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Climate Change and Corporate Financial Stability

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Abstract. *The paper looks into the impact of firms' carbon emission on their financial stability, using a unique set of granular data for companies in the Romanian economy. Carbon emissions are important for measuring companies' carbon footprint, so that the direct and indirect impact on the environment can be assessed and utilized to calculate the impact on banks' portfolio exposure to climate risk, or estimate the real sector financial stability risks. The paper uses Romanian companies' financial indicators from the financial statements reported to the Ministry of Finance, along with carbon emissions estimates collected from a robust sample of companies, to reveal the insights into how is the financial stability, measured through the Altman Z-score, impacted by the emission intensity. We confirm the hypothesis that higher carbon emissions have a negative influence on the Z-score of firms, in line with existing literature, for other economies. Further on, we discover that the existence of a governance structure responsible for environmental issues provides a stronger negative effect of increased emissions to financial stability. The study confirms the importance of monitoring carbon emission data at firm level in order to calibrate the corporate credit risk and contributes to the literature through the perspective of analyzing non-listed, smaller firms as well, compared to the majority of the available research, which is looking into data for public listed companies.*

Keywords: GHG emissions, carbon footprint, financial stability, scope 1, scope 2, non-financial companies.

Introduction

The global effects of climate change are no longer an abstract concept for people witnessing recent developments of extreme weather events, affecting economies worldwide, with repetitive new record high temperature levels in the past years. According to the Copernicus institute, 2024 was the hottest year on record, with 1.5 °C above the pre-industrial average level, surpassing the limit imposed by the Paris Agreement, adopted in 2015 during COP21. Policymakers and investors alike are looking more and more into ways of measuring economic actors' impact on the environment, as this will be the main input for new taxation measures and consumer preferences when drastic measures to reduce greenhouse gas (GHG) emissions, and implicitly its main component, the carbon emissions (CO_2 emissions), will have become inevitable.

Climate change affects the economy through two types of risks, according to how they materialize: physical risks of climate nature, which are represented by severe weather events like flooding, storms, droughts, affected ecosystems, or transition risks, which are the results of moving towards a low-carbon economy, leading to unanticipated and sudden adjustments of asset prices (Battiston et al, 2020). International institutions such as central banks and financial regulators (Financial Stability Board, European Central Bank, International Monetary Fund, Network for Greening the Financial System, and many others) explicitly recognize climate change as a new source of financial risk and analyze through extensive research the way in which the economy will be affected by the materialization of physical and transition risks. In order to quantify the effects

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of climate change risks and the interconnections between the financial sector and the non-financial sector, there is need to have access to climate-risks exposures of economic actors. The notable initiative of the G20 Financial Stability Board, creating the Task Force on Climate-related Financial Disclosures in 2015 paved the way forward to corporate disclosure of information relevant to assess and price risks related to climate change (FSB, 2017). Recent regulations at global and European level are making big steps into this direction. However, a lack of global consensus at international data collectors level on how climate change data is defined and reported is still posing concerns going further. G20 Finance Ministers and Central Bank Governors launched in 2009, after the Great Financial Crisis the Data Gaps Initiative (DGI) to solve the policy-relevant data gaps identified, which is currently at the third phase (DGI-3), addressing, among others, the climate change statistical area.

Most papers in the literature that focus on estimating climate risks are looking at global data, from major providers such as Bloomberg, MSCI, Refinitiv, S&P and Carbon Disclosure Protocol (CDP) (Barreau et al., 2024) or Refinitiv Eikon database (Ibishova et al., 2024), datastreams and entities which have own models to estimate GHG emissions, based on the few corporate climate disclosures available. However, methods used to calculate and disclose data for the few companies doing this often have different specifications, especially in the context of different supervisory jurisdictions. Going further, it is clear that measuring and reporting GHG emissions is very important for research in the field of green finance and in estimating transition risk and quantifying financial stability risks. Thus, already constructing models, despite low reliability of data, is a positive action for the future. Stakeholders, including shareholders and financial lenders are highly interested in having a clear view of the firm's environmental profile, including actions taken by highly polluting firms, also known as "brown" companies, to tackle their environmental footprint.

This paper is looking at granular data reported by Romanian non-financial companies related to own GHG emissions and examines the implications on the financial stability indicators. The topic is important in assessing any financial stability risks coming from the corporate sector, which can propagate further to the financial sector through bank exposures towards *brown* corporates. Transition risk is highly connected to the level of brownness of a firm/sector, and identifying the most exposed companies can offer the chance to proactively take steps intro carbon reduction initiative, where is possible. Actions taken for greening the economic activity can weight significantly in investment decisions, which look at the future compliance risk costs and reputation. We leverage granular database of financial statements submitted by companies to the Ministry of Finance, information from the Central Credit Registry of the National Bank of Romania related to bank exposures, along with data on carbon emissions and the existence of an environmental governance structure, collected through a survey run by the National Bank of Romania in collaboration with the Romanian National Institute of Statistics (NBR, 2022). The survey was addressed to 11,000 firms from Romania, representative at national and regional level based on economic sector and size, with a unitary methodology for estimating scope 1, scope 2 and scope 3 carbon emissions (more specifically, CO2e – carbon dioxide equivalent). Due to the difficulty of assessing Scope 3 emissions and low reliability of the collected data, only Scope 1 and Scope 2 emissions will be used in the analysis.

Our findings contribute to the existing literature by using highly granular collected data to estimate the influence of carbon emissions on financial stability indicators, offering proof for the benefits of corporate awareness of climate change risks and the need to prepare for transition risks.

The main research question driving this analysis is to find out if the impact of carbon emissions of a firm affects the financial stability of non-financial companies based on a sole economy sample data.

The next sections include a literature review of relevant work in the area, followed by methodology and data used for model estimations. Then we present the results and we evaluate the performance, and in the end we conclude with main findings and policy and strategy recommendations.

Literature review

More and more evidence show that climate change poses risks to ecosystems, as well as to the economy and implicitly to the financial stability. The ways climate change, such as extreme temperatures, floods and droughts affect the economy can be seen in the physical risks, which directly affect households or companies' plants and headquarters, or through indirect risks, where measures to reduce the factors influencing the heating of our planet will translate in discouraging highly polluting companies from performing their activity and transition to a more climate-friendly (greener) stance. National taxes on GHG emissions are expected to reduce territorial emissions in the future, but research show that their effect is limited in isolation, indicating an important need for international cooperation in reducing the global emissions (Schroeder & Stracca, 2023). However, even with a steep increase in emissions costs, as seen in the EU emissions trading system, some highly indebted firms fail to accomplish a low-carbon transition (Carradori et al., 2023)

Literature is scarce on the analysis of transition risk towards a carbon neutral economy, especially for countries such as Romania, characterized by a relatively small banking system relative to the GDP. Romania has the lowest financial intermediation among EU countries, with 27,8 percent corporate financial debt relative to GDP (NBR, 2024, p.30). The financial sector is supposed to have a very important role in financing the transition of the economy to a greener stage. Thus, the selection of their corporate portfolio should be based on accurate data of carbon emissions, as well as responsible projects of corporates in reaching a more sustainable activity. However, banking financing in Romania stands at only 27 percent of total firm debt according to 2023 financial statements, so we have to considerate the limited capacity that green policy investments might have, once adopted.

Reasons for banks to include climate risk in their operational strategy covers as well the will to improve reputation and image, responding to the market and shareholders' expectations (Toma & Stefanelli, 2022). Exposure towards carbon-intensive corporates and asset holding in their balance sheet is something both supervisors and investors pay attention to. However, climate considerations in terms of reputation and supervisory requirements might come in conflict with the creation of maximum value for shareholders, both for the financial and the non-financial corporate sector.

Current approaches of GHG emissions estimations are using major data providers such as Bloomberg, MSCI, Eikon Refinitiv, or CDP. As Barreau et al. (2024) are showing, using combined data sources make up for filling the eventual gaps in terms of time series or missing indicators. Matching the companies in the datasets leads to a lowers sample data, a compromise accepted by many authors in order to enlarge the variables coverage. Open source data is as well a reliable input choice for authors, with information collected from the World Bank or Ember (Barreau et al., 2024), or the EU emissions trading system (Carradori et al., 2023)

Early studies looked at the firm-value effects of carbon emissions and disclosures, in the context of scarce public data in the early 2000s. As pointed out by Matsumura et al. (2014), "markets penalize all firms for their carbon emissions, but a further penalty is imposed on firms

that do not disclose emissions information". Alsaifi et al. (2020) provide further evidence that investors react significantly negative to carbon disclosures via the Carbon Disclosure Project (CDP) and even more so for firms in carbon-intensive industries Looking towards the financial benefits of carbon emission reduction in companies, Ibishova et al. (2024) find that a decrease in carbon emissions improve companies' financial performance, measured by return on assets and return on equity. Benkraiem et al (2022) study how carbon performance affects the market value of firms, along with other variables like leadership and innovation capacity, finding a positive relation between these indicators and firms' market value. Even more, based on their panel data between 2013 and 2019, their results indicate that the most polluting firms increased their efforts to become more sustainable, increasing a positive effect of carbon performance on firm value. This particular characteristic is confirmed by more recent results (Ibishova et al., 2024), who show that carbon emissions reductions tend to improve the financial performance of companies, with the effect being even more intense for companies with higher carbon intensity.

Related to the connection between the financial stability of the firm and its carbon emissions, we find relevant studies analyzing this relationship by looking at Altman's Z-score of bankruptcy or financial distress prediction (Altman, 1968) with its subsequent re-estimations of the Z-score model to address different types of firms (Altman et al., 1983, 2017). One advantage of using the constructed Z-score is the possibility to derive it for non-listed companies, compared to other indicators like Credit Default Swaps (Bonacorsi et al., 2024). The indicator is used either as a stand-alone firms' financial stability proxy (Choi et al., 2024), a proxy for credit risk (Bonacorsi et al., 2024) or an alternative to default risk (Owolabi et al., 2024) measured by the distance to default or probability to default (Kabir et al., 2021). The usual analysis observed in the literature review is focused on panel data with various economies or a singular country, throughout several years, where the Z-score indicator is regressed against environmental indicators like carbon emissions (total, direct indirect carbon emissions), ESG scores, or individual ESG factors by which rating agencies construct the ESG scores. The results show that there is a positive association between stability and ESG activities, and a negative impact of carbon emissions on firm's distance to default. When looking separately at non-financial companies and financial firms, results indicate the same relationship of ESG scores improving financial stability of firms (Miah et al., 2021; Choi et al., 2024).

The paper contributes to the existing research by looking at granular data of non-listed non-financial companies, combined with carbon emission disclosures, at a representative national level for a European country. However, we acknowledge potential limitations in the accuracy of data, due to the fact that carbon emission information used is based on survey information, which was calculated for a part of firms as a first-time exercise.

Methodology

The data consists of 2021 micro-level information for the Romanian non-financial companies, based on a representative sample at national and regional level. We use a linear regression with robust estimator of variance to analyze the impact of carbon emission reported by firms on their financial stability. Independent variables used are financial indicators and additional information related to the existence of a governance structure related to climate change and environmental issues. The data comes from various granular sources: i) financial statements from the Ministry of Finance, ii) age of the firms from the National Trade Register Office, iii) loan information from the NBR Credit Registry, iv) carbon emission data and governance information collected through the Survey on the access to finance of non-financial corporations in Romania (NBR, 2022).

The sample comprises 7096 firms which are activating in Romania, which responded to the 2022 NBR's Survey on the access to finance of non-financial corporations. We intersected this sample with the available 2021 financial statements, leading to 6931 firms (out of which 83 percent were small and medium companies and the rest were large companies) for which both type of information was available. The amount of firms used for a single economy is more comprehensive compared to the other studies in the literature, where data is based on public disclosures of listed companies (Bonacorsi et al. 2024, Ren et al. 2024). The steps in processing the data consisted in aggregating and intersecting the information sources using Matlab, followed by identifying and treating for outliers and performing logarithmic transformation in Stata.

For the calculation of the Z-score as a measure for a firm's financial stability, we tested for both Z' and Z'' Altman's updated model from 1983, with the following formulas:

$Z' = 0.717 \cdot X1 + 0.847 \cdot X2 + 3.107 \cdot X3 + 0.420 \cdot X4 + 0 .998 \cdot X5,$

$Z'' = 3.25 + 6.56 \cdot X1 + 3.26 \cdot X2 + 6.72 \cdot X3 + 1.05 \cdot X4,$

where X1 = (Current assets – Current liabilities)/Total assets, X2 = Retained Earnings/Total assets, X3 = Earnings before interest and taxes/Total assets, X4 = Book value of equity/Book value of total liabilities, and X5 = Sales/Total assets. The larger the value of the score obtained, the lower the risk of financial distress for the firm. These formulas are developed for private firms as well, compared to the initial model (Altman, 1968), which was dedicated to public firms. The modified Z'' score developed for minimizing potential industry effects (Altman, 1983) was selected for our data sample due to the industrial diversity and good results for bankruptcy prediction (Altman et al. 2017). For the initial sample of 6931 firms, the mean Altman Z''-score was 6.58, with a standard deviation of 272.6. We will use in the study the simple notation Z-score going further, for simplicity, but the model used is the Z'' model described above.

To remove the extreme values, the sample data was first filtered for the firms who reported null Scope 1 emissions (622 firms removed), then for Scope 1 emission extreme values, removing the values up to the 10^{th} percentile and above the 95^{th} percentile (383 firms removed). In addition, the sample was winsorized by the Z-score values to remove the extreme values under the 5^{th} percentile and over the 95^{th} (other 581 extra firms removed). This approach ensures that the extreme values reported by some of the firms do not disproportionally affect the regression estimates, and preserves at the same time the overall structure of data.

From the resulted 5345 firms, 4494 are medium or small enterprises (SMEs), and the rest are large companies. The average firm age is 17 years and are distributed as follows across the industrial sectors: 17% agriculture, 3% mining industry, 31% manufacturing, 8% utilities, 9% constructions, 7% trade, 18% services and 8% real estate.

The dependent variable for the regression model is the Z-score, describing the financial stability of a firm. For the independent variables, the model uses financial ratios, return on assets (ROA) and leverage (debt-to-assets ratio), along with the age of the firm and the Scope 1 and Scope 2 emissions reported. The regressors are in line with existent literature (Bonacorsi et al. 2024, Choi et al. 2024, Kabir et al. 2021, Owolabi et al. 2024). We test as well an indicator of scaled emissions computed as natural logarithm of Scope 1+Scope 2 emission divided by natural logarithm of total assets, interacted with a binary variable showing the existence or absence of a dedicated governance structure for climate change in the specific firm. In addition, we use a credit flag, constructed as a dummy variable which equals 1 if a firm had an ongoing bank loan at the end of 2021 and an SME flag, to see whether the firm's size, as SME or corporation make a difference in our model.

Table 1 presents the definition of all variables included in the model specifications, while **Table 2** provides the descriptive statistics for all variables included in the regression models, after winsorization.

The model used to investigate the firms' probability to access bank loans has the following form:

$$Z\_score_i = \beta_0 + \beta_1 (\ln(S12emissions) * Governance) + \beta_2 ROA + \beta_3 Age + \beta_4 D2A + \beta_5 Credit\_flag + \beta_6 SME\_flag + \mu_{countyi} + \gamma_{sectori} + \epsilon_i$$

where Z_score_i represents the calculated Altman Z-score reflecting the financial stability for firm *i*, $\ln(S12emissions)$ is the natural logarithm of the Scope1 and Scope2 carbon emissions according to the GHG Protocol Corporate Standard, Governance is the categorical variable showing if the firm has a governance structure for climate change, which interacts with the carbon emissions, to assess whether governance moderates the impact of emissions on financial stability. ROA is the return on assets ratio, capturing firm's profitability, Age is the age in years of the firm, D2A is the debt-to-assets ratio, controlling for financial leverage, Credit_flag is the dummy variable indicating whether the firm has an ongoing bank credit. Further, ϵ_i is the error term, while county (μ_i) and sector (γ_i) capture regional and industry-level heterogeneity in the data.

Table 1. Variables included in the regression model

Variable name	Definition	Source
Z-score	Altman Z''-score model to predict for the possibility of bankruptcy in firms from emerging markets	Calculated based on information from the Ministry of Finance (annual financial statements)
Scope 1, Scope 2 emissions scaled by firm size	Carbon emissions as defined by the GHG (Greenhouse Gas) Protocol Corporate Standard. Scope 1 emissions are direct emissions from owned or controlled sources, while Scope 2 emissions are indirect to the firm, from the generation of purchased energy. Surveyed firms were given instructions on how to calculate these emissions. The natural logarithm of Scope 1 +Scope 2 emissions is divided by the natural logarithm of firm's assets	Calculated based on the National Bank of Romania's Survey on access to finance of the non-financial corporations in Romania (SAFE) – NBR (2022) and size of assets from the Ministry of Finance (annual financial statements)
Governance	Dummy variable showing 1 for the existence of a governance structure, by marking the first option of the response options below, and 0 for the rest. The survey question was formulated as follows: *Do you have staff in the organisation that is responsible for environmental issues and the effects of climate change?* *a)Yes; b) No, but it is planned in the near future (3 years); c) No, and we have no plans in the near future*	National Bank of Romania's Survey on access to finance of the non-financial corporations in Romania (SAFE) – NBR (2022)
Age	Age of the company as of 2022, measured in years, using the year the company was founded	National Trade Register Office (ONRC)
ROA	Return on assets ratio, calculated as net profit divided by total assets, as of 2021	Calculated based on information from the Ministry of Finance (annual financial statements)
D2A (leverage)	Calculated as debt to total assets, as of 2021. A higher value shows that a larger portion of assets is financed through debt	Calculated based on information from the Ministry of Finance (annual financial statements)
SME_flag	Dummy variable with value 1 if the firm is a small or medium enterprise, and 0 if it is a large corporation	Calculated based on information from the Ministry of Finance (annual financial statements)

Variable name	Definition	Source
credit_flag	Dummy variable with value 1 if the firm has an ongoing loan with a Romanian bank at the end of 2021, and 0 if not	Central Credit Registry
sector	The economic sector according to NACE Rev. 2 in which the firm activates	Ministry of Finance
county	The development region, NUTS-2 level, in which the firm is registered	Ministry of Finance

Source: Authors' own research.

Table 2. Descriptive statistics

Variables	Observations	Mean	Standard deviation	Minimum	Maximum
Z-score	5,345	8.38	4.83	-1.37	25.13
Ln(Scope 1, Scope 2 emissions)	5,345	4.88	2.21	-3.00	15.44
Ln (scaled Scope 1, Scope 2 emissions)	5,345	0.30	0.12	-0.24	0.95
Age	5,345	17.45	8.49	0.00	32.00
ROA	5,345	0.15	0.20	-1.31	2.80
D2A (leverage)	5,345	0.53	0.29	0.05	3.17

Source: Authors' own research.

Results and discussions

The regression results offer perspective on our research question: do carbon emissions impact Romanian firms' financial stability? To investigate the causal effect, we perform several sets of multivariate regressions, based on different specifications: (1) a baseline regression, where the Z-score is regressed against firm financial performance and characteristics, (2) a regression where the Scope1 Scope 2 carbon emissions scaled by asset size are included in the independent variables, and (3) an extended specification with the interaction of the scaled carbon emissions with the climate change governance existence.

The models specifications were tested with *linktest*, showing no errors in the specifications. We look as well at the relevance of introducing the regional and industry fixed effects, by comparing the R^2 of an OLS model (4) with the Fixed effects model on our selected variables, and we confirm that the fixed effects improve the model. VIF (Variance Inflation Factors) test performed on the OLS regression (4) show that there is no multicollinearity between predictors. In order to address potential heteroscedasticity, the regression models (1)-(3), are estimated using the *reghdfe* command in Stata with the option *vce(robust),* ensuring that standard errors remain valid even if the errors exhibit heteroscedasticity. The results of the estimations are presented in **Table 3.** All models present consistent results and the signs and significance of the variables are in line with the existing literature.

We find that the impact of carbon emissions influences negatively the financial stability of firms, as measured through the Altman Z-score, according to previous finding in the literature, assessed on multiple economies (Kabir et al., 2021, Owolabi et al., 2024, Bonacorsi et al., 2024). All coefficients are significant ($p<0.01$) across the presented regression models. The model (2), which analyses the impact of emissions scaled by size of the firm indicates a negative coefficient of -1.82. The model (3) confirms the negative impact and looks at the interaction between the carbon emissions and the existence of an environmental governance structure in the firm, and provides further insight: having this kind of structure increases the impact carbon emissions have over the financial stability of a firm. This finding might be counterintuitive, if one might expect that a dedicated structure would mitigate the effect of carbon emissions on the financial stability of a firm. The reason behind the result can be explained by the fact that mostly firms with very

intense polluting profile have this structure in place, at a time when they are already concerned about the impact of their emissions related to the impact on the financial performance. The results are quite similar when treating for economic sector and regional fixed effects (3), as to the case these effects are not taken into consideration (4).

Looking at the financial indicators, we observe as expected relationships: a positive increase in ROA leads to an increase of the Z-score of a firm, all coefficients being robust across all (1)-(4) models ($\beta_2 = 6.1$, 6.14, 6.03, respectively 6.09, with p<0.01). More precisely, a 1-unit increase in ROA value leads to an approximate 6 unit-increase of the Z-score. Turning to leverage, all the models indicate a large and negative coefficient (-11.47), confirming that firms with excessive debt have significantly lower financial stability. This is consistent with expectations related to financial stability. From the perspective of mitigating risks of transition to a green economy, Kabir et al. 2021 indicate that firm managers "should adjust financial decisions, such as lowering leverage to avoid potential distress costs associated with high emissions".

Table 3. Estimation results - coefficients

	(1)	(2)	(3)	(4)
VARIABLES	**Z-score**			
0.governance#ln(scaled_emissions)			-1.555***	-1.475***
			(0.346)	(0.335)
1.governance#ln(scaled_emissions)			-2.005***	-1.999***
			(0.320)	(0.309)
ln(scaled_emissions)		-1.821***		
		(0.312)		
roa	6.100***	6.046***	6.027***	6.093***
	(0.338)	(0.333)	(0.334)	(0.325)
credit_flag	-1.405***	-1.366***	-1.364***	-1.331***
	(0.084)	(0.084)	(0.084)	(0.083)
age	-0.0259***	-0.0242***	-0.0237***	-0.023***
	(0.005)	(0.005)	(0.005)	(0.005)
SME_flag	0.545***	0.398***	0.353***	0.308***
	(0.097)	(0.098)	(0.101)	(0.092)
Leverage	-11.44***	-11.47***	-11.47***	-11.44***
	(0.319)	(0.314)	(0.314)	(0.312)
Constant	14.27***	14.92***	14.95***	14.92***
	(0.245)	(0.249)	(0.250)	(0.248)
Observations	5,345	5,345	5,345	5,345
R-squared	0.709	0.711	0.711	0.707
Region FE	Yes	Yes	Yes	No
Sector FE	Yes	Yes	Yes	No
Robust standard errors in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Source: Authors' own research.

Next we look at firm structure, via the SME dummy variable, with results showing that there is a small but positive influence of SMEs being associated with higher financial stability, compared to corporations, holding all other things constant. This result can be supported by the fact smaller companies often rely on internal financing or equity, leading to lower debt, they adapt

more quickly to market conditions and are more adaptable to market changes and regulatory changes. Age, however, is seen to have a small but negative coefficient, indicating that older firms have slightly lower financial stability (each additional year reduces the Z-score by approximately 0.02 units).

Another interesting result we find is that firms with credits from banks display a lower Z-score in all (1)-(4) models, (β_5 = -1.4, -1.36, -1.36, respectively -1.33, with p<0.01) compared to firms without credits. This finding could be further investigated looking at the structure of debt that firms have, taking into consideration the low financial intermediation in the Romanian economy. Firms in this economy prefer commercial credits compared to financial loans, even though the costs of this choice might be higher (NBR, 2024, p. 37). On our data sample, the most probable explanation is that firms with strong financial position (and higher Z-scores) tend to prefer funds from internal sources rather than from financial lenders.

The results of the study provide a confirmation of the existing literature which indicates a negative relationship between carbon emissions and financial stability of firms, replicated on the Romanian economy, using very granular information. In addition, we investigate additional variables, such as the existence of a governing structure for environmental issues inside the firm, and whether or not the firm uses bank loans, to dive into subtler characteristics and open the way to future investigation. Our design confirms that banks should consider climate risk of corporates when constructing and evaluating their portfolios, in the perspective of future taxes and measures imposed by governments to reduce the climate change effects.

Conclusion

While most studies in the literature confirm that stakeholders are aware of climate change and its consequences, and financial markets are incorporating the climate exposure information when assessing creditworthiness, this research looks into non-listed firms and information, to assess whether the negative impact is confirmed. Rather than looking at a very large set of economies, the paper offers a robust sample data of almost 6,000 firms in Romania, with reliable sources for financial indicators and a unique set of carbon emission data for each, filling the gap of such an analysis in an EU member state.

The results of the used empirical models confirm, as a main finding, that carbon emissions of firms are negatively correlated to their financial stability, measured by the calculated Altman Z-score. Models are robust, and the treatment used for economic sector and regional (county) level fixed effects is proven to improve the estimation power. Further on, the independent variables used confirm that the model is well specified, with expected results for financial ratios such as ROA and leverage.

Based on the results and the negative impact of carbon emission on financial stability, the research suggests as further policy recommendation that, in the first place, companies should be made aware of climate change impact on their activity, climate risks in the near and long-term future, including carbon taxes, consumer preference and reputation, and most important, how to assess and calculate their risk exposure, through international standards, such as the GHG protocol. To achieve the mentioned objectives, financial institutions and governments should provide aid and information to firms so that progress is made in a timely manner. Further on, with available information on carbon footprint, financial institutions can benefit from a correct assessment of their exposure towards brown companies, and governments can evaluate the systemic risks induced by the effects of climate change and the measures of transition to a green economy. Alignment of

estimation methodologies at national level, and further on, with international standards, will be of utmost importance when aggregating and comparing data.

Further on, the research can be improved with additional time periods for data and the inclusion of different sources for carbon emissions, such as the EU ETS information, to assess how the changes in emissions impact financial stability or profitability indicators of firms. In terms of methodology, the analysis can be improved by using a machine-learning algorithm which could identify better the relevant variables to be included in the regression model.

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