1.5 Conclusion

The impact of climate change on financial system health is becoming one of the most urgent topics, capturing the attention among scholars, financial institutions and policy makers. Central banks and financial institutions play an important role in combating climate change. Indeed, they help the financial system to be resilient through the transition to a low-carbon

economy by providing transparent information to all market participants and, at the same time, by reducing greenhouses emissions.

This study tried to explain the nature of the relationship between the 45 main European carbon banks' emissions and relative stock returns over the period that goes from 2014 to 2020. These banks operate in 17 European countries. To the best of our knowledge, little is known about how carbon emissions affect European banking sector in terms of stock returns, and therefore, our study is aimed at solving this question. The originality of this study is twofold. First, what comes out is that before the introduction of European sustainable regulations such as the Sustainable Finance Action Plan, investors would claim a "carbon premium," i.e., greater stock price returns for those European financial institutions that are carbon inefficient. This is mainly due to the perception of the investors for the high climate risk exposure. Rauh et al. (2011) call this an "insurance-like protection against negative events." Secondly, the tiny negative relationship that exist between European banks performance and carbon emissions after the introduction of the European directive in 2018 ($\lambda = 0.0961 - 0.1011 << 0$) reveals a possible indication for stock market investors to address their investments toward sustainable portfolios, aligned with EU guidelines.

Indeed, nonetheless the negative coefficient, talking about a definitive reversal in the effect, is difficult given the empirical results, but at the same time these outcomes could be seen as a possible suggestion and indication for investors to address their portfolios toward low-carbon emission assets in the long run, in line with the increasing awareness of the regulatory European bodies toward sustainability. This is widely demonstrated by the growing mass of investors who are acting against climate change, creating sustainable portfolios for a low-carbon future and prompting the so-called portfolio decarbonization process.

Then, the findings of the work could add further information on how the financial market may perceives banks' carbon activities in the next years, raising the understanding of investors and market participants on allocating capital toward corporate environmental investments. What is certain is that investors will be exposed to transition-carbon risk in the next decades. Given the nature of the stock markets to look forward, it is natural to ask to what extent the carbon-climate risk is incorporated in stock returns.

This research is not without some limitations. We focus on European area banks only, not taking in account other financial institutions headquartered in other countries such as US, South America, or Asia. It might be interesting to extend the analysis to international banks as well. Furthermore, we do not consider the single business models of the banks taken in analysis and strategies of individual banks toward sustainability. In this view, we presume these may be some food for thought for future research.

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